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Report of the

INTERAGENCY TASK FORCE ON PERSISTENT MARINE DEBRIS

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Report of the

INTERAGENCY TASK FORCE ON PERSISTENT MARINE DEBRIS

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Department of the Interior, Fish and Wildlife Service, National Park Service, Minerals Management Service

Department of State

Department of Transportation, U.S. Coast Guard

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Marine Mammal Commission

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GC1085.U52 1988
18913168
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Acknowledgements

The Task Force acknowledges the many people in addition to the Task Force members who provided outstanding input and support on this project: Ronald Evans (EPA and Task Force staff); Jane Hannuksela and Maria DeCillis (NOAA and Task Force Staff); James Coe, Bernard Griswold, and Erik Reid (NOAA); David Redford, and Moira Shoen (EPA); Ray Beittel and LeRon Bielak (DOI); Joel Whitehead (USCG); Althaea Langston (USDA); and Sandy Werner (OMB).

REPORT OF THE

INTERAGENCY TASK FORCE ON

PERSISTENT MARINE DEBRIS

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ACRONYMS USED IN TEXT

APHIS	Animal and Plant Health Inspection Service
APPS	Act to Prevent Pollution from Ships
CEE	Center for Environmental Education
COPPE	Council on Plastics & Packaging in the Environment
CSO	Combined Sewer Overflow
DEP	Department of Environmental Protection, New Jersey
DOI	Department of the Interior
DOT	Department of Transportation
DPC	Domestic Policy Council
EEZ	Exclusive Economic Zone
EPA	Environmental Protection Agency
ESA	Endangered Species Act
GLO	General Land Office
FWS	Fish and Wildlife Service
LDC	London Dumping Convention
MARPOL	Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships,
MERP	Marine Entanglement Research Program
MMC	Marine Mammal Commission
MMS	Minerals Management Service
NAS	National Academy of Sciences
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOPPA	National Ocean Pollution Planning Act
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
PA	Polyamide (nylon)
PE	Polyethylene
POTW	Publicly Operated Treatment Works
PP	Polypropylene
MPPRCA	Marine Plastics Pollution Research and Control Act
RCRA	Resource Conservation and Recovery Act
SPI	Society of the Plastics Industry, Inc.
STP	Sewage Treatment Plant
TSCA	Toxic Substances Control Act

Chapter I
Executive Summary

The Problem

Modern society uses a variety of petro-chemical compounds generically referred to as "plastics". Plastics are often substituted for natural materials in clothing (polyesters and nylons instead of cotton, wool, and linen), building materials (fiberglass and similar resin products rather than wood and steel), a myriad of containers from food containers and small vials to underground tanks (polyesters and fiberglass rather than glass and steel), and numerous other applications.

The qualities of various plastic formulations -- strength, durability, light weight, ease of production and handling, versatility, and low cost -- often make them preferable to other materials. Some of these same qualities that make plastic products so desirable also make them potential environmental problems. Some discarded plastics may persist several decades when dropped on land, buried in a landfill, or disposed of at sea.

Most discarded plastic products end up in landfills or are burned. However, unknown amounts end up as litter on land and in marine and estuarine waters. Plastic products in oceans come from several sources: discarded trash from ships; fishing gear that has been accidentally lost or intentionally discarded; trash left by beach goers or tossed over the side by recreational boaters; effluent in rivers which carry plastic and other debris into estuaries and oceans; and sewage treatment systems, especially in times of heavy storm runoff. Federal laws restrict

the direct ocean dumping of all materials. No permits have been issued for the ocean dumping of garbage (including plastics) into the ocean.

Persistent marine debris causes problems worldwide. Based on information currently available, the problems have not reached crisis stage at most locations or for most species. By dealing with these problems now, through current efforts, particularly programs recommended in this report such as the research recommendations, it should be possible to avoid future problems and reduce existing impacts caused by persistent marine debris.

Plastic debris in ocean and coastal areas causes problems for wildlife, boaters, and people using beaches. An improperly disposed of plastic product could end up entangled around a seal's neck, ingested by an endangered sea turtle, washed up on a beach, or entwined in a vessel's propeller. Litter is the most obvious cause of public concern. Two categories of problems predominate:

-- death or injury of marine life such as fish, shellfish, marine mammals, seabirds, and sea turtles; and

-- litter on beaches, which is primarily an aesthetic irritant and an economic burden, but may cause health problems if the material has been contaminated.

Living marine resources are dying as a result of becoming entangled in marine debris or ingesting it. For example:

-- Scientists monitoring the Pribilof Islands population of North Pacific fur seals have documented that many animals, especially juveniles, become entangled in

persistent marine debris. Some scientists attribute a major portion of the current population decline to entanglement.

-- Virtually all species of sea turtles, all of which are endangered or threatened, are known to ingest plastic which may be confused with natural prey. Some scientists believe the potential exists for significant numbers of young turtles to be killed by interactions with plastics during the pelagic phase of their life cycle.

-- Many species of seabirds ingest a variety of plastic products including resin pellets, pieces of styrofoam, and fishing line. They also become entangled in derelict fishing gear, strapping bands, and six-pack yokes, leading to their deaths.

A number of marine and terrestrial birds and mammals, as well as marine and freshwater fish, become entangled in debris. Problems exist with "ghost fishing" by lost nets and traps, which can continue to entangle marine resources for years after they are lost. Anecdotal reports and local systematic surveys are increasing each year. To date, adverse impacts have been well studied for only a few wildlife populations, e.g., northern fur seals and the endangered Hawaiian Island monk seals. Without supporting data on population impacts, determining the "significance" of marine debris impacts on wildlife depends to a large extent on one's interpretation of "significant." Is the loss of a single individual "significant?" What if the species is threatened or endangered? What if a few losses occur each year? We need considerably more data to characterize accurately the effects of marine debris on wildlife populations. While

available data suggest that marine debris poses a serious problem for many species, data are not yet adequate to document the magnitude of effect on populations of any species.

Litter on beaches is ubiquitous and causes much of the public concern. Litter detracts from people's appreciation of beaches and the ocean. Coastal recreation forms the base of many coastal communities' economies. Accordingly, to avoid losing tens or hundreds of millions of dollars in tourism, coastal communities spend millions of dollars each year to maintain attractive beaches. State and local agencies are leading campaigns across the country to increase public awareness of problems caused by persistent marine debris. In 1984, the Oregon Department of Fish and Wildlife initiated local beach clean ups. The idea caught on and spread quickly. In 1987, over 26,000 volunteers participated in beach clean ups in every coastal state. People who coordinated the activities were government employees, citizens' groups leaders, and private sector employees. Several states, particularly Texas and Louisiana, sponsored "adopt-a-beach" programs in which organizations recruited volunteers to clean stretches of beach. Effectively combatting problems caused by persistent marine debris requires continued strong grassroots support in local communities.

We know very little about the specifics of marine debris. For instance, we do not know how much originates from different sources, or how much is currently in the oceans, some of which may be mixed with other flotsam and jetsam. How many birds, marine mammals, sea turtles, and fish are captured each year by marine debris? Is it stressing populations? Will efforts underway to reduce input of persistent marine debris be effective? What can be done about land-based sources? How often are vessels disabled by plastic line and sheeting? We need to

conduct additional research to answer these and other questions to assure that we select appropriate measures to mitigate the problems.

Charge to the Task Force

During 1987, Administration and Congressional leaders recognized the need to assess problems caused by persistent marine debris and develop a comprehensive, coordinated strategy to address them. On April 2, 1987, thirty Senators wrote President Reagan expressing their concerns about this problem (Appendix A). Numerous programs exist within the Federal government to address aspects of the problem. However, ongoing activities have not been well coordinated, and are scattered among agencies.

The White House Domestic Policy Council (DPC) formed an Interagency Task Force on Persistent Marine Debris and directed the National Oceanic and Atmospheric Administration (NOAA), within the Department of Commerce, to chair it. The DPC charged NOAA with convening the Task Force to: "assess the problem and the need for research, identify potential reduction measures, and consider alternative actions to address the problem of plastic marine pollution." Representatives of seven Departments, four independent agencies and the White House participated on the Task Force:

- -- Department of Agriculture, Animal and Plant Health Inspection Service
- -- Department of Commerce, National Oceanic and Atmospheric Administration
- -- Department of Defense, U.S. Navy
- -- Department of Health and Human Service, Food and Drug Administration
- -- Department of the Interior
- -- Department of State
- -- Department of Transportation, U.S. Coast Guard

-- Council on Environmental Quality
-- Environmental Protection Agency
-- Marine Mammal Commission
-- Office of Management and Budget
-- White House Office of Policy Development

The Task Force reviewed available data on sources and effects of persistent marine debris and developed a series of recommendations to reduce the problems.

Since the Task Force began, President Reagan signed the Marine Plastic Pollution Research and Control Act (Title II of Public Law 100-220). This law, among other things, amends the Act to Prevent Pollution from Ships and implements Annex V of the Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships, 1973/1978 (MARPOL 73/78).

Annex V of MARPOL 73/78 prohibits discharge into the sea of "all plastics including, but not limited to, synthetic ropes, synthetic fishing nets, and plastic garbage bags." It also prohibits discharge of food wastes and other floating materials within specified distances from land.

The U.S. Coast Guard, within the Department of Transportation, is currently preparing regulations to implement Annex V of MARPOL 73/78. The regulations will become effective December 31, 1988.

The Task Force report addresses the issue of persistent marine debris-- plastics in the marine environment. The best indicator of the marine debris problem is the volume of plastic material that washes ashore. Types and quantities of plastic products that wash ashore vary considerably between locations depending on a variety of factors such as proximity to fishing grounds,

shipping lanes, urban centers, offshore currents, and prevailing winds. The most commonly found items throughout the country are plastic bottles, sheeting, bags, fishing nets and fragments, styrofoam cups and fragments, and resin pellets.

Persistent marine debris is part of two larger problems--marine pollution and solid waste disposal. Oceans receive a range of chemical pollutants from industrial, agricultural, and urban sources. A recent study by the Congressional Office of Technology Assessment entitled "Wastes in the Marine Environment" focuses on some of these larger issues. Similarly, many cities and rural areas are facing crises over what to do with all solid wastes. Federal regulations prohibiting disposal of plastic wastes in the marine environment will require mariners to dispose of their plastic wastes when they come to shore. Ports and marinas will have to provide additional refuse services for marine-generated wastes which have traditionally been thrown overboard. This report does not address the broader issues of marine pollution and of solid waste disposal. However, it recognizes that some of the potentially most effective solutions, such as recycling and degradable products, may only be cost effective when received within the broader context of solid waste management.

Recommendations

The Task Force presents five general recommendations to the Domestic Policy Council. Each general recommendation includes additional, more specific recommendations.

These recommendations are aimed at reorienting the priorities of the Federal government to address appropriately the problems of persistent marine debris within the confines of existing

budgets. New budget authority is not contemplated. The recommendations are written to give individual agencies discretion in committing their own resources and implementing the recommendations. Agencies will have to determine funding levels for relevant programs within the context of their separate missions. These recommendations direct agencies to increase their level of effort and provide technical as well as educational materials to state and local governments, private citizens and industry.

Recommendation 1: **Federal Leadership:**

Federal agencies should provide leadership and continue formal and informal coordination activities related to marine debris with international organizations, state and local governments, private industry and environmental groups. Federal agencies acknowledge that an effective program is only possible with strong state and local involvement.

Recommendation 1A: Federal agencies should cease disposal of plastic materials into the ocean from all Federal vessels as soon as possible.

Recommendation 1B: Federal agencies should review their procurement and concession policies in coastal facilities to reduce the amount of plastic packaging, containers, and other products that are improperly disposed of and become persistent marine debris.

Recommendation 1C: Federal agencies should continue to participate actively in international forums to reduce persistent marine debris.

Recommendation 1D: Federal agencies should encourage plastic waste recycling by: 1) providing separate receptacles for different types of trash at coastal facilities; 2) purchasing and using recyclable products and materials whenever possible; and 3) providing technical support to state and local agencies and industry on recycling.

Recommendation 1E: NOAA should coordinate and disseminate information related to persistent marine debris. NOAA should call at least two meetings of appropriate Federal agencies each year to discuss each agency's education, regulatory, and research programs, as well as to ensure that a contined coordinated effort is made to maximize the effect of existing Federal programs.

Recommendation 1F: NOAA should continue to sponsor the informal Marine Debris Roundtable.

Recommendation 1G: The Administration should support the NOAA/Marine Entanglement Research Program by including it in the Administration's FY 1990 budget and for at least five years thereafter.

Recommendation 1H: Persistent marine debris should be included as an element in the 5-Year Federal Plan for Ocean Pollution Research, Development, and Monitoring.

Recommendation 2: Public Awareness/Education Program:

Concerned Federal agencies should work with each other, state and local governments, private industry, and environmental groups to develop comprehensive educational materials on problems caused by marine debris and ways to solve them.

Recommendation 2A: Federal agencies should cooperatively support a major public awareness campaign by providing seed money and encouraging funding by the private sector.

Recommendation 2B: The U.S. Coast Guard, U.S. Navy, and other Federal agencies should include materials relative to persistent marine debris problems in all educational materials for employees and candidates for licenses.

Recommendation 2C: Federal agencies should use all appropriate media to explain both problems marine debris causes and proper disposal methods. Federal agencies should support formation of an interagency information exchange for available educational materials.

Recommendation 2D: The U.S. Coast Guard should begin a public education campaign on the requirements of the Marine Plastic Pollution Research and Control Act as soon as possible to assure that owners and operators of all vessels, ports, and the boating public are aware of requirements prior to their entering into force.

Recommendation 3: Vigorously Implement All Laws Related to Marine Debris:

The Department of Transportation, EPA, NOAA, and Navy should vigorously implement the Marine Plastic Pollution Research and Control Act and other laws to reduce plastic pollution in the marine environment.

Recommendation 3A: Each agency should make compliance with requirements of the Marine Plastic Pollution Research and Control Act a high priority.

Recommendation 3B: The Coast Guard and other Federal enforcement agencies should make enforcement of regulatory requirements of the Marine Plastic Pollution Research and Control Act a high priority.

Recommendation 3C: NOAA should encourage regional fishery management councils to include requirements that fish and shellfish traps and pots have degradable panels or latches.

Recommendation 4: Research and Monitoring:

Federal agencies should carry out research to:

a) identify and quantify deleterious effects that marine debris causes for fish and wildlife, coastal communities, and vessels;
b) determine land-based sources of marine debris; and
c) assess potential uses for, by-products of, and effects of by-products of degradable plastic products.

Recommendation 4A: NOAA, the Fish and Wildlife Service, the Marine Mammal Commission and other agencies should expand

research and monitoring activities to determine more precisely impacts of persistent marine debris on fish and wildlife populations, particularly endangered, threatened, and depleted species.

Recommendation 4B: Federal agencies should work with state and local governments, universities, merchant vessel owners and operators, commercial and recreational fishermen, and local communities to quantify economic impacts caused by persistent marine debris.

Recommendation 4C: EPA, NOAA, Coast Guard, and other agencies should carry out research to determine contributions of land-based and vessel sources of plastic refuse to the overall problems, as well as ways to reduce plastic debris from all sources.

Recommendation 4D: NOAA should work with fishermen and equipment manufacturers to develop pragmatic ways to:

1) reduce loss of fishing equipment, particularly traps, trawl nets, and gill nets;
2) improve ways to recover lost fishing traps and nets; and
3) recycle used fishing nets and net fragments.

Recommendation 4E: The National Bureau of Standards should work with the ASTM (formerly known as American Society for Testing Materials) and other industry associations to develop standards and criteria for what constitutes "bio-degradable" and "photo-degradable".

Recommendation 4F: EPA, FDA and NOAA should work with plastic manufacturers to examine how degradable plastics

react in the environment, including potential environmental effects as the plastic degrades.

Recommendation 5: Beach Clean-up and Monitoring:

Federal agencies should work cooperatively among themselves, as well as with state agencies, private industry, and environmental groups to remove marine debris from beaches and other parts of the marine environment. Federal agencies should encourage coordination with state and local authorities to conduct systematic monitoring of marine debris accumulation and impacts to assess compliance with regulations prohibiting disposal of plastics and controlling other solid waste discharges into U.S. waters.

Recommendation 5A: Federal agencies which manage coastal properties should step up actions to remove persistent marine debris.

Recommendation 5B: Federal agencies should support local volunteer beach clean-up efforts as well as the collection and interpretation of data on what the volunteers remove. Federal managers should encourage employees to participate in volunteer clean-ups.

Chapter II
Problems Caused by Marine Debris

Plastic debris in marine and coastal environments affects fish and wildlife, commercial and recreational fishermen, recreational boaters, maritime transporters, and people who enjoy beaches and other marine activities. Volunteer beach clean-ups provide useful information on the variety of items such as bags, six-pack rings, bottles, sheeting, and fish nets and lines, which wash ashore in various areas. However, data from beach clean-ups cannot clearly define all problems caused by marine debris nor identify with certainty the exact sources of most material. Most descriptions of effects on fish and wildlife caused by marine debris rely on incidental reports by scientists.

Five groups of wildlife are most susceptible to injury from discarded plastic: sea turtles; marine and terrestrial mammals; birds; fish; and crustaceans. Marine debris affects wildlife in one of two ways--they can become entangled in it or ingest it (Laist, 1987). When an animal becomes entangled or ensnared in plastic debris (strapping bands, beverage container rings, or nets, ropes, and lines), it can strangle, suffocate or exhaust itself. Injury or death may be immediate or prolonged. When an animal ingests small pieces of plastic, it is likely to pass (regurgitate or defecate) it. Large sheets of plastic and other items have blocked intestinal passages of turtles and whales.

Currently available reports on wildlife entanglement in marine debris indicate that many species of marine and terrestrial birds and mammals, as well as marine and freshwater fish, become entangled in debris. Anecdotal reports and local systematic surveys are increasing each year. Although individual animals of many species are harmed, to date, scientists can identify adverse

impacts to only a few wildlife populations, e.g., northern fur seals and the endangered Hawaiian monk seals. Without supportive data on population impacts, determining "significance" of marine debris impacts on wildlife depends to a large extent on one's interpretation of "significant." Is the loss of a single or a few individuals "significant?" What if the species is threatened or endangered? Is the potential, but presently undocumented loss of larger numbers of individuals, considered significant? We need considerably more data relating marine debris relationships to wildlife population levels before we can conclude that marine debris has significant adverse impacts on such populations. It is known, however, that marine debris affects individuals of many endangered, threatened, and commercially valuable species. Data are not sufficiently reliable to conclude that its effects are not a significant factor in the health of at least some of these species' populations.

Scientists regularly report "scars" and bruises on marine mammals as evidence of entanglement. They point out that it is difficult, if not impossible, to know if the scar is from active or discarded fishing gear. Scientists doing this research collect most of their data on land, using stranded sea turtles and cetaceans as specimens. There are no reliable estimates of the fate of marine animals which entangle in debris while at sea or ingest plastic products, because these animals either sink or are eaten, or go unnoticed by human observers due to the vastness of the oceans.

Marine debris affects commercial and recreational fishermen in several ways. First, target species continue to be captured in lost traps, nets, or lines. The extent of losses is unknown, but in some cases, such as lost crab traps, losses may be significant. Second, marine debris may foul or damage active

fishing gear as well as damage fishing boats, foul ship propellers, and clog vessel water intake systems. The latter two impacts also affect pleasure, merchant, and military vessels, although such occurrences do not appear to be common.

A. Fish and Wildlife

1. Marine Mammals

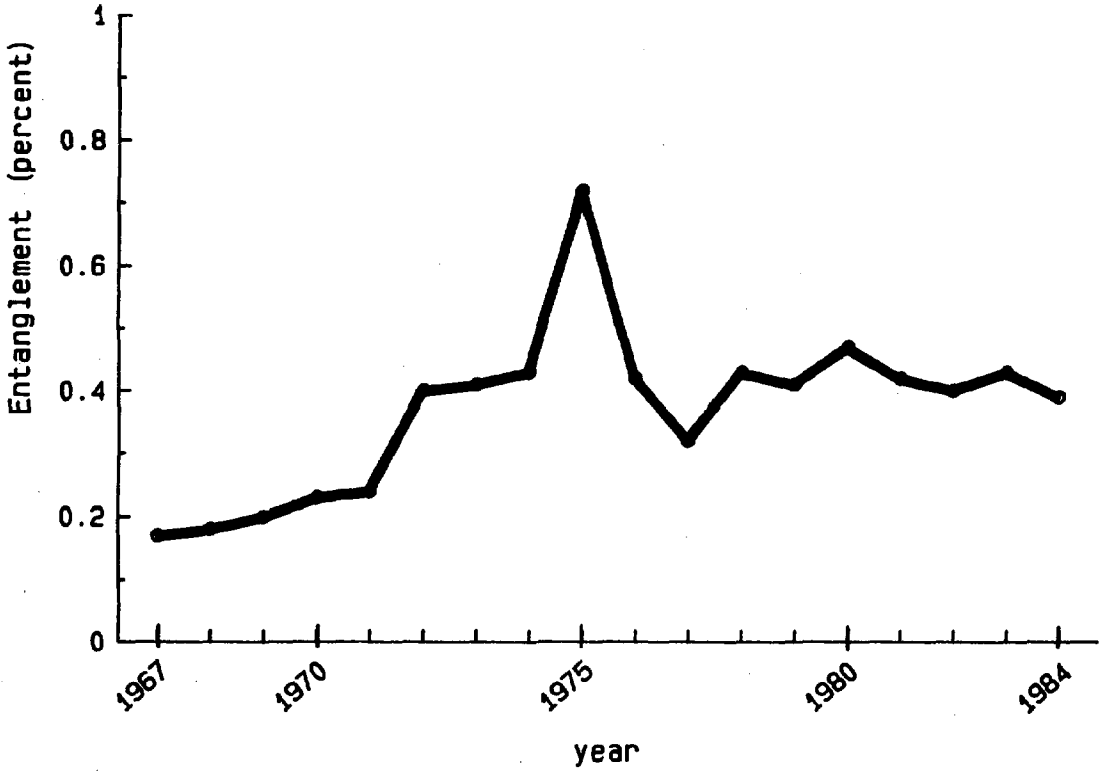
Reports of marine mammals entangled in marine debris have increased. This may be due to an increase in the actual number of such incidents or an increase in concern and recognition of the problem. Most of the reports come from areas where fishing or marine transportation is common. The most commonly reported entangling debris items are fishing nets, scraps of fishing nets, plastic strapping bands, ropes, and plastic sheeting (Laist, 1987).

a. Seals and Sea Lions

Perhaps the best documented research on entanglement in marine debris has been done on northern fur seal populations on the Pribilof Islands (Fowler, 1985; Scordino, 1985). From the mid-1970s to the mid 1980s, the Pribilof fur seal population has been declining at about 4 to 8 percent per year. Scientists monitoring annual seal harvest between 1981 and 1984 examined harvested seals for evidence of entanglement such as scars around the seals necks, or materials attached. The most common debris entangling seals was net fragments with mesh size of 20 cm or greater. Of the animals harvested, 0.42 percent had indications (scars or bruises) that they had encountered debris (Figure II-1). The observed entanglement has remained relatively constant at about .04 percent since it peaked in 1976 at .076 percent. Fowler (1985, 1987) concludes that this observed rate of

Figure II-1

Entanglement rate observed in the harvest and research drives of subadult male fur seals for St. Paul Island, Alaska, 1960 - 1985



source: Fowler, 1987

entanglement contributes significantly to the decline of the population. He bases this mortality theory on correlations between observed entanglement, pup production, and female harvest. Scientists count only those animals that become entangled in small enough net fragments that they are able to swim back to land. However, they believe that most entangled animals never return to land. Coe (1986) concludes that existing data are insufficient to conclude reliably that the decline of fur seals population is due solely to entanglement in lost fishing gear.

Scientists have also studied entangled seals and sea lions at other breeding and haul-out beaches. Stewart and Yochem (1985) examined sea lions, elephant seals, and harbor seals at San Nicholas and San Miguel Islands in California and found the numbers of seals and sea lions plastic encounters shown in Table II-1.

Henderson (1985) summarizes reports of 27 to 35 Hawaiian monk seals, a highly endangered species, entangled between 1974 and 1984. Since these seals inhabit remote, seldom visited, islands in the Hawaiian archipelago, this is likely to be a minimum estimate. Hawaiian monk seals are highly endangered and number only 1,000 to 1,800 animals. They are particularly susceptible to buoy lines marking spiny lobster traps, and net debris from high seas gill net and groundfish trawl fisheries in the north Pacific, much of which washes ashore on the leeward side of the archipelago. In general, it appears that pups and young animals are more likely to become entangled and killed, than older, more experienced individuals.

Table II-1. California Marine Mammal Plastic Encounters

Source: Stewart and Yochem (1985)

	Sea lion	Elephant seal	Harbor seal
Examined	13,175	11,054	1,877
Encircled with plastic	11	10	1
Scars indicating entanglement	13	7	1

b. Cetaceans

Many observers throughout the world have reported incidences of whales and dolphins entangled in fishing gear. The most common types of gear entangling cetaceans are gill-nets (and fragments of them) and buoy lines used to mark traps. Weinrich (1987) reports that 56 percent of endangered right whales photographed by the New England Aquarium have scars from probable gill-net or lobster gear entanglement. Center for Coastal Studies photographs of endangered humpback whales in New England waters show nearly 40 percent of those animals bear scars indicating they have encountered nets or lines (Center for Coastal Studies as cited in Weinrich, 1987). It is not clear whether these scars are due to entanglement in lost or active fishing gear. As with seals, juvenile whales appear to be more susceptible than adults. Weinrich estimates that net mortality of whales in New England waters caused by entanglement is a "moderate, but not severe, problem."

In the Pacific offshore fisheries, there are few reports of cetacean entanglement in gear known to be lost or abandoned. Mate (1985) reports several incidences of gray whales off the Oregon coast with active crab-pot buoy lines between their baleen plates, and each year there are a few reports of gray whales becoming entangbled in gill nets.

There is some evidence that whales ingest plastic materials. Of 38 sperm whale stomachs examined, one contained "about 1 liter of tightly packed trawl net." (Harvey, in Mate, 1985). Walker (1988) reports that pelagic cetaceans rarely have plastic in their digestive tracts. He collected data from approximately 1,500 free roaming cetaceans (6 different species including Dall's porpoise, bottlenose dolphins, sperm whales, killer

whales, Stenella species, and Baird's beaked whales) and found no evidence of plastic in their stomachs. Whales and dolphins, which feed on the bottom, rarely had ingested any type of man-made objects. However, he identified a single incident of a captive killer whale dying after it had eaten a plastic bag.

c. Seabirds and Shorebirds

Plastics in the marine environment cause similar problems for all types of birds. Seabirds and shorebirds, particularly, become entangled in actively fishing nets, discarded nets, and other marine debris such as beverage container rings and monofilament line. These can lead to drowning, choking, or lacerations.

There have been some reports of pelicans with beverage container rings and monofilament around their beaks which prevented them from catching prey. A greater source of concern, however, appears to be entanglement of monofilament fishing line around the wings and legs of pelicans and egrets which then become tangled in trees where the birds roost. Birds become caught in trees then die of exhaustion or starvation (Weisskopf, 1988).

Day, Wehle, and Coleman (1985) compiled data on ingestion of plastic debris by seabirds. Researchers have found plastic particles in the stomachs of approximately 25 percent of the world's 250 seabird species. Of the species identified as having ingested plastic, only 12 species have consumed an average of one or more plastic particles per individual (Table II-2).

Shearwaters and parakeet auklets show the highest incidences of ingesting plastic, as high as 21.7 particles of plastic per individual (short-tailed shearwater) in a California study (Baltz and Morejohn, 1976 as cited in Day, et al, 1985).

Table II-2. Rates of plastic ingestion in families of birds and in groups of similar species. Note: The mean % individuals with plastic ingested was calculated by: (1) estimating the frequency of occurrence of plastic for each species, where possible; and (2) calculating a mean frequency of occurrence for these estimates. These mean values are approximate and should only be viewed as indicating trends among taxa.

Source: Day et al, 1985.

Taxon	No. of species examined for plastic in taxon	Occurrence of plastic in taxon (%)	Mean % individuals with plastic ingested
PROCELLARIIFORMES			
Diomedeidae	5	100	28
Procellariidae	21	86	24
Gadfly petrels	4	100	8
Prions	4	100	40
Shearwaters-fulmars	9	67	31
Other	4	100	32
Hydrobatidae	6	83	38
Pelecanoididae	1	0	0
SPHENISCIFORMES			
Spheniscidae	2	0	0
PELECANIFORMES			
Phaethontidae	1	0	0
Fregatidae	1	0	0
Phalacrocoracidae	4	0	0
Sulidae	5	20	?(low)
ANSERIFORMES			
Anatidae	6	0	0
CHARADRIIFORMES			
Scolopacidae (phalaropes)	2	100	45
Laridae	$\leq$26	$\leq$47	$\leq$3
Skuas-jaegers	3	0	0
Gulls	14	71	6
Terns	$\leq$9	$\leq$11	?(very low)
Alcidae	$\leq$16	$\leq$50	$\leq$11
Murres-guillemots-murrelets	$\leq$6	$\leq$17	<1
Auklets-dovekie	6	67	18
Puffins	4	75	14

Resin pellets are the most frequently identified plastic type consumed by birds (Day et al, 1985). Several shearwater and alcid species, e.g., puffins, auklets, and murres, ingest floating resin pellets, probably because they resemble fish eggs or invertebrate prey. They are the most common form of plastic ingested by seabirds. These pellets and other plastics may be especially harmful to young birds which rely on regurgitated food from their parents during the first weeks of life. When an adult feeds resin pellets to young birds, the young may not able to pass them. Therefore, their stomachs can fill with pellets, preventing them from obtaining adequate nutrition.

No scientists have yet attributed a decline of a seabird population to persistent marine debris.

3. Sea Turtles

Five species of sea turtles inhabit U.S. waters -- Kemp's ridley, hawksbill, leatherback, green, and loggerhead--each of which is listed as either endangered or threatened under the Endangered Species Act. Their preferred habitats and foraging patterns differ significantly. However, like other wildlife, they can ingest and become entangled in plastic debris. Entanglement can cause a turtle to drown, reduce its swimming efficiency, and lacerate exposed appendages.

Balasz (1985) reviewed published literature documenting sea turtle encounters with plastic debris worldwide. He identified 79 reports on ingestion of plastic and 60 reports of entangled sea turtles from all over the world. He further reports the findings of several researchers who have examined sea turtle digestive tracts and found very little or no plastic items:

green turtles off Nicarauga (Mortimer, 1981); loggerhead turtles from Cumberland Island, Georgia (Shoop and Ruckdeschel, 1982); and loggerhead, Kemp's ridley and leatherback sea turtles from Virginia, Maryland, and Delaware (Musick, in Balasz, 1985).

Sea turtles spend up to their first five years of life drifting with oceanic currents. As with other floating material, they appear to be concentrated along lines of current convergences or at the centers of major current gyres, such as the Sargasso Sea in the Atlantic. Carr (1987) reports that these zones have high concentrations of plastic marine debris, particularly pieces of styrofoam, resin pellets, and floating nets which intermingle with sargassum weed and other flotsam. Young sea turtles are especially vulnerable to plastic debris because these zones are their essential habitat and the plastic beads are suggestively similar to their standard food--sargassum floats--and resembles natural prey items such as invertebrates. Also, as the turtles move about in the sargasso weeds, they may become entangled in nets and line.

Large leatherback sea turtles are pelagic and highly migratory. They subsist primarily on jellyfish. Researchers have found dead leatherback sea turtles stranded on beaches with plastic bags and sheets in their digestive tracts. They attribute leatherback consumption of plastic sheeting to its resemblance in the water to jellyfish (Carr, 1987).

The National Marine Fisheries Service within the National Oceanic and Atmospheric Administration, Department of Commerce, has coordinated a nationwide sea turtle stranding reporting network since 1978. NMFS scientists and others have necropsied stranded sea turtles, some of which included analysis of stomach contents for some of the turtles. These indicate that one-third to one-

half of endangered and threatened sea turtles are ingesting plastic products or byproducts (Table II-3). These estimates are slightly higher than information presented by Balazs that 13 percent of 140 leatherback sea turtles and 23 percent of 39 green sea turtles examined had consumed plastic bags.

Only Plotkin (1987) attributes the death of any animals directly to ingestion of plastic. She attributes the death of one loggerhead turtle to a plastic bag which was completely blocking the animal's digestive tract.

4. Fish and Shellfish

Fishing pots (traps), gill nets, and other fishing gear may continue to capture fish and shellfish after they are discarded or lost. Commercial and recreational fishermen primarily use traps or pots to capture crustaceans such as crabs and lobsters although they are sometimes used to catch demersal fish (e.g., snappers). High (1985) estimates that king crab and Dungeness crab fishermen in Alaska and along the Pacific coast lose over 10 percent (over 1,200) of their pots annually. In baited pots, predators consume bait within several days. Lost pots continue to trap fish and shellfish which in turn attract new predators, such as crabs. Scientists found that escape panels prevent about 20 percent of legal size crabs and 8 percent of sublegal crabs from escape. The cycle continues until the trap disintegrates. This may take up to several years (High, 1985).

The advent of monofilament gill nets enabled fishermen to string long curtains of nets in ocean waters. Fishermen use different types and sizes of gill nets throughout the world, depending on target species. In the Bering Sea and North Pacific Ocean,

Table II-3. Reports of Sea Turtles Ingesting Plastics

1. Location: Texas
   Source: NMFS, Caillouet, pers. comm.

	Number turtles necropsied	No. stomachs containing plastic	% stomachs containing plastic
Kemp's ridley	47	11	23
Green	2	2	100
Loggerhead	30	10	33

2. Location: Texas
   Source: Plotkin, pers. comm.

Green	4	2	50
Loggerhead	31	15	48

Japanese salmon and squid fishermen use nets up to 25 miles long. The mothership salmon fleet within the U.S. EEZ sets approximately 1,100 miles of gill nets each night during the 4 to 6 week salmon season (NOAA/NMFS, 1987). U.S. observers aboard these fishing vessels estimate that this fishery incidentally captures thousands of pelagic seabirds, approximately 2,000 Dall's porpoises, and other species of marine mammals each year. These are data from actively fishing nets, not debris. However, one anticipates continued capture of target as well as non-target species in lost gill nets as long as they fish. Even a small rate of net loss from such an extensive fishery could produce substantial quantities of net debris.

One study shows the changes in shape of derelict gill net fragment of varying sizes over time and determines the fishing ability of these nets (Gerrodette et al, 1987). Gerrodette deployed and tracked gill net sections of 50, 100, 350, and 1,000 meters. He observed them for between 57 and 309 days. The 50 meter net had collapsed, or folded in accordion fashion within 30 minutes after deployment, although it was still hanging freely in the water. The 350 meter net collapsed to 40 percent of its original length in a few hours, and had collapsed completely by the 10th day after deployment. The 1,000 meter net followed a similar pattern of slower contraction. Very little marine life was caught in any of the gill nets during the first 3 days of observation, only a small marlin and a large flying fish. After 10 days, a rotting shark and several unidentifiable bony fish were observed. No large animals were entangled when the nets were recovered. The study showed that drifting gill nets will eventually collapse and ball up, thus reducing their fishing ability. Nets less than 100 meters long collapse in less than a day, while longer ones may take several days to several weeks.

The collapse rate may be shortened if a large animal is caught and struggles. It may be lengthened if any buoys are attached. A collapsed gill net can still catch fish, but its effectiveness is diminished. Collapsed gill nets still pose a hazard because nontarget species attract fish which may attract predators which may be more effectively ensnared in the many folds of the collapsed net.

No one knows for sure how long lost gill nets continue to capture animals after they are lost. High (1985) reports that synthetic gill net materials in the marine environment remain strong enough to capture fish and wildlife for at least six years. Carr, et al (1985) surveyed from a submersible over 100 acres (40.5 ha) of actively fished gill net areas near Gloucester, Massachusetts. They found nine lost gill nets, six of which were balled up and rising from the bottom up to 10 feet (3.6 m). The other three stretched horizontally with reduced float line heights. These researchers estimated the time that nets had been submerged by algal and invertebrate animal growth on them. Eight of nine nets were thought to be over three years old. The nets had caught over ten species of marine life. Like lost crab traps, lost gill nets continue a cycle of ensnaring marine life which dies, thereby attracting more predators and scavengers which themselves become entangled and die.

No data are available on frequencies of fish ingesting plastic debris, although this is known to occur (Carpenter, et al, 1972 in Coe, 1976).

B. Beaches

Plastic debris goes largely unnoticed so long as it remains at sea. When it washes ashore, everyone sees it. It creates three basic problems:

-- it is aesthetically irritating to beachgoers;
-- certain wastes, such as hospital wastes, may pose health risks to people and wildlife and may result in beach closures;
-- it can be very expensive to clean up.

In some areas, plastic debris washing ashore occurs only occasionally. In others, it is routine, varying only in amount. One of the best data sources for estimating marine debris is the volume and variety of litter that washes ashore. In 1987 over 23,000 volunteers in coastal states picked up trash on beaches (see Table II-4). The quantities of debris that they found varied tremendously from almost 2 tons/mile in Texas to 60 pounds/mile in Delaware.

The Texas coast around Padre Island National Seashore (PINS) has the most severe beach litter problem of any area cleaned by volunteers during Coastweek. Peart (1987) estimates that PINS receives approximately 580 tons of marine debris per year, over 10 tons per mile. The debris consists of numerous items likely to have come from foreign merchant ships, domestic commerical and recreational fishermen, offshore oil and gas industry, domestic trash, and onshore industrial plants (Table II-5). People regularly attempt to identify sources of debris. Only a few of the items in Table II-5 have single sources.

Table II-4. Coastweek 1987 Beach Clean-up Results

Source: Center for Environmental Education, 1987

State	Volunteers	Miles Covered	Tons Debris Collected	Tons per Volunteer	Tons per mile
Alaska		(clean-up held in spring)			
Alabama	127	3	NR		
California	4,000	1,000	75.0	0.019	0.075
Connecticut	15	1	0.1	0.007	0.100
Delaware	700	50	1.5	0.002	0.030
Florida	1,232	50	4.0	0.003	0.080
Georgia	20	5	.5	0.100	
Hawaii	2,726	NR	36.8		
Louisiana	3,300	NR	200.0	0.061	
Maine	350	31	3.0	0.009	0.097
Massachusetts	391	39.5	1.9		
Mississippi	100	5	3.5	0.035	0.7
New Hampshire	112	3	2.0	0.018	0.667
New Jersey	1,250	100	40.0	0.032	0.400
New York	80	2	1.5	0.019	0.750
North Carolina	1,000	150	10.0	0.010	0.067
Oregon	2,600	120	17.0	0.007	0.142
Rhode Island	450	40	NR		
Texas	7,132	154	306.5	0.043	1.99
Washington	1,000	100	6.0	.006	0.06
Total	26,585	1,851	709.3		

NR = not reported

Table II-5. 1987 Texas Coastal Clean-up

PLASTICS	Number of Items TEXAS (158 miles)	PINS (58 miles)
BAGS	31773	3646
CAPS/LIDS	28540	3154
MISCELLANEOUS PIECES	21619	1603
ROPE	18878	1993
BOTTLES-OTHER	16784	3039
BEER RINGS	15631	1087
CUPS/UTENSILS	12486	950
MILK JUGS	7460	852
BOTTLES-GREEN	7170	1610
BOTTLES-SODA	6341	793
STRAP BANDS	4933	479
LARGE SHEETING	4817	971
FISH LINES	4225	376
LIGHT STICKS	4179	337
GLOVES	4127	518
EGG CARTONS	3417	375
TOYS	2820	341
STRAWS	2639	181
LIGHTERS	2429	195
WRITE RINGS	2337	213
VEGETABLE SACKS	2023	301
DIAPERS	1914	93
SHOES/SANDALS	1750	245
FISH NETS	1719	167
BUCKETS	1703	232
TAMPON APPLICATORS	1040	78
SYRINGES	930	142
HARDHATS	225	26
TOTAL PLASTICS	213914	24002
PIECES OF GLASS	21214	703
BOTTLES	17902	1470
LIGHT BULBS	2327	238
FLOURESCENT TUBES	1088	136
TOTAL GLASS	42531	2547
STYROFOAM		
MISC. PIECES	22609	2154
CUPS	14998	798
BUOYS	1048	85
TOTAL STYROFOAM	38655	3037

METAL	Number of items TEXAS	PINS
BEVERAGE CANS	20580	2037
PULL TABS	8925	243
BOTTLE CAPS	8273	400
OTHER CANS	4469	399
MISC. PIECES	3658	128
WIRE	2807	228
LARGE CONTAINERS	1105	98
DRUMS-RUSTED	268	24
DRUMS-NEW	225	3
TOTAL METAL	50310	3560
PAPER		
MISC. PIECES	12292	381
CUPS	4511	238
BAGS	4428	152
CARTONS	4073	213
NEWSPAPER	1415	58
TOTAL PAPER	26719	1042
WOOD		
MISC. PIECES	9386	679
PALLETS	605	44
CRATES	292	30
TOTAL WOOD	10203	753
TIRES	546	23
TOTAL ITEMS	382878	34964
TOTAL RECORDS TALLIED	1580	125

-- write rings, hard hats, and drums (new and rusted) clearly originate from industrial sources; and
-- fish nets, light sticks, and fish lines originate with fishermen;

Of the 45 categories of trash identified in the Texas report, one can determine the origin of only seven. Almost all of the remaining items, like plastic bags and milk jugs, could have come from vessels or platforms at sea or land-based sources.

Volunteers in Massachusetts Coast Week Beach Clean-Up collected almost 2 tons of debris along 39.5 miles of beach. The clean-up coordinator summarized the debris gathered as shown in Table II-6 (Bigford, 1987). He estimates that roughly 60 percent of the debris on shore came from vessels and 40 percent was left by beach visitors there based on the types of debris found during the clean-up. The proportion of ocean-originating versus beach-originating debris varied along different parts of the coast depending on proximity to harbors, fishing grounds, and convenience stores.

Merrell (1984) reports on plastic debris surveys taken between 1972 and 1982 on Amchitka Island, Alaska. He estimated that commercial fishing operations produced 85-98 percent by weight and 70 to 81 percent by number (excluding small plastic fragments) of plastic debris on Amchitka beaches. The highest amount of trawl webbing he found during his survey was 272 kg/km (approximately 950 pounds per mile) in 1974.

Table II-6. Plastic Debris Collected During Massachusetts 1987 Beach Clean Up

Note: Percentages shown indicate number of items or lengths of ropes.
Source: Bigford, 1987.

Material	Composition (Number of Items)
plastic bags and sheeting	12.6%
plastic rope or strapping	13.2
6-pack yokes	2.4
plastic eating utensils	9.4
plastic containers	16.9
other plastic pieces	10.4
styrofoam	19.5
rec. fishing gear	2.1
commercial fishing pots, traps, netting, etc.	9.3
glass	4.2
	100%

Johnson and Merrell (1988) surveyed six beaches on islands in the Gulf of Alaska in 1984. They estimated that commercial fishing operations produced between 40 and 67 percent by number of items, (excluding fragments) of the plastic debris on those beaches.

Cleaning up marine debris when it washes ashore can be very expensive. Comprehensive data are not available. Texas estimates that communities spend approximately $14 million per year to clean beaches (Mauro, 1987). The following examples at Federal facilities further indicate the significance of the problem.

-- Padre Island National Seashore in Texas. During the 1986 volunteer beach clean-up at PINS, 477 volunteers cleared 13.6 miles of beach and collected over 13 tons of trash in three hours.

-- Gateway National Recreation Area in New York and New Jersey spent over $500 thousand to clean its 53 miles of public beaches in 1987.

Three times during the summer of 1987, a large number of floatables, including medical wastes and garbage washed onto beaches in the New York-New Jersey area (EPA Region II). This occurred on 27-28 May 1987 in Ocean County, New Jersey where a 20 mile segment of beach was affected although not closed because the beach had not been opened for the summer yet; 23 June 1987, in Nassau County, Long Island when the beach was closed for 2 days; and 13 August 1987, in Ocean and Atlantic counties, New Jersey, where approximately 50 miles of beaches were closed for at least three days while being cleaned up. Other New Jersey beaches were closed twice in August due to unsafe bacteria levels which were totally unrelated to persistent marine debris.

Similar beach closings occurred in June 1976, on Long Island, New York, when larger quantities of sewage and debris washed up and the Governor of New York declared the area a disaster area and beaches were closed for about two weeks until they were cleaned up (Heneman, 1987).

C. Damage to Vessels and Fishing Gear

Plastic debris can damage vessels in three ways:

1) fishing nets or lines wrap around propeller and propeller shafts,
2) plastic sheeting clogs cooling water intake ports, and
3) gill nets entangle vessels.

All types of vessels -- fishing, recreational, merchant transport, and military -- can fall victim to plastic debris. No comprehensive data are available to determine the number of times that debris causes problems. In their survey of Coast Guard, Navy, and local marine operators, researchers at the Center for Environmental Education found that estimates of the extent of the problem varied widely (CEE, 1987).

As part of its Marine Refuse Disposal Project, the Port of Newport, Oregon, conducted a survey of fishermen at the Seattle Fish Expo in October, 1987 (Recht, 1988). Fishermen from 90 vessels completed the survey, of which 58 (64 percent) stated that they had had problems with plastic debris. They estimated the costs of repairs and lost fishing time to be over $110,000. The most frequent problem was propellers fouled in nets (14 times).

Although U.S. Coast Guard maintains records of vessel disablements in domestic waters, entanglement with plastic debris is not one of the causes of disablement listed on Coast Guard report forms. Therefore, the U.S.C.G. is not a source where information on this aspect of marine debris would be available. U.S. Navy submarines have encountered actively fishing gillnets and other fishing gear. In November 1987, a submarine became entangled in a gill net in Hood Canal, Washington (Buls, 1988). It caused approximately $6,000 in damage to the fishing vessel and its gear. No figures are available from the U.S. Navy on this event or similar instances of submarine or other military vessels becoming entangled in actively fishing or discarded nets.

Chapter III
Sources of Persistent Marine Debris

Numerous scientists have characterized plastic debris found on local beaches and tried to determine its origin; Merrell (1980, 1984, 1985) for Alaska beaches; Amos (1985) for Texas beaches; Dahlberg and Day (1985) for the surface of the North Pacific Ocean; and Winston (1972) for Florida beaches. Nevertheless, comprehensive data on quantities and sources of persistent marine debris are limited. The best records available come from beach surveys. However, beach surveys cannot provide a complete picture of debris in the marine environment.

Most existing data on sources of marine debris apply to the local areas where the information was gathered. These data are valuable in demonstrating the frequency of problems throughout the country. Local factors (current patterns, climate, tides, proximity to a city, a heavy industrial area, shipping lanes, or major fishing grounds) greatly influence the types and amounts of plastics which end up in the marine environment and wash ashore.

This section reviews information on the sources of plastics in the marine environment. The first part describes the status of plastic products. The second part describes major sources of plastic materials in the marine environment.

A. Trends in Production and Use of Plastic

As society has developed new uses for plastics, the variety and quantity of plastic items found in the marine environment, whether in the water or on shore, has increased dramatically (Horsman, 1982, Pruter, 1987, Bean, 1987). These products range from common domestic material (bags, cups, bottles, balloons) to

industrial products (strapping bands, plastic sheeting, hard hats, resin pellets) to lost or discarded fishing gear (nets, buoys, traps, lines).

The growth rate for plastics production from 1960 to 1985 can be seen in Figure III-1, (SPI, 1986).

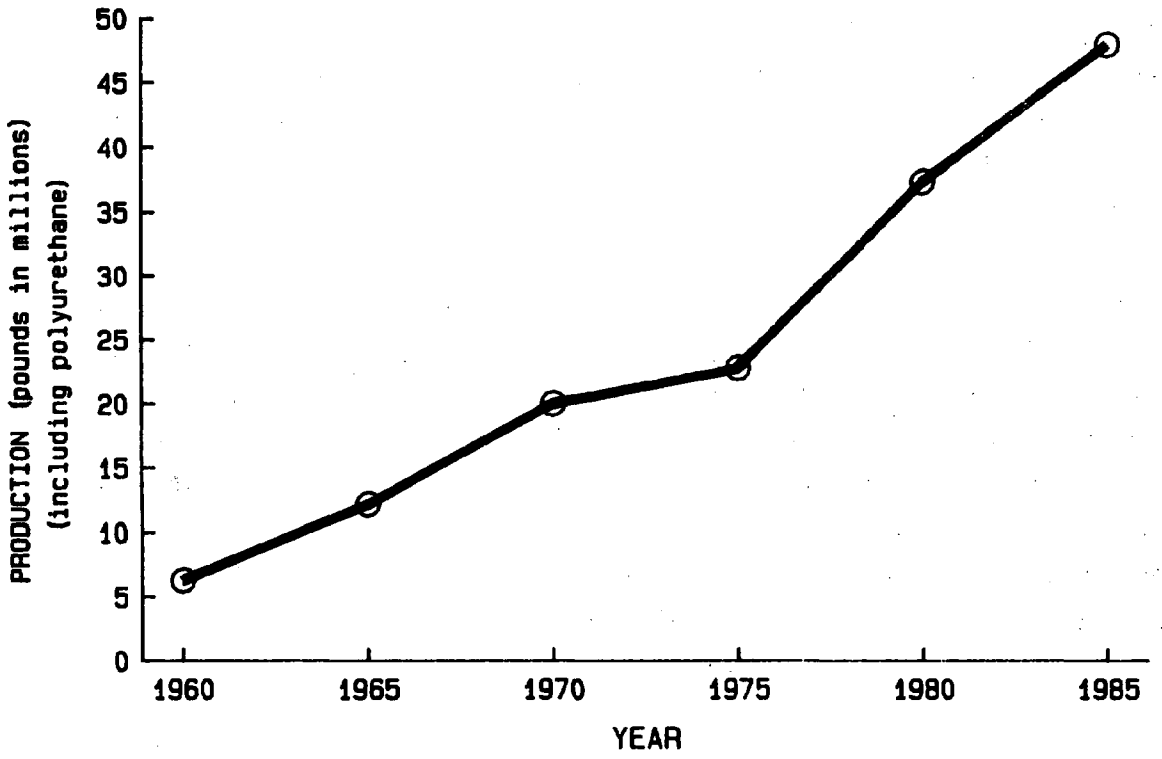
This growth rate shows a rise in production from roughly 6 billion pounds in 1960 to almost 48 billion pounds in 1985. The compound growth rate for the years 1960-1985 is 8.4 percent for total production. These statistics show a trend of increasing plastics production which is expected to continue. Guillet (1974) estimates that between 1961 and 2025, the production of plastics should have increased by a factor of 20. This means that in the U.S., three-quarters of a ton of plastic will be produced per person in 2025.

The EPA estimates that 7.2 percent of municipal solid waste is plastic. This amounted to nearly 9.6 million tons in 1984 (Franklin, 1986). By 2000, this will increase to 9.8 percent, or approximately 15.5 million tons of plastic. State and local governments generally manage solid wastes. As a result of the MPPRCA, mariners will have to dispose of waste products on shore rather than in oceans. Ports and marinas will have to provide additional solid waste management services for marine-generated wastes. This could place additional burdens on local solid waste management facilities.

During beach clean-ups around the nation, a wide variety of plastic material has been found (Tables II-5 and 6). Industrial materials such as plastic strapping bands and plastic sheeting used on construction sites, fishing vessels, and merchant ships are often found. The strapping bands, typically polypropelyene,

Figure III-1

Total U.S. Production of Plastic Resin
1960 - 1985



data for 1960 - 1970 from U.S. Tariff Commission
data for 1971 - 1985 from SPI

From: SPI, 1986

recycled polyester terephthalate (PET) or nylon are used to bind items together or around boxes. The plastic sheeting (typically polyethylene) is used aboard ships to cover items during transportation. Other industrial products include hard hats, gloves and plastic parts (CEE 1987b).

The most commonly reported domestic type plastic materials include: bags, sheets, six-pack yokes, milk jugs, containers, bottles, tampon applicators, and cups. These plastic products are made up of a variety of polymers but are principally made from polyesters, polyethylenes, polystyrene, and polyvinyl chloride. Blends of different types of polymers in a single product are also common (CEE 1987). Burst mylar and latex balloons, probably released during promotional activities, sporting or charity events have recently been reported washed ashore on beaches (Schoelkopf, 1988).

B. Sources of Persistent Marine Debris

Plastic materials end up in oceans and estuaries from a number of sources and for a wide variety of reasons ranging from accidental losses and system failures, historical practices, inappropriate or illegal disposal and littering. Little of this material is easily traced back to its source.

Litter that washes onto beaches comes from land and ocean sources. In different regions, predominant sources differ (Bigford, 1987, Merrell, 1985, and Texas Coastal and Marine Commission, 1985). For instance, Coleman and Wehle (1984) found that most of the plastic debris worldwide comes from ocean sources. Where commercial fishing is significant, larger quantities of fishing related plastic materials are found. In other areas, such as New England, beach litter and ocean disposal

of trash by merchant ships create the biggest problems. A study of Texas beaches estimated that 80 percent of the material on Texas beaches came from offshore sources, primarily oil and gas platforms (Texas Coastal and Marine Council, 1985). In others, land-based sources contribute most of the material.

Identifying sources of marine debris is difficult. Some of the items may be attributed to a single source such as nets to the fishing industry, while other items such as household bags could come from any number of sources. Table III-1 lists a number of items commonly found on the nation's beaches and shows potential sources. As the table shows, many items originate from several sources.

We divide persistent marine debris into two categories based on its origin: ocean-source and land-based. Ocean-source includes debris which is generated by vessels and platforms during the normal course of their operations. This category includes commercial fishing vessels, recreational vessels, merchant vessels, cruise ships, military and research vessels, offshore oil rigs and platforms, and supply vessels. Land-based debris includes those materials disposed of on land which wash, blow, or are discharged into the marine environment. Sources in this category include plastic manufacturers and processors, solid waste disposal sites, combined sewer overflows, sewer systems, litter, and illegal dumping.

1. Ocean-sources

The National Academy of Sciences (NAS) issued a report on ocean pollutants, including marine litter (NAS, 1975)[1]. The NAS report listed sources of marine debris, and estimated the amount of refuse going into the oceans from these sources (Table III-2). NAS estimated that people aboard ships--passenger, merchant transportation, commercial and recreational fishing, and military--dispose of over 14 billion pounds (6.4 million metric tons) into oceans each year worldwide. Of this, approximately 44.8 million pounds (0.7%) was plastic.

Since 1975, container ships have become a significant method for moving cargo over the seas. Therefore, decreasing the quantity of cargo generated waste in the oceans. NAS estimated the actual amount of plastic ranged from 0.7 percent in certain types of litter to probably 100 percent for lost fishing gear. While only a small quantity is likely to be plastic material, even a hypothetical 1 percent would amount to 140 million pounds per year. Given the trends in plastic use since 1975, it is reasonable to assume that the percentage of total plastic materials entering the marine environment has increased since 1975.

a. Commercial Fishing

By the late 1960's synthetic fishing nets and line, principally made from polyamide (PA, also known as nylon), polyethylene (PT),

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[1]/The 1975 NAS study is the most comprehensive compilation of data on marine debris sources. The authors of this report recognize that the NAS study is dated and that some of the NAS sources lacked precision.

Table III-1. Sources of Marine Debris

	Commercial Fishing	Shipping Transport.	Recreational Fishermen & Beach goers	Offshore Oil & Gas	Shore-based Solid Waste	Plastic Manuf. & Processors	STP & CSO
trawl net/fragments	X						
gill net/fragments	X						
crab/fish traps	X		X				
bait boxes	X						
light sticks	X						
light bulbs	X	X		X	X		
salt bags	X						
strapping bands	X						
ice bags	X		X		X		
dunnage	X						
monofilament line	X		X				
bait boxes		X					
suntan bottles			X				
hard hats		X		X			
write-protect rings				X			
gloves	X		X				
buckets	X		X	X	X		
medical wastes					X		
tires					X		
resin pellets		X				X	
tampon applicators			X				X
condoms			X		X		X
diapers					X		
household bags	X	X	X	X	X		X
cups	X	X	X	X	X		X
jugs and bottles	X	X	X	X	X		X
strapping bands	X	X		X	X		
sheeting	X	X		X	X		
plastic toys			X		X		
balloons			X				

Table III-2. Ocean Disposal of Litter

	TOTAL AMOUNT OF LITTER PER YEAR (1,000 METRIC TONS)			PLASTIC LITTER
	DOMESTIC	COMMERCIAL	TOTAL	
Passenger Ships	28	NA	28	0.20
Merchant Shipping				
Crew	110	NA		0.77
Cargo	NA	5,600		
Total	110	5,600	5,710	0.77
Recreational Boating	103	NA	103	0.72
Commercial fishing				
Crew	340	NA		2.38
Gear	NA	1		
Total	340	1	341	2.38
Military	74	NA	74	0.52
Oil Drilling and Platforms	4	NE	4	0.02
Total	659	5,601	6,260	4.61
(%)	(10.5%)	(89.5%)	(100.0%)	

NA = Not Applicable.

NE = Not Estimated.

Adapted From: National Academy of Sciences (1975).

and polypropylene (PP) but also including blends with vinylon, vinylidine, vinyl chloride, and polyester, almost completely replaced natural-fiber based netting (Andrady, 1987). Fishermen switched to plastic gear for three principal reasons; strength, durability and overall lower cost. These factors are the reasons that lost or discarded nets and lines can create problems for wildlife. The strength of the netting prevents entrapped marine animals from ripping the nets and freeing themselves. At the same time, the durability of the nets and lines means that when lost or discarded, they may continue to entangle fish and other marine life for several years. Relatively low cost also means they may be replaced without excessive economic burdens.

Two types of nets, drift gill nets and trawl nets, are routinely lost or discarded. By virtue of the amount of netting deployed, the most likely net type to become lost or damaged and discarded during fishing operations is the drift gill net (Uchida, 1985). Drift gill nets are usually made of nylon mesh. Fishermen place them in the path of schools of fish or squid. Drift gill nets may be up to 15 miles long. Both gill and trawl nets can continue fishing once lost (ghost fishing), by entangling organisms like fish and crabs. Gill and trawl nets also wash up as litter onto the beaches.

Trawl nets are PE or PA bag-shaped nets which are towed through the water. Trawl mesh sizes vary from about 1-1/4 inches for small shrimp to approximately 6 inches for pollock and cod. Fishermen trawl by dragging nets at specific depths or along the bottom, depending on the target species. The nets may snag objects, or become overloaded, tearing the net or causing loss of the entire net or portions of it. Pieces of trawl nets frequently wash ashore in Alaska (Fowler, 1987; and Johnson and Merrell, 1988) and other locations where trawling occurs. Many

of these appear to be scraps which may be as harmful to wildlife as complete nets. PA trawl webbing usually sinks where it may entangle and kill crabs and other crustaceans. Polyethylene webbing usually floats, even if no floats are attached.

Recreational and commercial fishermen use monofilament line to catch a number of species. Monofilament easily tangles on reels, and fishermen simply throw it away when it does. Fishermen lose an unknown quantity of monofilament line in marine and fresh water. Birds, sea turtles, and marine mammals and become entangled in monofilament line (Coe, 1986).

Plastic material is increasingly replacing the wood and netting portions of crab and lobster traps. Thus, when buoys marking the traps become separated from the trap due to storms or propellors, these traps remain lost on the bottom, fishing for unknown periods (CEE 1987). Several states (e.g., Maine and Florida) require traps to have degradable panels or latches to allow captured animals to escape (Keeney 1987).

Other plastic fishing gear, such as floats, net buoys and ropes, may become marine debris. Plastic bags and containers, which fishermen use for supplies of bait, ice and salt, are commonly found on beaches (CEE 1987b).

The commercial fishing fleet contributes plastics to the marine environment in two ways. Like many sea farers, commercial fishermen routinely discard their garbage, including plastics, into the water. They also may lose or dispose of nets lines, traps, and other fishing gear in the marine environment.

Synthetic fishing gear is a significant part of all plastic material in the marine environment (Pruter, 1987, Merrell,

1985). In 1985, there were 24,300 commercial fishing vessels over 5 gross tons registered in the United States. The total number of commercial fishing craft (primarily motor boats) was estimated to be 129,800 (NMFS 1987). The U.S. issued roughly 550 permits for foreign fishing vessels which include fishing, processing, and transport vessels.

Parker and Yang (1986) estimated that there were approximately 125,700 commercial fishing vessels with 223,000 fishermen in the U.S. They used estimates of wastes produced by seamen from Horsman (1982) to approximate various types of materials disposed of in the ocean. Seamen produce approximately 3.04 lbs/person/day of solid waste, of which 0.01 pounds is plastic. The largest components are food wastes (1.22 pounds), paper (0.90 pounds), and metal (0.52 pounds). Using these estimates and assuming fishermen are at sea for 220 days per year, Parker and Yang concluded that the U.S. commercial fishing fleet disposes of approximately 245 tons of plastic material in the oceans each year.

Fishermen lose fishing gear for a variety of reasons. Some gear wears out and breaks into pieces. Storms or operator error cause broken nets and ropes. During repair of nets, fisherman throw net scraps and fragments overboard. Coast Guard officials have reported some deliberate cutting of nets by foreign fishing vessels to avoid citation for violation of U.S. laws (Whitehead, 1987). In some fisheries, regulatory schemes make it reasonable to abandon certain gear to save time. For instance, the Alaska halibut season lasts only a few days. Fishermen may set more lines than they can retrieve before the end of the season to allow as large a catch as possible. Once a season closes, fishermen risk citations if they retrieve their lines.

b. Recreational Boating

An estimated 16 million recreational boaters routinely sail the oceans or estuaries or lower reaches of rivers which directly empty into coastal areas. These boaters throw a variety of plastic articles such as food wrap, beverage containers, bags and fishing gear (principally nylon monofilament fishing line) into marine or freshwater environments. In some areas, monofilament fishing line is one of the most frequently observed plastic items on beaches.

c. Merchant Vessels

Merchant ships dispose of plastic debris in the marine environment. As noted above, Horsman (1982) estimated waste disposed of by merchant shipping by analyzing what they brought aboard. Ships regularly take on 2 to 3 months of supplies at a time depending on voyage schedule. Horsman estimated that each seaman used and disposed of between 0.3 and 0.4 plastic items per day. He then took the 1979 Lloyd's register of 71,000 merchant ships worldwide, assumed 30 people per ship, and determined that 639,000 plastic containers are disposed of at sea each day. Although his data are based on an extremely small sample size, his estimates are among the few attempts to asses the amount of material discarded at sea from ships.

Merchant ships are possible sources of plastic resin pellets which may be lost during loading or off-loading. No estimate of the amount of pellets lost from ships is available.

Two changes in shipping in the last 10 years are likely to have caused a reduction in the amount of plastic material entering the ocean from merchant ships. First, the general cargo ships are

being replaced by container ships (Table III-3). As can be seen in the table, in 1976, roughly ten percent of the world's fleet was containerized. By 1986, one-third of the fleet was containerized. Container ships contribute little cargo-related debris since the container is not opened during loading, off-loading or shipment. Crew sizes have also decreased in the last 10 years going from an average of 40 to 25 people. This means less domestic-type garbage is generated on-board. Such reductions, however, may be offset as plastic materials have been used for more every day items.

d. Cruise Ships

Cruise ships contribute primarily domestic garbage containing plastic to the marine environment. Approximately 15 cruise ship companies operate out of 6 major and 32 smaller ports of call, in the U.S. Ships carry between 200 and 1000 passengers. Because cruise ships call on several ports it is difficult to determine annual number of passengers and crew members at sea per year.

Two of the cruise lines, Carnival Cruise Lines and Norwegian Cruise Lines, both use incineration as a method of handling garbage and other materials (Colenda, 1988). The Royal Caribbean Cruise Line ships use an onboard incinerator for all burnable refuse, grind food products before deep ocean disposal, and pulverize glass products before deep ocean disposal.

e. Military and Research Vessels

The U.S. Navy operates approximately 600 vessels worldwide carrying nearly 285,000 personnel. The Navy generates and discharges into the oceans roughly four tons of plastic per day

Table III-3. Types of Merchant Ships from 1976-1986.

Year	General Cargo (number of vessels)	Container, partial container (number of vessels)	Percent container vessels(%)	U.S. Trade (million tons)
1976	11,468	1,107	9.6	49.8
1986	10,451	3,486	33.3	71.8

Cox, 1988

(Koss, 1988). MARPOL Annex V does not apply to public vessels. However, U.S. implementing legislation requires public vessels to stop disposing of plastic into marine environment by 1993. In addition, the U.S. Coast Guard and NOAA have 226 vessels, most of which remain in domestic waters. They carry nearly 9,000 personnel. NOAA and the Coast Guard have internal operating orders which prohibit disposal of plastic at sea.

f. Offshore Oil Rigs and Supply Vessels

There is some dispute as to whether a majority of the beach litter in Texas can be attributed to the offshore oil industry (Texas Coastal and Marine Council, 1985; King, 1985). However, there is no disagreement over the theory that offshore oil and gas activities contribute significantly to the problem of beach litter in Texas. Plastic wastes from oil associated industries include domestic garbage as well as the following items (in order of abundance found in a beach clean-up study, King, 1985), plastic sheeting, computer write-protect rings, seismic markers, drilling pipe thread protectors, diesel oil and air filters, and deck light bulbs. In 1987, there were slightly over 4,700 oil and gas platforms in the Gulf of Mexico, of which 1,700 were serviced by supply vessels. Only about 1,000 platforms and mobile drilling units have people stationed aboard. These were serviced by several thousand supply vessels.

Minerals Management Service (MMS) regulations prohibit disposal of solid waste from offshore oil and gas platforms 30 C.F.R. §250.43; 30 C.F.R. §250.54; notice to Lessees and Operators of Federal Oil and Gas Leases in the Outer Continental Shelf Gulf of Mexico Region-Guidelines for Reducing or Eliminating Trash and Debris in the Gulf of Mexico, 542 Fed. Reg. 25,924(1987). Oil

companies have cooperated with the MMS, state authorities and public interest groups to reduce the amount of waste material dumped into the Gulf of Mexico.

2. Land-based sources

The actual share of plastic debris in the marine environment which originates from land-based sources is unknown and difficult to trace. However, in some regions, land-based sources may contribute significantly. Land-based sources of marine debris include: recreational beach users; plastic manufacturing, transportation, and processing facilities; solid waste management facilities; and combined sewer overflows and sewer system overloads.

The Clean Water Act and Marine Protection, Research and Sanctuaries Act (Ocean Dumping Act) regulate disposal into marine and estuarine waters of solid wastes produced on land. EPA issues permits to discharge wastewater under Clean Water Act. Those permits prohibit discharge of visible floatable debris. EPA has not issued any permits under the Ocean Dumping Act which would allow transport and dumping of garbage generated onshore, at sea.

a. Plastic Manufacturing and Processing

When petrochemical plants convert chemicals into plastic, the plastic is in the form of small pellets, 0.12 to 6 millimeters in diameters. Pellets are transported in bulk (train car loads or 50-100 pound bags) to processing plants where they are melted and fabricated into industrial and consumer products.

Pellets generally float on water and can be found there and on beaches. The most common pellets found in the marine environment include polystyrene, polyethylene, and polypropylene (CEE, 1987).

Plastic fragments, which result from the breakdown of larger manufactured articles, are frequently found on beaches and in the water. These fragments can be of any chemical composition but primarily result from the disintegration of other plastic articles listed above. Pieces of polystyrene foam cups and floats are ubiquitous in the marine environment.

Plastic resin pellets are ubiquitous in the marine environment. As mentioned above, these pellets may come from the ships transporting them. Three other potential sources are the resin pellet manufacturing sites, the processing sites where the pellets are converted into manufactured articles, or trucks and trains which might release pellets during transport with subsequent runnoff into the waterways. No specific data have been found to determine actual sources of pellets in the marine environment. During both manufacturing and processing operations for many plastics, resin pellets could enter a wastewater stream from several processes. However, EPA Clean Water Act permit regulations require a prohibition against discharging solid materials in every permit. Some pellet manufacturing and processing plants have installed recapture systems.

b. Combined Sewer Overflows and Sewage Treatment Plants

Properly operated publicly owned sewage treatment works (POTWs) should not discharge plastics to the marine environment. However, plastic materials associated with POTWs may enter the marine environment under the following circumstances:

- when storm water volume exceeds a plant's capacity and it is a combined sewer system, sewage/storm water is discharged directly into the receiving water;

- if the facility is designed to handle dry weather flow (insufficient capacity) and sewage bypasses the system and is discharged directly into the receiving water; and

- during breakdowns or "upsets" of the POTW, where influent bypasses treatment.

Many cities have combined sewer systems which collect and carry both sewage and storm water runoff from streets to POTWs for treatment. Of the nation's 15,000 POTWs, 2,307 are located in coastal counties, most of which discharge their effluent into rivers and streams. However, 570 of these POTWs discharge treated effluent directly into estuaries and coastal waters (OTA, 1987).

Most POTWs are designed to handle the volume of sewage generated by the population and industry during "dry weather flow." During times of little or no precipitation, POTWs effectively remove large solid articles such as plastic debris from incoming waste water. During primary treatment, bar racks/course screens and the process of skimming large settling tanks remove large items. The aqueous effluent is then discharged to local waters or the ocean.

The solids that are removed are usually disposed on land where the materials collected by the screens or skimmed from the top of settling tanks are landfilled or incinerated, and the sludge from the bottom of settling tanks is landfilled, incinerated or may be used as fertilizer. The sludge may also be disposed in the ocean by discharge through an outfall pipe, such as in Boston, Massachusetts, or by barging for direct ocean dumping such as at the 106 mile site for sludge from the New York/New Jersey area. The sludge which is disposed at sea by barge is tested by EPA and required to contain negligible amounts of plastics which indicates that the plastics are removed by the primary treatment and skimming process, and do not settle in the tanks with the sludge (Caspe, 1987).

At times of heavy precipitation, storm water runoff can cause the amount of POTW influent to exceed the plant's treatment or storm water storage capacity. When this happens, part of the combination of storm water and sewage may bypass some of the processes provided by the POTW, sometimes even before the bar racks, and circumvent the entire treatment process. This untreated sewage/storm runoff is then discharged directly into the receiving water through Combined Sewer Overflow (CSO). Because this effluent is not fully treated, it would include solid materials from street-runoff and from sewage, including tampon applicators and condoms. Similar discharges may also occur when a POTW is undergoing maintenance or malfunctions. Under these conditions, treatment capacity is reduced.

There are large urban CSO systems such as that of Boston, Massachusetts, which do not have sufficient capacity to handle all the sewage generated in their cities. Several of these cities have upgraded their systems with Federal assistance over the past few years and have made significant improvements (OTA,

1987). Nevertheless, unknown quantities of sewage and plastics in it bypass POTWs and are released into the marine environment. Of the 2,307 sewerage treatment plants in coastal counties, 135 have one or more combined sewer overflows. Thirty-six of the nation's 100 largest (by volume) sewage treatment plants have CSOs. Thirty of the 36 are between Virginia and Massachusetts, with 12 in New York (NOAA, 1987).

c. Solid Waste Management Practices

Solid waste management practices, both legal and illegal, may contribute to the problems of plastic debris in the marine environment in a number of ways through:

- o inadvertant release of materials from coastal landfills;
- o inadvertant release of materials during overwater transport of garbage, including transfer station (this appears to be the problem in New York metropolitan area primarily);
- o beach litter;
- o roadside litter;
- o illegal deliberate dumping of land-generated garbage into coastal/marine waters.

No documented information exists to characterize the extent of the problem related to garbage transportation and landfill practices. This is a source of particular concern in the New York Bight area, where New York City and New Jersey reached an agreement on transportation of garbage by New York City to Fresh

Kills Landfill on Staten Island to prevent inadvertent releases to waters.

The extent of deliberate illegal dumping of land-generated garbage into coastal/marine waters is not known.

d. Litter

All of us (beach goers, recreational boaters, fisherman) inadvertently contribute trash that becomes marine debris. Some carelessly discarded litter ends up in the oceans. People walking along boardwalks of Atlantic City drop their soft drink cups, beach goers in Miami forget their bottle of suntan lotion, fishermen on the shores of the Columbia River leave their plastic bait containers, and promotional releases of balloons, all contribute to the problem. Typically, litter discarded onto shores or directly into the water, subsequently washes out to sea and back to shore depending on the tides, winds, storms and currents.

The kinds of materials on beaches varies considerably depending on the location of the beach. Padre Island National Seashore in Texas receives items from many sources, including foreign merchant ships, domestic commercial and recreational fishermen, offshore oil and gas industry, domestic trash, and onshore industrial producers (Peart, in press). In Alaska, Merrell (1984) found that commercial fishing opeations were the source of roughly 92 percent (by weight) and 75 percent (by number) of plastic debris on Amchitka Island beaches. On an island in the Gulf of Alaska, approximately 54 percent of the plastic debris was due to commercial fishing operations (Johnson, 1987). A summary of debris from 39.5 miles of beach in Massachusetts, shows that roughly 60 percent was from vessels and 40 percent

left by beachgoers (Bigford, 1987). The proportion of ocean versus land-based sources varied depending on proximity to harbors, fishing grounds, and convenience stores.

Chapter IV
Current Activities Addressing Marine Debris

A. Federal Programs

1. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)

The Department of Commerce, through NOAA, is involved in a number of efforts to address the problems related to persistent marine debris. In addition to working with other Federal agencies, NOAA is working with various universities, state governments, industrial, educational and recreational associations, and environmental groups.

NOAA's responsibilities and concerns relating to persistent marine debris are statutorily derived under the Marine Protection, Research, and Sanctuaries Act, the Marine Mammal Protection Act, the Endangered Species Act, and the Magnuson Fishery Conservation and Management Act. Under these statutes, NOAA is charged with protecting, conserving, and managing a wide range of marine species and their habitat. NOAA is in the process of investigating the role of entanglement in the population dynamics of marine organisms.

Research. The Marine Entanglement Research Program (MERP) within the National Marine Fisheries Service (NMFS) sponsors research on the sources of plastics, such as pellets, fishing gear, cargo straps, six-pack yokes, and bait bags, and its effect on wildlife in the marine environment. Some of the work on impacts to wildlife includes research on the northern fur seal, Hawaiian monk seal, northern sea lion and sea turtles.

Additionally, research is conducted on high seas drift gillnet fisheries, impact of ingested plastics on sea birds, methods for surveying the distribution and abundance of marine debris, benthic effects of marine debris, floating plastic particulates, and accumulation and disappearance rates of marine litter at sea and on along the coast. A Marine Debris Reference Center has been established. Research on degradable plastics is being funded.

The National Ocean Pollution Program Office (NOPPO) held a workshop on June 9-11, 1987, to gather information regarding the extent of the problem of persistent marine debris. The workshop's results will be considered in writing the next National Marine Pollution Program Plan, which is due to Congress in September 1988.

Researchers around the country are studying a number of marine debris issues.

Education. NOAA has sponsored three meetings on marine plastic pollution, the International Workshop on the Fate and Impacts of Marine Debris, held in Honolulu, Hawaii, 1984; the Sixth International Ocean Disposal Symposium, held in Pacific Grove, California, 1986; and Oceans of Plastic, held in Portland, Oregon, 1988.

MERP is funding a Marine Refuse Disposal Project in the Port of Newport, Oregon. Additionally, MERP is developing and implementing an education program aimed primarily at industries contributing to the problem in the North Pacific, Atlantic, and Gulf of Mexico. Its objectives are to identify the most significant non-degradable debris generators and develop means

for educating them, and to convince key manufacturers of raw materials and finished products to lessen the impact on the marine environment.

Several NOAA-cooperative university programs, notably, Texas A & M, Alaska, and Oregon, have published and distributed a wide variety of materials on the debris problem. The Alaska Program sponsored and organized the meeting from February 9-11, 1988, in Portland, Oregon, on plastics pollution. The Hawaii Program is assisting the NMFS and MMC in convening the Second International Workshop on Marine Debris to be held in April 1989.

In 1986, MERP began the Marine Debris Roundtable, an informal, national discussion group focusing on solutions to the marine debris problem.

Mitigation. MERP is developing methods to reduce disposal of ship-generated refuse into the marine environment, and is looking at the problem of vessel refuse reception facilities at remote ports in Alaska.

NOAA has been working closely with the U.S. Coast Guard and other Federal agencies to ratify and implement MARPOL Annex V. Currently, NOAA is helping the Coast Guard with promulgating regulations pursuant to Pub. L. No. 100-220 which implements Annex V.

2. DEPARTMENT OF THE INTERIOR
   Mineral Management Service (MMS)
   National Park Service (NPS)
   U.S. Fish and Wildlife Service (FWS)

Activities within the Department of the Interior related to persistent marine debris are conducted primarily in three bureaus: Minerals Management Service (MMS); National Park Service (NPS); and the U.S. Fish and Wildlife Service (FWS). In addition, Interior coordinates the interagency Take Pride in America campaign which contains elements designed to address the problem of improper solid waste disposal.

a. Minerals Management Service

The MMS's link with marine debris issues stems from its responsibility to implement outer continental shelf (OCS) mineral resource development policies and programs. In order to discharge these responsibilities, MMS funds marine research to support decision making, and regulates most aspects of the oil and gas industry's Federal offshore activities. In addition, MMS, under the aegis of Take Pride, has taken an active role in developing methods to mitigate the impacts of persistent marine debris. Specific activities include:

Research: Examination of physical oceanographic properties of marine waters on the OCS and in coastal areas. The aspects of these studies most relevant to persistent marine debris (although conducted primarily for other purposes) are measurement and modeling of surface water transport.

Education: The MMS Director serves as Chairman of the interagency, public/private, Take Pride Gulf Wide Task Force. The task force objective is to develop methods for making the various users of the Gulf (e.g., beach users, fishermen, commercial shippers, offshore oil and gas operators) aware of the persistent marine debris problem and the need to control it.

Mitigation: Through regulation, MMS strictly controls disposal of persistent solid wastes from Federal OCS oil and gas facilities into marine waters. The disposal of sanitary wastes, drilling muds and cuttings, and produced water are regulated by the EPA. Through voluntary participation, MMS supports the Louisiana state-wide beach clean-up campaign. Employees have "adopted" a 1-mile stretch of Fourchon Beach in LaFource Parish, Louisiana, and periodically picked up and disposed of litter found on the beach.

b. National Park Service

The NPS is responsible under several authorities (e.g., National Park Service Organic Act) for managing all beach areas that are part of the National Park system. Currently there are 40 parks that have moderate to severe problems with persistent waterborne debris that originates outside park boundaries. In response, NPS conducts some directly related reseach and has established programs to address disposal and clean-up. In addition, NPS actively participates in the Take Pride education program. Specific NPS activities include:

Research: NPS works cooperatively with the state of Texas and the Center for Environmental Education to assess the types of persistent marine debris that wash up onto the beach at Padre Island National Seashore in Texas. The purpose is to help identify sources of debris and identify possible methods to mitigate the impacts. Less formal beach debris monitoring efforts are also ongoing at various other coastal park units. NPS is currently evaluating a proposal to join with NOAA to conduct a nationwide marine debris survey.

Education: NPS is a member of the Gulf of Mexico Take Pride Gulf Wide Task Force described above under MMS. In addition, NPS actively supports other Take Pride public education/awareness activities at or related to national seashores, lakeshores and rivers, including: park unit interpretive programs which include information on effects of improper solid waste/litter disposal; use of anti-litter posters, signs, and handouts; and community outreach (e.g., lectures/slide shows at schools/clubs). NPS also participates in the Take Pride awards program which has recognized significant efforts to address the marine debris problem (e.g., clean-up efforts of the North Carolina Beach Buggy Association). Finally, it works with private groups (e.g., Keep America Beautiful) to develop solutions to solid waste disposal problems.

Mitigation: NPS regulates disposal of trash at beaches and park units, in general. This minimizes the likelihood that trash deposited on beaches by visitors will become persistent marine debris. NPS's principal mitigation efforts are related to clean-up activities which take place in nearly all park units. Specific types of activities, many under the aegis of Take Pride or Federal Lands Clean-up Day, include providing beach access to citizen clean-up groups, organizing volunteer clean-ups, and directly funding beach maintenance activities including cleaning of beaches and disposal of debris. Park visitors are often given litter bags upon entering park units and reminded to bring out their trash.

c. U.S. Fish and Wildlife Service

The FWS activities related to marine debris are associated with its responsibilities under various authorities (e.g., National Wildlife Refuge Administration Act) for managing the

National Wildlife Refuge system, numerous migratory bird species, and certain marine mammal species. Marine debris accumulates in some coastal refuges, and various birds and mammals under FWS jurisdiction are subject to the entanglement and ingestion problems associated with persistent marine debris. Specific FWS activities include:

Research: FWS conducts research (under contract to NOAA) on marine debris ingestion rates in seabirds, and the possible adverse effects. Ongoing habitat research in Florida has also provided information on debris-related entanglement/ingestion in the endangered manatee. Ongoing beach surveys in Oregon and Alaska are conducted to monitor mortality in seabirds and marine mammals. FWS is represented on an interagency technical committee (with NOAA lead) that evaluates technical proposals to study plastic debris impacts on wildlife.

Education: FWS cooperates with NOAA to educate commercial and recreational fishermen in Oregon about the hazards discarded plastic materials pose to fish and wildlife. FWS also cooperates with the state of Florida and others in a campaign to make boaters and recreational fishermen aware of the potential effects of discarded plastics on endangered manatees.

Mitigation: With the exception of disposal within refuge boundaries, FWS has no authority to prohibit disposal of debris that may affect resources under its jurisdiction. Accumulated debris is collected and disposed of by FWS at some coastal refuges to prevent entanglement by birds and turtles.

d. Take Pride in America

The Take Pride in America program is a public/private partnership consisting of 9 Federal Agencies, 43 states, 2 U.S. Territories, and numerous private sector organizations. The partnership is committed to the careful stewardship of the nation's public lands and waters and natural and cultural resources in order to make the public (individuals and institutions) aware of the need to respect and protect public lands and waters. The campaign has two major thrusts: 1. a public awareness/education effort; and 2. a national awards program that recognizes individuals and groups that conduct outstanding stewardship activities or awareness efforts. The Advertising Council, Inc., has made the campaign one of its major national public service efforts soliciting the assistance of campaign spokesmen Clint Eastwood, Louis Gossett, Jr., and Charles Bronson, who profess that it is "bad guys who abuse public lands, and good guys that save them."

As initiater for this national effort, Interior often provides advice and support for activities that address the problem of persistent marine debris. Under the auspices of the campaign, participating Federal partners, states, and private sector participants have initiated and supported activities ranging from public awareness to actual beach and water clean-ups. They have solicited assistance from businesses, associations, corporations, public interest groups, the media, youth groups, and concerned citizens in this effort. Take Pride focuses on public awareness and volunteer efforts, as well as identification of and recognition for outstanding stewardship activities.

3. DEPARTMENT OF DEFENSE

Navy

The Navy has approximately six hundred large ships and several hundred smaller vessels which operate around the world. These ships discharge their waste at sea. The Navy recognized many years ago that the discharge of waste at sea has a negative impact on the environment, the aesthetic quality of ocean life, safety of navigation, and national security. As a result, the Navy initiated a reseach and development program in the mid-1970's to find solutions for these problems. This program should be completed within the next few years.

Research: The Navy is currently pursuing the research and development of a shipboard compactor, pulper, and thermal processor for plastics. Additionally, the Navy is studying the feasibility of installing this equipment aboard all ships fleet-wide to eliminate problems posed by all forms of floatable waste.

Education. The Navy has acquired significant experience and information about technology and equipment which is cost-effective and can be installed aboard ship to successfully minimize/eliminate ocean debris. This information can be transferred to other Navies and commercial maritime fleets.

Mitigation: The Navy complies with all relevant environmental legislation, regulation, and treaties at the international, national, state, and local levels. The Navy maintains Status of Force Agreements under which it complies with the discharge policies applicable in foreign coastal waters.

4. DEPARTMENT OF TRANSPORTATION

U.S. Coast Guard

The Coast Guard is currently leading an Administration initiative to control at-sea disposal of garbage including plastics from ships through U.S. ratification and implementation of Annex V (Regulations for the Prevention of Pollution by Garbage from Ships) of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). Annex V of MARPOL 73/78 establishes international regulations for prohibiting or otherwise restricting disposal into the oceans of all types of garbage generated during the normal operations of ships. It contains a provision that prohibits, with limited exceptions, the disposal into the sea of all plastics, including but not limited to synthetic ropes, synthetic fishing nets, and plastic garbage bags. Additionally, reception facilities capable of accepting garbage from ships would also be required at ports and terminals. The Coast Guard prepared the Administration's proposed implementing legislation for Annex V and is working with NOAA in a joint effort at the International Maritime Organization to establish international guidelines to assist in effective implementation and enforcement of the Annex V provision.

Education. The Coast Guard Auxiliary provides boating safety classroom instruction and conducts related courtesy examinations for pleasure craft on behalf of the Coast Guard. As with the classes, the courtesy examinations are primarily educational so as to assist boaters in knowing and understanding what specific safety equipment is required onboard. Currently, no aspects of these classes or examinations pertain to marine debris. The Coast Guard Auxiliary will include a segment covering marine debris problems and the new requirements. The Coast Guard's and/or the Coast Guard Auxiliary's public service

announcements and advertisements will also highlight marine debris. In addition, the Coast Guard is considering coordinating the implementation of similar segments into various state boating safety programs to which the Coast Guard provides funding support, certification and licensing of officers.

Mitigation. The Coast Guard is currently preparing regulations to implement Annex V provisions which will take effect December 31, 1988.

The Coast Guard currently requires its own vessels to comply with the Annex V provisions and has incorporated these provisions in the Coast Guard Shipboard Regulations Manual.

5. DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE (APHIS)

Mitigation. The purpose of APHIS's regulatory activity with maritime garbage is to prevent the entry in garbage of damaging plant and animal pests and diseases not native to the United States. These pests and diseases would endanger the U.S. agricultural economy, and result in a diminished food supply, diseased or dying wildlife and plant resources, and a reduced export market for our agricultural commodities, both plant and animal.

APHIS regulates garbage on ships which arrive at U.S. ports and have previously visited ports other than continental U.S. and Canadian ports. Garbage regulated by APHIS includes not only food material, but food wrappers and any other material which has been in contact with or commingled with regulated garbage. Regulated garbage (also called foreign garbage) must be destroyed at an APHIS-approved facility, either by incineration to an ash

or by sterilization to an internal temperature of at least 212°F for at least 30 minutes. Sterilized garbage is then landfilled, and may not be fed to animals.

APHIS officers board vessels and monitor compliance with garbage regulations. When MARPOL Annex V is implemented, APHIS officers will also monitor compliance with Annex V on the category of ships we currently board. When MPPRCA regulations become effective, additional APHIS-regulated wastes are likely to be brought ashore for disposal. Provisions need to be made to assure that APHIS approved disposal facilities are accessible to vessel operators in small ports. APHIS will also participate with the Coast Guard in the approval of reception facilities to ensure that these facilities are capable of destroying regulated garbage as required by USDA regulations.

6. DEPARTMENT OF STATE

The Department of State currently has no specific program relating to marine debris research, education, or mitigation. The Department of State, however, leads or serves on delegations to various international meetings where these issues are discussed and assures that they receive appropriate attention. Additionally, the Department of State is involved with persistent marine debris via the numerous international treaties, conventions, and agreements existing between the United States and foreign countries. The Department of State also assures that the U.S. complies with its international obligations under these agreements.

7. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA has been involved with activities related to marine debris issues under its toxic substances, water quality, ocean dumping, and Superfund programs. EPA has several statutory authorities which relate directly or indirectly to marine debris, including the Marine Protection, Research, and Sanctuaries Act (the Ocean Dumping Act); the Clean Water Act; the Resource Conservation and Recovery Act (RCRA); the Toxic Substances Control Act (TSCA); and the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund). EPA has no specific program directed entirely to marine debris issues; past Agency activities have been primarily focused on specific geographic areas.

Research. EPA funded the Center for Environmental Education's analysis of marine debris which led to their report "Plastics in the Ocean: More than a Litter Problem." In connection with the floatables problems in the New York/New Jersey coastal area, EPA jointly funded a New Jersey Department of Environment/US EPA floatables study to identify the types of floatables found on New Jersey beaches and the possible sources. EPA is also funding a study in the New York Bight area to sample discharges from combined sewer overflows (CSO) for releases of floatables to determine the extent of CSO contribution to the problem.

Regulation/Mitigation: EPA has regulatory activities which directly and indirectly impact marine debris controls. Under the Clean Water Act, all permits for discharge of wastewater from point sources contain a prohibition on the discharge of visible floatable materials. Under the Ocean Dumping Act, EPA (New York region) has taken actions to ensure that floatables are not released during ocean dumping. EPA has established sampling

procedures and sampled sludge prior to ocean dumping and found no significant floatables. EPA is carefully considering both the site designation and permit applications for the woodburning site to also ensure no release of floatable materials (wood).

EPA's New York region has developed a plan in conjunction with state, local and other Federal agencies to address future garbage wash-up events. The plan includes the continued use of helicopter overflights of coastal areas to identify potential problems and possible sources.

EPA's Superfrund program has funded the removal of unmarked drums which wash up on Padre Island National Seashore.

EPA's Seattle region provide funding support for the Seattle Aquarium's Adopt-a-Beach program to clean litter from Puget Sound beaches.

8. MARINE MAMMAL COMMISSION (MMC)

The MMC was among the first Federal agencies to recognize that increasing amounts of marine debris posed a serious threat to marine mammals and other species of marine life. The MMC was instrumental in calling the matter to the attention of domestic and international agencies/organizations, and it assumed a leading role in initiating a Federal response to the problem.

Research: To help develop information on the extent of the marine problems and possible solutions, the MMC has funded several research and studies programs. The projects supported include: The Workshop on the Fate and Impact of Marine Debris held in 1984 organized by the National Marine Fisheries Service; an analysis of domestic and international legal authorities

applicable to the marine debris problem; a survey of lost and discarded fishing gear on beaches on Southeast Alaska; collection of information on problems caused by marine debris in Australia; and a survey of marine debris on beaches along the Atlantic coast of Argentina.

Education: The MMC has been actively involved in bringing the problem of persistent marine debris to the attention of the public both at the international and national levels. At the international level the MMC has: caused the issue of marine debris to be included on the agenda of annual meetings of the Commission on the Conservation of Antarctic Marine Living Resources; drafted a U.S. paper for the 24th Session (Feb. 1987) of the International Maritime Organization's Marine Environment Protection Committee which recommended, inter alia, that the committee develop guidelines on actions that could be taken to help implement MARPOL Annex V; presented a paper on persistent marine debris in Paris which resulted in the issue becoming part of the agenda for the Global Investigation of Pollution in the Marine Environment, and assisted NOAA in organizing and convening the Second International Workshop on Marine Debris to be held in April 1989. Nationally, the MMC has assisted the National Oceanic and Atmospheric Administration and the U.S. Coast Guard in drafting guidelines for consideration by the Marine Environment Protection Committee and organized public awareness and beach clean-up efforts in Oregon, Washington, Calfornia, and New England.

Mitigation: The MMC was established under Title II of the Marine Mammal Protection Act of 1972. In general, the MMC is responsible for developing, reviewing, and making recommendations on actions and policies for all Federal agencies with respect to marine mammal protection and conservation. Among other duties,

the Act directs that the MMC: undertake "such studies as it deems necessary or desirable in connection with its assigned duties as to the protection and conservation of marine animals" [section 202(a)(3)]; recommend "to other Federal officials such steps as it deems necessary or desirable for the protection and conservation of marine animals" [section 202(a)(4)]; and "recommend to the Secretary of State appropriate policies regarding existing international arrangements for the protection and conservation of marine mammals, and suggest appropriate international arrangements for the protection and conservation of marine mammals" [section 202(a)(5)].

B. Private Industry/Public Interest Groups

Private interest groups, including industry associations and individual companies as well as public interest groups, are attacking the problem. Among other things, these groups help organize clean-ups, sponsor public and industry awareness campaigns, and perform research in degradable plastic technology. Many of these projects are coordinated efforts involving cooperation between industry, private citizens, public interest groups and government agencies.

These private activities vary considerably. We have selected a few examples that show the range of different private activities currently underway. Lack of mention here should not be taken as diminishing the contributions of any other private effort. Each group's effort, especially in dealing with the specific circumstances of a local area, is vital to the success of any National efforts to deal with the problem of plastics in the marine environment.

Due to the cooperative nature of many of the projects, some examples listed under specific organizations should not be solely attributed to them. To the best of our abilities we have tried to list all the major contributors to each of the examples listed.

We have broken this section into three segments. The first segment deals with industry activities, and the second with public interest group activites. The final segment discusses a coordinated group of concerned public interest, industry and government representatives who meet on a routine basis to exchange information and attempt to coordinate activities.

1. Private Industry

While pointing out that plastics are not the only pollution problem in the marine environment and that proper disposal would take care of a significant portion of the problem, private industry groups recognize that they have a role in helping to address this issue. Several organizations and companies are taking active steps to assess how plastics are manufactured, transported, used and disposed of and how plastics, as a part of the solid waste, stream can be handled. This section provides some examples of projects private industry has completed or has underway that are related to plastics in the marine environment.

a. Society of the Plastics Industry, Inc. (SPI)

The SPI is a trade organization representing all segments of the plastics industry. They have been involved in several activities which directly relate to the amount of plastics that reach the marine environment. Examples of these include:

- Sponsored a symposium on degradable plastics in June 1987. Contributors presented papers on how some plastics can be made to degrade as well as perspectives on what products could or could not, or should or should not, be made degradable.

- Developed an ad campaign, in cooperation with the Center for Environmental Education and the NOAA, geared toward the maritime, commerical fishing, and plastics industries, alerting these groups to the problems of plastics in the marine environment and what they can do to help.

- Designed a survey of the manufacturers, processors and transporters of plastic pellets to determine the extent that these groups are inadvertently releasing plastic pellets to the marine environment and what steps can be taken to minimize these releases.

b. Council on Plastics and Packaging in the Environment (COPPE)

The COPPE is a newly formed coalition of plastic suppliers, consumer goods companies, equipment makers and trade associations. COPPE's mission statement acknowledges that plastics and packaging represent a growing share of the Nation's solid waste stream and that industry involved with manufacture and use of plastics packaging must help solve the problem. In the months ahead COPPE plans to engage in public relations

campaigns to help promote "environmentally safe and economically viable answers" to the plastics portion of the solid waste problem.

c. North Pacific Rim Fishermen

In October 1987, representatives of the fishing industry from Canada, the Republic of China, Japan, the Republic of Korea and the United States meet in Hawaii to discuss the problems associated with marine debris. At the conclusion of this meeting the group passed a resolution recognizing that synthetic marine debris constitutes a growing threat to marine life and safety at sea and that the fishing industries have a role to play in reducing such debris. This resolution outlined several goals that members could undertake ranging from increased efforts to reduce loss of plastic items at sea to promoting educational programs addressing the problem, and encouraging cooperation with local authorities in the establishment of effective onshore disposal systems. The conference members also outlined nine reseach areas which they felt would contribute to the understanding of the scope and magnitude of the problem of plastics in the marine environment and potential methods of dealing with the problem.

d. EcoPlastic

There are several companies actively developing the technology to produce commercially acceptable products from photodegradable and biodegradable plastics. One of these companies is EcoPlastics Limited, a Toronto-based producer of photodegradable resins. EcoPlastics' President, Dr. Anthony Redpath, claims that their Ecolyte (TM) resins, when combined with normal resins such as polystyrene, polyethylene, polypropylene, can render most any

commercial product photodegradable when exposed to sunlight. Dr. Redpath claims that while use of the product is expected to raise the price of the purchased raw materials by a few percent, when the reduced costs of having to deal with less litter are factored in, the use of photodegradable plastics becomes economically favorable from a societal viewpoint.

EcoPlastics is currently working with a variety of companies to test and market the technology. In September 1987, Safeway Canada Limited placed its first order for EcoPlastics' photobiodegradable grocery bags. EcoPlastics recently entered into a joint agreement with a Massachusetts based company (Polysar) to produce degradable polystyrene cups.

e. Dow Chemical Company

Numerous companies have programs to reduce wastes and prevent the release of plastic materials to the environment. One example of this type of effort has been in operation for the last ten years at Dow Chemical Company's polyethylene plant in Plaquemines, Louisiana. At its Plaquemines plant, Dow produces approximately one billion pounds of polyethylene plastic pellets per year. Dow sells these pellets to processors who remelt the pellets and form them into plastic parts.

During manufacture and processing some pellets can be lost at various stages and ultimately end up in the wastewater stream. Dow installed a collection system for these pellets that has significantly reduced the loss of pellets. While this system provides important environmental benefits, Dow also recovers 500 pounds of salable polyethlyene product each day.

f. Anheuser-Busch

Anheuser-Busch is one of the largest breweries in the United States. They have a nationwide system of distributors which sell their products across the country in various types of containers. One of the most popular means of holding 12 ounce beer cans together is the six-pack yoke. In 1985, Anheuser-Busch decided that all the six-pack yokes on their products would be made of degradable plastic, able to meet the most strigent local requirement. As of December 1987 the conversion was completed.

g. Plastic Industry Recycling Activities

Recycling is only successful when there is a reliable source and a market for the product. Plastics which are currently recycled include beverage containers (polyethylene terephthalate (PET) -- two-liter soft drink bottles), pellets (polyethylene) and milk jugs (high-density polyethylene).

Until recently, recycling plastic occurred only when particular items could be separated into specific plastic compositions. A new technology has been developed which permits co-mingled plastics to be recycled. The Plastics Recycling Foundation (industry-sponsored), which is sponsoring research at the Center for Plastics Recycling Research at Rutgers, N.J., has developed a process which co-mingles recycled plastics and produces a lumber-like product which can be used as a substitute for wooden boards or posts.

Another significant landmark in recycling recently occurred within the plastics industry. In April 1988, the Society of the Plastics Industry, Inc. announced a voluntary container coding system to identify plastic formulations, thereby facilitating

sorting for recycling. Containers 16 ounces and larger will be so coded. Specific resin types, which will be coded for subsequent sorting, will be high-density polyethylene, polystyrene, PET, poilyvinyl chloride (PVC), polypropylene, low-density polyethylene, and mixed resins.

2. Public Interest Groups

The public interest community is addressing the problem of plastics in the marine environment in a variety of ways. Several nationally active organizations are working with industry and government groups to develop recommendations on the ways to deal with the problem, gather data from around the country and help organize local activities such as beach clean-ups. This section provides examples of activities that the public interest community has undertaken in its attempt to lessen the problem of plastics in the marine environment.

a. Center for Environmental Education (CEE)

The CEE, a Washington, D.C., based public interest group, has taken a strong interest in the problem of plastics in the marine environment. Their activities have included:

- o research on techniques for saving entangled animals;
- o promoting beach clean-ups by private citizens around the country. CEE is also putting together a data base which will indicate the types and quantities of trash, including plastics, that are collected during the beach clean-ups.
- o providing information and technical advice to Congress, federal and state agencies, and a variety of local organizations.

b. Entanglement Network

The Entanglement Network is a consortium of 31 environmental[1], conservation and animal protection groups. This group is a cooperative effort to facilitate the exchange of information on the problem of marine debris entanglement and incidental take. Members of the network have testified before Congress, participated on the U.S. delegation to the International Maritime Organization and published numerous articles to increase public awareness.

3. Marine Debris Roundtable

A diverse group of experts from the industrial, governmental and environmental communities were first brought together in December 1986 by the National Marine Fisheries Service to evaluate strategies for future research and development to mitigate the

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[1]/Members and/or participants in the Entanglement Network: American Cetacean Society; American Humane Association; Animal Protection Institute of America; American Society for the Prevention of Cruelty to Animals; California Marine Mammal Center; Center for Coastal Studies; Center for Environmental Education; Cetacean Society Institute; Defenders of Wildlife; Earth Island Institute; Earthtrust; Environmental Defense Fund; Environmental Task Force; Friends of Animals; Friends of the Sea Otter; Greenpeace USA; Greenpeace New Zealand; H.E.A.R.T.; Humane Society of the United States; International Fund for Animal Welfare; International Wildlife Coalition; Living Ocean Society; Long Term Institute; Maine Audubon Society; Massachusetts Society for Prevention of Cruelty to Animals; Monitor Consortium; National Audubon Society; National Wildlife Federation; Natural Resources Defense Council; Northwind Under Sea Institute; Oceanic Society; Sierra Club Wildlife Committee; Society for Animal Protective Legislation; Sun Coast Seabird Sanctuary; Whale Center; and World Wildlife Fund.

impacts of non-degradable debris in the oceans. Meetings have also been held in June 1987 and March 1988.

C. State and Local Programs

State and local governments and local citizens' organizations are leading battles in their communities against persistent marine debris. They are sponsoring beach clean-ups, placing public service announcements on radio and television, and mounting anti-litter campaigns. The level of effort a state or community devotes to persistent debris depends largely on local problems. The following discussion describes some of the activities occurring in Texas, Oregon, and New Jersey to combat persistent marine debris. Enthusiastic leadership by state officials produced effective programs in each of these states. Other states have equally impressive programs; we cite these merely as examples.

1. Texas

Litter washes onto south Texas beaches in astounding quantities. It lands there because currents and winds push anything that floats in the Gulf of Mexico in that direction. It seems to come from many sources and all parts of the world (on transport ships). The only thing good about the volume of litter on Texas beaches is that it has united the state's citizens, government officials, and industry leaders to fight it.

Garry Mauro, Texas Land Commissioner, leads the fight. The Texas General Land Office (GLO) manages state lands, including beaches below the high water line. When Commissioner Mauro realized the major nuisance and hazardous problems that debris was creating, he began several campaigns to get rid of it.

The Texas Highway Department was conducting a highly visible "Don't Mess With Texas" campaign to reduce litter on roads. The GLO expanded the anti-litter campaign to become a "Don't Mess With Texas Beaches" campaign.

Texas citizens eagerly mobilized to remove debris from their beaches. Texas now has two beach clean-ups annually, one each in the fall and spring. In the fall of 1987, over 7,000 volunteers participated. As a way of supporting volunteers, local hotels rented rooms at discounts and restaurants gave food discounts. Many corporations and citizens' groups "adopted" sections of beach to clean.

Texas officials are also actively promoting international efforts to have the International Maritime Organization designate the Gulf of Mexico a "Special Area" under MARPOL. Special area designation would place further restrictions on materials that vessel operators could dispose of in the Gulf.

2. New Jersey

Litter on New Jersey beaches received national attention in 1987 when large quantities of debris washed onshore in three separate incidents. New Jersey beaches receive a large amount of litter from land-based sources including the combined sewer overflows from New York City, beach goers, and rivers. The water mass from

the New York Harbor area follows the New Jersey coastline after it leaves the harbor, carrying wastes from the 20 million people in the New York City area.

The State of New Jersey has an aggressive program to reduce litter on its beaches.

- The State Department of Environmental Protection (DEP) coordinated the 1987 beach clean-up with a coordinated clean-up by Clean Ocean Action, a local environmental group.
- The DEP is conducting floatable studies from potential major sources of plastics pollution such as the Fresh Kills Landfill.
- The state is conducting a public awareness campaign called New Jersey Shore-Keep it Perfect. This is basically an anti-litter campaign aimed at both educating the public about the problem and at encouraging coastal communities to provide proper disposal facilities at beaches and marinas.
- Governor Kean has a 14-point action plan which includes direct loans to coastal communities for more beach clean-up.
- As a result of the medical waste washing ashore in the summer of 1987, the New Jersey Attorney General negotiated a consent decree with New York whereby New York City will spend $15 million to prevent floatable pollution by instituting such measures as covering garbage barges going to the Fresh Kills landfill on Staten Island and using booms to contain any material that may escape into the marine environment.

- o The New Jersey legislature passed a bill creating a marine police force of 60 to 70 new officers based in the New York Harbor area to conduct surveillance and enforcement against illegal disposal.
- o A New Jersey helicopter will fly over the state's coast every day between Memorial Day and Labor Day to detect any signs of illegal dumping.
- o After the 1987 incidents of medical wastes washing ashore in New Jersey and dolphins dying, a blue ribbon panel was convened to report on the causes of these events. The report should be completed in the summer of 1988.

3. Oregon

Most of the beaches along the Oregon coast are publicly owned and managed as state parks. They receive a variety of litter from many sources. Oregonians' awareness of problems caused plastic debris on beaches and the marine environment led the Oregon Department of Fish and Wildlife to hold the nation's first beach clean-up in 1984. The Department assigned Judie Nielson to coordinate the beach clean-up campaign called "Get the Drift and Bag It". Under her enthusiastic tutelage, and the support of Department officials, the annual clean-up effort is now well established. Working with the state-wide "Stop Oregon Litter and Vandalism" network of local civic, school, fishermen, and environmental groups, over 2,000 volunteers have removed debris from Oregon beaches each fall since 1984. Each spring Oregon State Parks along the coast sponsor a beach clean up campaign called "Company's Coming" to provide more attractive beaches for summer visitors.

The Port of Newport, Oregon serves as home-port to approximately 600 fishing vessels and small fleet of merchant and recreational

vessels. Local fishermen, recreational boaters, and seamen agreed to bring to shore their plastic refuse and any plastic they found floating. The citizenry enthusiastically supported the project, which addressed the problem by increasing public awareness and providing solid waste disposal services at the docks. The Port provided separate receptacles for different types of debris--synthetic nets, glass, cardboard, wood, and household garbage. They located firms to recycle much of the trash. The success of the Port's program can be measured in many ways. One notable success is the reduced amount of plastic debris on beaches near Newport during recent spring and fall beach clean-ups.

Chapter V
Legal Authorities for Persistent Marine Debris

Numerous treaties, Federal laws, and state laws address persistent marine debris. Some of these legal authorities directly target marine debris while others do so indirectly. This chapter briefly sets out each of the legal authorities which relate to marine debris in the categories of international, Federal, and state, and further breaks them down into those directly or indirectly related to the subject.

Current laws do not provide adequate authority for implementing some of the recommendations discussed in this report. There is no direct authority for banning non-degradable plastics or conversely, for requiring degradable plastic products. While some states have "bottle bills" and "6-pack yoke bills," most do not. Another gap in the legislation is lack of expressed Federal authority to penalize individuals whose plastic debris washes ashore or entangles wildlife.

A. International

1. Treaties Directly Affecting Persistent Marine Debris

a. International Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, London, 1972, entered into force 1975; 26 UST 2403. (London Dumping Convention, LDC)

The LDC prohibits dumping into the sea of "persistent plastics and other persistent synthetic materials" such as netting and ropes, which float or remain in suspension causing them to interfere with fishing, navigation, or other legitimate uses of the sea. The LDC defines dumping as "any deliberate disposal at sea of wastes or other matter from vessels, aircraft, platforms,

or other man-made structures at sea." The LDC definition of dumping specifically excludes "disposal at sea of wastes or other matter incidental to or derived from the normal operations of vessels..." Therefore, plastics and other persistent synthetics may not be transported to sea for the purpose of dumping or dumped at sea. This prohibition does not reach the synthetic marine debris which is disposed of in the course of normal vessel operations, such disposal is instead subject to MARPOL Annex V.

b. Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships, 1973/1978, 17 I.L.M. 546, 1978. (MARPOL)

The purpose of MARPOL is to prevent ships from polluting the marine environment by discharging harmful substances. Annex V of MARPOL, which has been ratified by the United States and will come into force December 31, 1988, restricts at-sea discharge of garbage, and bans at-sea disposal of plastics and other synthetic materials such as ropes, fishing nets, and plastic garbage bags with limited exceptions. Plastics may be disposed at sea when: 1) it is necessary for the safety of the ship or to save lives; 2) the disposal results from damage to the ship provided all reasonable precautions have been taken to prevent or minimize the escape; or 3) when nets or other synthetic net repair items are accidentally lost, provided all reasonable precautions have been taken to prevent the loss. Adequate reception facilities capable of handling garbage from ships are required at ports.

MARPOL Annex V has a direct effect on plastic pollution in the marine environment because it prohibits disposal of plastic wastes generated during the normal operation of vessels everywhere in the ocean. However, Annex V does not completely alleviate the problem because its prohibition applies only to synthetic material discarded from vessels, not land-based sources of synthetic debris which travel to the ocean.

2. Treaties Indirectly Affecting Marine Plastics Pollution

There are many regional conventions which provide for conservation and protection of the marine environment and pollution control. These conventions include:

- Convention on the Conservation of Antarctic Marine Living Resources, 1980;
- Convention on the Protection of the Marine Environment of the Baltic Sea Area, 1974;
- Convention for the Prevention of Marine Pollution from Land-based Sources, 1970;
- International Convention for the High Seas Fisheries of the North Pacific Ocean, 1952;
- Convention for the Protection of Marine Pollution by Dumping from Ships and Aircraft, 1972;
- United Nations Regional Seas Program which has the following conventions;
- Convention for the Protection and Development of the Wider Caribbean Region, 1983;
- Convention for the Protection of the Mediterranean Sea Against Pollution, 1976;
- Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution, 1978;
- Convention for Cooperation in the Protection and Development of the Marine Environment of the West and Central African Region, 1981;
- Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment, 1982.

The United Nations Convention on the Law of the Sea, 1982, also has sections regarding protecting and preserving the marine environment.

B. Federal Authorities

1. United States Statutes Which Address Persistent Marine Debris

a. Act to Prevent Pollution from Ships, as amended, 33 U.S.C. 1901 et seq. (APPS)

APPS is the implementing legislation for the MARPOL treaty. Currently, Annexes I (Oil), and II (Noxious Liquid Substances in Bulk), have been implemented. Title I of the Plastic Pollution Research and Control Act (Pub. L. No. 100-220) implements Annex V by amending the APPS. The U.S. Coast Guard is preparing appropriate regulations. The APPS amendments and regulations will become effective on 31 December, 1988, when Annex V comes into force in the U.S. and worldwide. Therefore, the United States will have a ban on discharge from vessels of plastics and other synthetic material, and requirements of certain disposal techniques for all other kinds of ship-generated garbage disposed at sea. Adequate reception facilities at ports or terminals are required for oil and noxious liquid substances, and will be required for ship-generated garbage. Civil penalties are assessed for violations of APPS. Refuse record books will be required for certain ships, and ships will display placards notifying the crew of Annex V requirements. The Coast Guard implements and enforces the provisions of APPS. APPS applies to U.S. registered ships anywhere and to foreign registered ships in

the navigable waters and Exclusive Economic Zone of the U.S. with respect to Annex V requirements, and within five years, will also include ships owned by U.S. government agencies, such as the Navy.

b. Subtitle B of the Marine Plastic Pollution Research Control Act of 1987, Pub.L. 100-220.

Subtitle B, Studies and Report, of Pub. L. No. 100-220 requires the Environmental Protection Agency (EPA) to study means to reduce plastic pollution and the Department of Commerce to determine the effect of plastics on the marine environment. This Act also requires that NOAA and EPA, in consultation with the Secretary of Transportation, conduct a public outreach program to educate the public regarding plastics pollution. These studies should help Congress and the agencies determine the best methods to reduce persistent marine debris. The public outreach program should also help reduce the amount of debris.

c. Driftnet Impact Monitoring, Assessment, Control Act of 1987, Pub.L. 100-220, Title IV.

This Act requires the Secretary of Commerce to collect statistical information on the numbers of U.S. marine resources killed, retrieved, discarded, or lost by foreign government, driftnet fishing vessels which are fishing beyond the exclusive economic zone of any nation. The Secretary must provide a report on the nature, extent, and effects of driftnet fishing in the North Pacific Ocean on U.S. marine resources. The Secretary will also enter into enforcement agreements with each foreign government that has nationals fishing in the high seas in the North Pacific Ocean and taking U.S. marine resources.

The Act requires the Secretary to conduct an evaluation of establishing a driftnet marking, registry, and identification system to provide a method for determing the source of abandoned driftnets and fragments. Alternative materials for driftnets to hasten decomposition of the netting will also be evaluated, as will the feasibility of a driftnet bounty system and a driftnet vessel tracking system.

d. Refuse Act of 1899, as amended, 33 U.S.C. 407.

This Act prohibits disposal of any kind of refuse matter except street or sewer discharges, into any navigable waters of the U.S. or their tributaries. Permits may be issued by the Army Corps of Engineers for depositing materials in navigable waters within the conditions set by the Secretary. The Refuse Act permit program has been subsumed into the National Pollutant Discharge Elimination System (NPDES) permit program established by the Clean Water Act, and as a result, Refuse Act permits are no longer issued. The Refuse Act may still be used to prohibit discharges of plastic and other persistent synthetics within United States navigable waters and extending to 3 miles offshore. The U.S. Army Corps of Engineers and Department of Justice administer the Act, while the U.S. Army Corps of Engineers has permitting authority.

e. National Ocean Pollution Planning Act of 1978, as amended, 33 U.S.C. 1701 et seq.

This Act requires NOAA to prepare 5-year plans for ocean pollution research and monitoring. The most recent plan briefly discusses the problem of entanglement and ingestion of marine debris by marine organisms. NOAA is the lead agency for the plan preparation.

f. Marine Protection, Research, and Sanctuaries Act, Title I, as amended, 33 U.S.C. 1401 et seq. (Ocean Dumping Act)

Among other things, the Ocean Dumping Act implements the previously discussed London Dumping Convention (LDC). The Act prohibits transporting any material for the purpose of dumping it in ocean waters unless authorized by permit. The Administrator of the EPA issues permits for dumping of everything except dredged materials, which are permitted by the U.S. Army Corps of Engineers. Consistent with the LDC, no permits have been issued for the Ocean dumping of persistent plastics or synthetic materials. The Act provides for civil and criminal penalties for violations.

g. Federal Water Pollution Control Act, as amended, 33 U.S.C. 1251 et seq. (Clean Water Act)

The Clean Water Act has the broad goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters. Under the Act a permit is required for point-source discharges, including those into the territorial sea or oceans. These permits are issued under the National Pollutant Discharge Elimination System (NPDES) and in the case of discharges into the territorial sea and oceans, must meet the special guidelines established by EPA for ocean discharge under Section 403(c) of the Act. Although plastic and other synthetic materials are not specifically prohibited by the 403(c) guidelines, the permitting authority must determine that the discharge will not cause unreasonable degradation of the marine environment based on a number of factors.

h. Magnuson Fishery Conservation and Management Act, as amended, 16 U.S.C. 1801 et seq.

The Magnuson Act's purposes include, to "conserve and manage the fishery resources found off the coasts of the United States..." and to promote "sound conservation and management principles;" The Exclusive Economic Zone (EEZ) is established, extending from the baseline of the territorial sea to 200 miles. A permit is required for foreign fishermen to fish within the EEZ. The regulations for operators of foreign fishing vessels include a prohibition from disposal in the EEZ of fishing gear and other articles including bale straps, plastic bags, oil drums, petroleum containers, oil, toxic chemicals, or any manmade items retrieved in fishing gear. The Magnuson Act, thus, is used to prevent the disposal of marine debris, although its application is limited.

i. Outer Continental Shelf Lands Act, as amended, 43 U.S.C. 1331 et seq. (OCSLA)

One of the stated policies in the OCSLA is that the exploration, development, and production of minerals on the continental shelf should not affect the character of the waters above the continental shelf, navigation, or fishing. The Department of the Interior operating regulations prohibit disposal of all solid wastes, including plastics, from OCS operating structures and vessels.

2. Federal Statutes Indirectly Relevant to Persistent Marine Debris

a. Wildlife Statutes

i. Marine Mammal Protection Act of 1972, as amended, 16 U.S.C. 1361 et seq.

The Marine Mammal Protection Act states a goal of obtaining the optimum sustainable population level of marine mammals depending on the carrying capacity of the habitat. To further this goal, the Act places a moratorium on the taking of any marine mammal from waters under United States jurisdiction or by U.S. citizens anywhere in the world. This Act also establishes the Marine Mammal Commission which is responsible for making recommendations on actions and policies for all Federal agencies with respect to marine mammal conservation and protection, and for carrying out a research program. Marine debris has a direct effect on maintaining the health of marine ecosystems and on obtaining optimum sustainable population levels of marine mammals. Therefore, the Commission sponsors marine debris research and recommends actions to mitigate problems associated with marine debris.

ii. Endangered Species Act of 1973, as amended, 16 U.S.C. 1531 et seq.

The purposes of the Endangered Species Act (ESA) are to protect and conserve ecosystems upon which endangered and threatened species depend, and to conserve endangered and threatened species. The ESA prohibits "taking" any endangered or threatened species. Marine debris, including lost or discarded fishing gear, can potentially harm or kill endangered or threatened species. Therefore, if ownership of an item which harmed an endangered or threatened species could be determined, then the owner could be considered to have violated the ESA by "taking" the animal. This is an interpretation which has not been adopted by courts nor enforced by Federal agencies.

iii. Migratory Bird Treaty Act, as amended, 16 U.S.C. 703 et seq.

This Act protects migratory birds listed in certain treaties by prohibiting their taking. Many species of seabirds are susceptible to entanglement in fishing gear and other marine debris. Thus, if a protected species is harmed by fishing gear or other marine debris, a violation of this Act has occurred. Determining who is the violator, however, would be difficult.

iv. Fur Seal Act of 1966, as amended, 16 U.S.C. 1151 et seq.

This Act makes it unlawful to harm fur seals in the North Pacific Ocean. Any harm or killing of a North pacific fur seal caused by marine debris could be a violation of this Act.

b. Resource Conservation and Recovery Act of 1976, as amended, 42 U.S.C. 6901 et seq. (RCRA)

The general objectives of RCRA are to promote the protection of health and the environment and to conserve material and energy resources. Solid wastes controlled by RCRA include discarded solids or liquids from commercial, mining, or agricultural operations. Discarded fishing gear is a solid waste. Plastics are not classified as hazardous waste.

Management of solid waste under subtitle D, is delegated to the states after EPA approves of the state plan. Regulation is within the jurisdiction of the state, however, EPA promulgates regulations establishing criteria for solid waste management. Subtitle C requires EPA to regulate generation, transportation,

treatment, storage, and disposal. Fishing gear and other shipboard plastic wastes that seamen will bring to shore will have to be properly disposed of at land facilities.

c. Toxic Substances Control Act, 15 U.S.C. 2601 et seq. (TSCA)

The purpose of TSCA is to regulate chemicals which present an unreasonable risk of injury to health or the environment. The EPA Administrator may require testing when there is insufficient data to determine the effects of chemicals on the environment and activities involving chemicals may present an unreasonable risk. If testing indicates an unreasonable risk, the Administrator may take action to limit or prohibit manufacture, processing, and distribution; limit or prohibit amounts for a particular use; require warning labels; or institute other protective measures. The EPA also is required to coordinate with other Federal agencies and within EPA to use laws other than TSCA to prevent or reduce risk. The EPA could regulate constituent substances of persistent marine debris or consider the advantages and disadvantages of degradable versus nondegradable plastics.

d. Deepwater Port Act, as amended, 33 U.S.C. 1501 et seq.

A policy of this Act is to protect the marine and coastal environment from any adverse impacts due to the development of deepwater ports. Regulations and procedures can be promulgated to prevent pollution, clean up pollutants, and otherwise prevent or minimize adverse environmental impacts from the construction

and operation of these ports. These regulations could include prohibitions on marine disposal of synthetic materials and require disposal in proper shore-based reception facilities.

e. Garbage Regulations on Storage and Movement on Certain Means of Conveyance, 9 CFR Part 94.5 (1987)

The purpose of these regulations is to prevent dissemination of plant pests and livestock or poultry diseases to the U.S. from any place outside the continental U.S. or Canada. Garbage containing plant and animal material must be contained in tight, leak-proof, covered receptacles. If unloaded, it must remain in the approved receptacle and be taken to an approved facility for incineration, sterilization or grinding into an approved sewage system under supervision of an inspector. Other handling arrangements may be used if authorized by the Administrator, Animal and Plant Health Inspection Service.

These regulations do not specifically address plastics, but do regulate the disposal of food wastes and all associated materials which contact foods such as plastic wrappers, packaging material, plates, and utensils.

C. State Laws

1. State Laws Directly Affecting Persistent Marine Debris

A number of states have laws which help reduce persistent marine debris by banning items which are part of the problem and which help reduce entganglement in active fishing gear. These laws are described generally. The states with them laws are listed.

a. Bottle Bills

Bottle bills reduce litter by banning the sale of beverage containers which are non-returnable, have detachable pull tabs, or are connected with plastic rings that are non-biodegradable.

States with these laws: Oregon, California, Connecticut, Delaware, Iowa, Maine, Massachusetts, Michigan, New York, Alaska, New Jersey, and Vermont.

b. Fishing Gear Laws

The general requirement in these laws is for biodegradable material in fish and crustacean traps or pots.

States with these laws: Florida, Texas, Alaska, Washington, Oregon, Maine, New Hampshire, and U.S. Virgin Islands and Puerto Rico.

Chapter VI
Assessment of Degradable Technologies

A. Products and Service Life

Recent beach clean-ups provide detailed information on plastic products encountered on the beaches. Based on semi-quantitative observations made in beach surveys, it is possible to identify the plastic products generally associated with the debris. The plastics denser than sea water are often excluded in the beach surveys. Persistent marine debris includes a significant amount of fishing gear often not encountered on beaches (except in locations where the beach is in close proximity to an active fishery).

Table VI-1 summarizes classes of plastic products which are generally found as beach debris, and believed to be a significant component of the debris at sea (Pruter, 1987). In addition to the relative frequency of occurrence in beach debris, potential hazards of the product to marine life were also considered in formulating the list of products given in the table. All of the products show up as litter and are aesthetically obtrusive. Table VI-2 shows the production processes of items which are commonly found as marine debris.

The "lifetime" of a plastic material in the environment depends upon the criteria used to define "degradation." Deterioration of a plastic product occurs in stages during which several physical changes are readily apparent (Figure VI-1).

Table VI-1. Plastic Items Commonly Encountered in Marine Debris

	Item	Possible Marine Problems	Service life Code
1.	Six-pack yokes	Entanglement	A
2.	Plastic bags/sheets/film	Entanglement/Ingestion	A/B
3.	Tampon applicators	Ingestion	A
4.	Net fragments	Entanglement	C
5.	Ropes, strapping and lines	Entanglement	B
6.	Lost traps	Entanglement	C
7.	Balloons	Ingestion	A
8.	Styrofoam pieces	Ingestion	B
9.	Bottles and containers	---	A
10.	Resin pellets	Ingestion	---

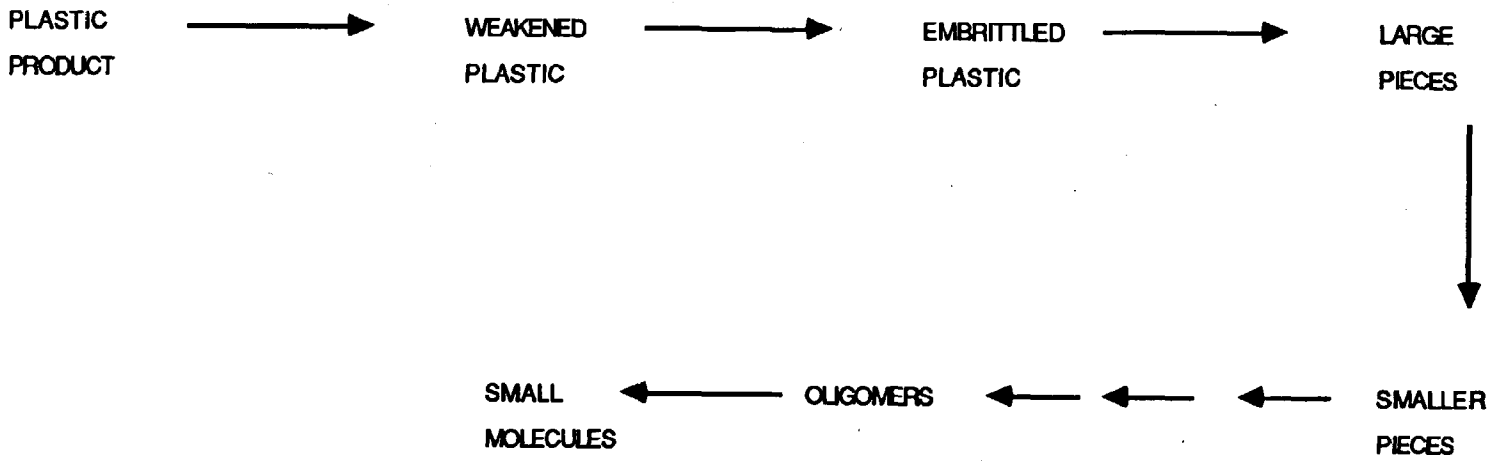
Service Life Code
A - Very short (single use items)
B - Short (multiple use, replaced within a year)
C - Moderate (multiple use, replaced after 1-5 years use)

Table VI-2. Classes of Plastics and Processing Methods Associated with Target Products

	Resin	Products	Process
1.	Polyolefins	Six-pack yoke plastic bags/films tampon applicators ropes/strapping trawl webbing	extrusion extrusion film blowing calendering molding
2.	Polystyrene	Containers floats	molding (foam) thermoforming (extruded foam)
3.	Polyamide (nylon)	Gill netting Monofilament line	extrusion
4.	Polyester	bottles	blow molding
5.	Synthetic/natural rubber	balloons*	latex dipping

*some balloons are made of polyester.

Figure VI-1. Fate of Plastic Material in the Environment



a. Loss of strength - Mainly due to the action of sunlight (McKellar and Allen, 1979), moisture and microbial action (Potts, 1972) (in the case of some polymers), plastics slowly weaken. If the exposure to these elements, particularly sunlight, is continued, the strength might be reduced to a point that any movement due to wind or contact with animals results in the brittle material breaking up into several smaller pieces. This "embrittled" plastic may no longer be a threat via entanglement, but ingestion still presents a risk or it may present an aesthetics problem.

b. Pieces of plastics produced during the slow embrittlement will continue to break down to progressively smaller fragments. Depending on the particle size, ingestion of the plastic material at this stage might lead to blockage of the digestive tract in a variety of animals (Day et al, 1984). However, small plastic fragments may pass through the digestive tract of animals without any ill effects.

For a given species, a narrow range of particle sizes (irrespective of the type of plastic material involved) might be identified as the critical maximum size of plastic fragment which might be ingested without serious consequences. A similar particle size below which the plastic is not readily recognizable as litter distinct from the background on which it lies, also exists.

c. The minute plastic fragments, although small enough to be ingested by the larger species without ill effects, are yet not degraded from a chemical standpoint. The long chain structure typical of polymeric materials still persists in the powdery residue. With the decrease in particle size and consequent increase in the particulate surface area (as well as the generation of oxidation products), the plastic becomes progressively more amenable to microbial degradation (Jones et al, 1974). This slow process continues until the long chain polymer is eventually degraded into simple organic molecules possibly including monomers.

d. In the strictest chemical sense, the degradation is not complete until these products of degradation are broken down to simpler compounds such as carbon dioxide and water.

Neither the exact sequence nor the time scale for any of the natural stages of deterioration of any of the plastics have been determined, especially with regard to performance in the marine environment. This fundamental question needs to be addressed to appreciate the full impact of plastic debris in the marine environment. While field observations of the change would involve long-term tests, reliable accelerated weathering tests under laboratory conditions might be developed to obtain good estimates.

While the lifetimes of plastics at sea are not known with any degree of reliability, there is little doubt that the durations involved are quite long regardless of the definition of "degradation" adopted. With probable lifetime on the order of

hundreds of years, the service lives of most plastic products, particularly single-use items, constitute only a minute fraction of the total lifetime of the material.

B. Degradable Plastics

Currently available controlled lifetime plastics technologies accelerate the environmental weathering process of polymers by chemical means. These might broadly be classified into two groups: a) enhanced photodegradable polymers and; b) enhanced biodegradable polymers. In both cases, the plastic is chemically modified by pre-reaction or using an additive incorporated into the plastic to make it degradable. However, not all these technologies have developed to the point of commercial production.

1. Photodegradable compositions

a. Ethylene - copolymers

Several U.S. resin manufacturers produce ethylene-carbon monoxide copolymers which are photodegradable (Brubaker, 1950; Scott, 1972 and 1974; and Omichi, 1983). The presence of a ketone group in the chain of the polymer allows it to absorb ultraviolet light and consequently rapidly photodegrade.

Low density polyethylene copolymers prepared in this manner form the basis for the photodegradable six pack yoke which is currently commercially available.

b. Ecolyte (TM) process

Unlike in the above process, the ketone group might be incorporated as a branch on the polymer chain by using vinyl ketone as a comonomer (Guillet, 1973 and 1975; Redpath, 1987). The ecolyte process is based on this pathway and yields a product which photodegrades. Blends of the Ecolyte low-density polyethylene are claimed to successfully degrade. Even polymers such as poly(vinyl chloride) and polyesters become photodegradable by this technique.

The company markets a polyethylene masterbatch and, through Polysar, a polystyrene masterbatch (and a degradable polystyrene grade as well) (Redpath, 1987).

c. Princeton Polymer Laboratory additive

An additive consisting of a pro-oxidant (typically a salt of transition metals) and a photoactivator such as benzophenone might be used to render polyolefins and polystyrene enhanced photodegradable (Princeton Polymer Laboratories, 1985). The company holding the relevant patent offers technology and licensing in the U.S.

d. Metal salt additive

Salts of transition metals generally act as pro-oxidants enhancing the rate of photodegradation (Mellor et al, 1973; Osawa and Nakano, 1976). Some metal compounds, however, at certain concentrations may act as photostabilizers. Depending on the relative concentrations of each, a mixture of the two types of compounds is claimed to act as a controlled lifetime additive for polyolefins.

e. Ampacet technology

A proprietary additive system which renders polyethylene enhanced photodegradable is available through Ampacet company (Carlson and Mimeault, 1987). The additive is used currently in the manufacture of photodegradable garbage bags.

2. Biodegradable compositions

a. Inherently biodegradable polymers

Several thermoplastic resins are inherently biodegradable. These do not include any of the commodity resins widely used in packaging, but higher priced specialty polymers, such as lactic acid based polymers and Biopol (recently marketed by ICI) (Biopol).

These resins cost from a few dollars to a few hundred dollars per pound compared to the 30-40 cents per pound for the currently used packaging materials. Furthermore, the suitability of the newer resins as packaging materials has not been demonstrated.

b. Starch-plastic composites

Use of starch as an additive in plastics has been proposed to enhance degradability (Griffin, 1972, 1975, and 1977). The presence of starch granules within the matrix of a polymer tends to make the composite system deteriorate faster. However, it is only the starch that biodegrades in the environment. There is a little evidence that the presence of starch in the matrix promotes degradation of the matrix itself. Degradation of the starch weakens the polymer matrix leading to rapid embrittlement

and small particle size. Resulting polymer particles are likely to biodegrade faster due to increased surface area (Griffin, 1975).

Several masterbatches of starch-resin are available through the current patent holder, a Canadian company, and through a U.S. company which has acquired a modified, more recent patent from the original invention. The starch-plastic composite can be readily extruded as blown-film.

c. Starch bound plastic compositions

This technology, based on a recent patent held by the U.S. Department of Agriculture, is substantially different from the starch-plastic composites (Otey et al., 1985). This method requires pre-reaction of the gelatinized starch with the polymer to obtain a partially biodegradable material. The material mixed in the proper proportions with polyolefins can be extruded as films. Depending on the amount of starch incorporated, the material is expected to biodegrade and embrittle in a relatively short time.

3. Limits to Degradable Plastic Use

Both photodegradable and biodegradable compositions have several serious limitations. The degradability of these polymers under marine conditions has not been demonstrated. There is a clear need to establish if these technologies degrade successfully at sea and the speed of degradation. Those systems which employ a low molecular weight additive in the resin also raise concerns about both the introduction of additives into the ocean via leaching and the loss of product effectiveness due to additive loss via the same process.

A serious limitation is the inability to apply photodegradable technology to a relatively large class of debris -- those products which sink in sea water and are, therefore, not exposed to light. Even lower density floating debris may partially sink under the weight of biofoulants in coastal waters. Sea water is a good absorber of ultraviolet light; as plastic products sink, available light levels decline precipitously, thereby limiting photodegradability.

Controlling degradation rate is another critical issue. It is crucial to ensure that the performance of the product does not suffer due to it degrading. As yet, controlling degradation rates for key technologies has not been fully demonstrated. Availability of such data is critical in assessing the feasibility of using these techniques in target products.

The rate of degradation must be slow enough to maintain product integrity and meet use needs, but rapid enough once in the marine environment to have the desired effect of minimizing or eliminating the risk of ingestion or entanglement, and the aesthetic damage. These two goals may be directly competing. Photo or biodegradable plastics which enter the marine environment may degrade more quickly than regular plastics, but that rate may still allow the product to exist long enough to pose these risks. It is by no means certain that enhanced degradable plastics would do more than reduce the problem. It only takes one six-pack ring to cause harm - this can occur the first day in the marine environment, or the product could cause harm months later.

In spite of these and other limitations, controlled lifetime polymers represent a practical, promising technology which might be used to reduce problems caused by marine plastic debris, particularly litter problems. The basic lack of technical data in this area might be attributed to the general lack of public interest in these technologies until recently. The required data are not difficult to generate. With only a minimal research effort, the data needed to evaluate the suitability of the various technologies can be obtained.

B. Applicability of Degradable Plastic or Substitute Material for Specific Products

A variety of controlled lifetime plastics are currently available in the U.S. Several major plastic producers as well as a number of small companies are developing additional materials that are bio- or photodegradable. Table VI-3 summarizes plastic composition and degradable technology of six plastic items commonly found on beaches.

1. Six-pack yokes

The most widely-used (non-degradable) six-pack yokes are currently manufactured from low density polyethylene (LDPE) and account for about 1/2 to 3/4 of one percent of the total LDPE resin market in the U.S. Appropriately compounded material (based on a photodegradable resin available from U.S. manufacturers) is extruded and the yokes are die-cut from the extruded plastic. The leading manufacturer of the yokes also owns the rights to their unique design.

The nature of the product is such that alternative non-plastic materials cannot easily be substituted in its construction. The

Table VI-3. Summary of Options Available

PRODUCT	PLASTIC TYPE	USEFUL LIFE	ENVIRON. EFFECTS	SUBSTITUTES	DEGRADABLE TECHNOLOGY	FEASIBILITY	RESEARCH NEEDS
Six-pack yoke	PE	one-time	Litter Entanglement	cardboard shrink wrap	Photodegradable Biodegradable	available available	minimal low
Tampon applicators	PE	one-time	Litter Ingestion(?)	paper	Photodegradable Biodegradable	adaptable adaptable	minimal low
Styrofoam material	PS	one-time short	Litter Ingestion	paper cover floats	Photodegradable Biodegradable	adaptable feasible	minimal low-mod.
Balloons	Rubber PET	one-time	Litter Ingestion	none	Photodegradable Biodegradable	feasible feasible	low low
Trap panels	PE/PP/PA	moderate	Entanglement Ingestion	natural fiber material	Biodegradable	feasible	moderate
Drift nets	PA/PP	moderate long	Entanglement	natural fibers	Biodegradable	not avail.	moderate to high

KEY:

Plastic Type - PE = Polyethylene, PP = Polypropylene, PS = Polystyrene, PA = Polyamide, PET = Polyester

Useful Life - Short = used several times but discarded within a few days, e.g., plastic bags. Moderate = multi-use product replaced within a year. Long = a multiuse item used for several years.

Substitutes - Materials which might be used to fabricate a similar or comparable product without sacrificing any of the desirable performance characteristics.

Feasibility - Technological feasibility only. This does not include economic or consumer preference analysis.

manufacturers market a rapidly photodegradable version of the six-pack yoke (which carries a diamond shaped imprint on it for identification) for use in those states which require them. The rapidly photodegradable product is based on an ethylene carbon monoxide copolymer readily available in the U.S. from Union Carbide. The producer claims it becomes brittle after exposure of about 3 months outdoors. However, some variability is associated with this estimate which invariably depends on the available light and the ambient temperature.

There is no evidence at this stage indicating that degradable products differ substantially in toxicity from the regular six-pack material. A single study by the leading manufacturer of six-pack yokes seems to support that view (ITW, 1987). However, no comprehensive studies have been carried out on the toxicity of products from enhanced photodegradation. From a chemical point of view, the reaction products in the case of both the rapidly degradable and the regular product are expected to be identical. The major difference is that the rapidly degradable material generates products much faster in the environment compared to the regular six-pack yoke material. The micro-ecological impact of high local concentrations of these products has not as yet been addressed.

The effectiveness of rapidly degradable products under marine conditions has not been completely demonstrated. Preliminary experiments indicate the six-pack yoke material currently marketed by ITW HiCone, Inc. performs well under marine exposure, i.e., floating in sea water (Andrady, 1987). However, bio-fouling, particularly growth of algae on the surface of the material, was apparent from the experiments. To be successful, the photodegradation process has to occur faster than the rate of

surface algal growth and also before the sample accumulates sufficient foulant to sink. These variables depend on the season and climatic factors.

In spite of the lack of detailed information on all factors which control the rates of deterioration, degradable six-pack yokes now make up about one-third of the U.S. market. Change-over to the degradable product adds between 7 and 10 percent of cost to the finished product according to the manufacturer.

There is a need to understand more completely: a) effectiveness of the technology at sea under various climatic conditions; b) the nature and rates of release of degradation products into the environment; and c) the extension of the technolgy to plastic bottle carrier devices. Furthermore, some efforts must be made to determine if biodegradable plastic technologies are applicable to six-pack yokes. The photodegradable product can only perform where the plastic material is exposed to light, which excludes debris which is buried under soil and/or is under water.

2. Tampon applicators

Plastic tampon applicators are manufactured from polyethylene by a moulding process. The volume of plastic used for this application is not known. While the device can be made out of paper, using plastics in its fabrication has several advantages. Not only is the plastic material non-wettable, leachate-free and stiffer (for a given wall thickness) than paper, but is it biologically and chemically inert. Consumers associate the smooth plastic surface with clean aseptic conditions.

Tampon applicators on beaches can be reduced by one of three methods: a) by making the devices photo- or biodegradable; b) by making them negatively buoyant so that they sink in sewers or sea water; or c) by substituting paper instead of plastic. A rapidly biodegradable applicator ensures the reduction of the device to smaller particles and eventually to small molecules. Adapting one of the currently available rapidly photodegradable technologies (except for those using a leachable additive) for the case of the thicker walled tampon applicators is also fairly easy. However, as with the six-pack yoke materials, neither the life-time of the device under marine conditions nor the performance of the various enhanced degradable technologies under marine conditions has been fully established.

An easy technological approach would be to increase specific gravity by using an appropriate filler or resin blend. If the applicators reach the sea they will sink to the bottom. Except for the limited threat to benthic life in the latter unlikely event, both approaches will solve the problem of plastic debris.

Another answer to the problem is to make all tampon applicators of paper. At least one company has done this for a long time and continues to do so. This is an example of a substitute degradable material which is already in use.

3. Styrofoam Containers

Expanded polystyrene (styrofoam) is widely used as a packaging material because of its thermal insulation, strength, lightness and low cost. Some polystyrene items tend to be used either once, e.g., food/beverage packaging, or only a few times before being discarded. The material is also widely used in docks and marinas as floatation materials. The life-time of this material

in the marine environment is not known. However, if the styrofoam used in docks and marinas is covered with an outer shell of hardened plastic material, small pieces would not break off as the material aged.

Early studies indicate that the rate of degradation of the material is slower at sea than on land, under comparable exposure conditions. As in the case of six-pack yoke material, this might at least in part be attributed to the shielding of sunlight by surface biofoulant films.

A grade of rapidly photodegradable expandable polystyrene is currently being marketed by a speciality resin supplier in Canada. They claim this product degrades in several months (again depending on exposure conditions) on exposure to sunlight outdoors. The use of degradable material is expected to increase the cost of the product by about 10 percent. The degradability under marine exposure conditions has not been demonstrated. No biodegradable grade of polystyrene is presently commercially available.

Using a non-plastic alternative for most products in this category would involve a compromise on the performance characteristics. For instance, in floats, expanded polystyrene would be very hard to replace as no alternative material with the combination of low cost, low specific gravity and low strength is readily available. In some container applications, the plastic can be replaced by paper, but that would drastically reduce thermal insulation and strength, and increase its cost.

Comparatively less information is available on the enhanced degradation of polystyrene than on that of polyolefins. The nature of the oxidation products is also not completely

understood for the former reason. As in the case of other photodegradable materials, there is a need for research to determine the following: a) performance under marine conditions; b) variability introduced by climatic and other factors; c) toxicity of reaction products; and d) feasibility of rendering the material biodegradable.

4. Balloons

Most balloons released in promotional balloon launches are helium-filled rubber latex balloons. Higher priced mylar (metal over polyester) balloons are used to a lesser extent. Both are single-use products and have a relatively short useful life. While their lifetime in the environment is not known, there are indications which suggest that the ratio at which the balloons degrade is much slower in water than on land. Under east-coast conditions in summer, latex balloons were observed to become brittle in 3-5 months when exposed on land (Andrady, 1988).

No degradable balloons are currently available in the U.S. market. Yet the product is a good candidate for enhanced degradability because it is used only once and used under circumstances where prolonged exposure to sunlight and invariably to water are unlikely. Development of degradable rubber balloons should require only a minimal research effort. Currently there is no incentive for manufacturers to develop the enhanced degradable product which will be marginally more expensive than regular balloons.

A rapidly degradable balloon can be easily developed. Any such product needs to be tested for rate of degradation and toxic leachates under marine exposure conditions. The feasibility of using rapidly biodegradable elastomers for balloons is also

worthwhile as the degradation of such a balloon would occur independent of exposure to sunlight.

5. Panels on fishing traps

Fishing traps and pots are major capital investments for fishermen. They purchase pots and traps to last several seasons. Pots typically have panels which enable fishermen to remove their catch. Some panels are degradable. As the definition of "degradability" with reference to these panels is not clear, a variety of natural fiber-based materials might be used in them. As the degradation is expected to occur under water, a suitable plastic material would have to be enhanced biodegradable. Except for higher-priced speciality polymers, there is no plastic material readily available for this purpose. Some technologies such as the starch-polymer systems might be adapted for trap panels with a moderate research effort.

Non-plastic alternatives such as wood and cotton twine, which are cost effective, currently exist for this product and a substitute is currently feasible. It is also important to assess the impact of substitutes on the "catchability" of traps for target species.

6. Drift nets

Drift nets are usually made from polyamide (nylon) and polypropylene. They are extensively used as surface, mid-water and bottom gill nets. Polyamide nets are negatively buoyant and, therefore, sink when being discarded. Lost active gear attached to float lines will, however, remain in surface or mid waters for long periods (months to years). The useful lifetime of drift nets is difficult to determine as it depends on both target species as well as regional fishing practices. In general, salmon gillnets used in west coast fisheries are expected to last

1-3 years with minor repairs. The multi-monofilament shark and swordfish surface drift nets in the California fishery, on the other hand, are used up to 7 years with repair. Like other plastics, nylon persists in the ocean for many years.

Plastic represents an excellent material for the fabrication of fishing gear. Its success is due to several key properties including exceptional strength, light weight, low cost and excellent durability. There are no natural substitutes with equivalent properties for this product at the present time.

In discussing the applicability of enhanced degradable plastics technology to fishing gear, a key consideration should be the effect of the technology on the effectiveness of the gear. The most important issue is perhaps the likelihood of premature failure of the gear while being used. If a suitable technology was available, the controlled lifetime of the gear might be fixed at a lifetime well outside the known service lifetimes of the product. Even if this is done, the complex patterns of gear usage (as well as storage, in the case of seasonal fisheries) needs to be studied to determine the impact of using rapidly degradable technologies on net "catchability."

None of the available biodegradable plastic technologies have been demonstrated to work in sea water or have controlled rates of degradation to be used for drift nets. These technologies have been hitherto used mostly in products which are designed for a one-time use.

Chapter VII
Task Force Recommendations

In this chapter, the Task Force summarizes significant events which have taken place regarding marine debris in the past year and makes recommendations to address problems through research, coordination activities, and public education. The Task Force groups its recommendations into five categories, each of which contains more specific recommendations.

When the Domestic Policy Council established the Interagency Task Force on Persistent Marine Debris in June 1987, legislation was pending to address the problem. Several agencies had been operating programs regarding persistent marine debris with little coordination. Since then, three important things have happened:

-- President Reagan signed the Marine Plastics Pollution Research and Control Act (MPPRCA).

-- The U.S. ratified Annex V of MARPOL 73/78 which will bring the convention into force worldwide on December 31, 1988.

-- During Coastweek 1987, in October, over 26,000 volunteers in 20 coastal states removed over 700 tons of debris from almost 2000 miles of US beaches.

The Administration enthusiastically supported legislation to implement Annex V of MARPOL 73/78. Within two days of Congress passing the legislation, President Reagan signed it. In accordance with MPPRCA agencies are undertaking several new activities:

-- The U.S. Coast Guard is preparing regulations to implement the provisions of the MPPRCA which include a prohibition against disposal of plastic materials from ships into the marine environment. Final regulations will become effective by December 31, 1988.

-- The NOAA, EPA, Coast Guard, and Department of the Interior are collectively developing campaigns to increase public awareness of marine debris issues, including Citizen's Pollution Patrols. NOAA and the DOI are augmenting existing programs.

-- The NOAA is preparing a report on the extent of impacts to wildlife and local communitites caused by persistent marine debris.

-- The EPA and NOAA are conducting studies on ways to reduce plastic in the marine environment.

-- The EPA is preparing studies and plans to address problems in the New York Bight, including assessing ways to reduce plastic pollution there.

These activities, when combined with ongoing agency efforts as well as those recommended by the Task Force, will effectively address problems caused by persistent marine debris. Problems created by persistent marine debris are not yet critical for most species of wildlife. By implementing these recommendations now, we should be able to avoid the problems becoming crises later.

Recommendations

The Task Force proposes 23 recommendations grouped into five general categories:

- Federal leadership;
- Public awareness/education program;
- Implementing laws related to marine debris;
- Research and monitoring; and
- Beach clean-up and monitoring

In the following discussion, we present the five general recommendation categories and the 23 specific recommendations within them. Each of the 5 discussions of general categories contains a section on 1) current activities, 2) recommended actions, and 3) benefits of taking the recommended actions.

Recommendation 1: Federal Leadership:

Federal agencies should provide leadership and continue formal and informal coordination activities related to marine debris with international organizations, state and local governments, private industry and environmental groups. Federal agencies acknowledge that an effective program is only possible with strong state and local involvement.

Recommendation 1A: Federal agencies should cease disposal of plastic materials into the ocean from all Federal vessels as soon as possible.

Recommendation 1B: Federal agencies should review their procurement and concession policies in coastal facilities to reduce the amount of plastic packaging, containers, and other products that are improperly disposed of and become persistent marine debris.

Recommendation 1C: Federal agencies should continue to participate actively in international forums to reduce persistent marine debris.

Recommendation 1D: Federal agencies should encourage plastic waste recycling by: 1) providing separate receptacles for different types of trash at coastal facilities; 2) purchasing and using recyclable products and materials whenever possible; and 3) providing technical support to state and local agencies and industry on recycling.

Recommendation 1E: NOAA should coordinate and disseminate information related to persistent marine debris. NOAA should call at least two meetings of appropriate Federal agencies each year to discuss each agency's education, regulatory, and research programs, as well as to ensure that a contined coordinated effort is made to maximize the effect of existing Federal programs.

Recommendation 1F: NOAA should continue to sponsor the informal Marine Debris Roundtable.

Recommendation 1G: The Administration should support the NOAA/Marine Entanglement Research Program by including it in the Administration's FY 1990 budget and for at least five years thereafter.

Recommendation 1H: Persistent marine debris should be included as an element in the 5-Year Federal Plan for Ocean Pollution Research, Development, and Monitoring.

Recommendation 2: Public Awareness/Education Program:

Concerned Federal agencies should work with each other, state and local governments, private industry, and environmental groups to develop comprehensive educational materials on problems caused by marine debris and ways to solve them.

Recommendation 2A: Federal agencies should cooperatively support a major public awareness campaign by providing seed money and encouraging funding by the private sector.

Recommendation 2B: The U.S. Coast Guard, U.S. Navy, and other Federal agencies should include materials relative to persistent marine debris problems in all educational materials for employees and candidates for licenses.

Recommendation 2C: Federal agencies should use all appropriate media to explain both problems marine debris causes and proper disposal methods. Federal agencies should support formation of an interagency information exchange for available educational materials.

Recommendation 2D: The U.S. Coast Guard should begin a public education campaign on the requirements of the Marine Plastic Pollution Research and Control Act as soon as possible to assure that owners and operators of all vessels, ports, and the boating public are aware of requirements prior to their entering into force.

Recommendation 3: Vigorously Implement All Laws Related to Marine Debris:

The Department of Transportation, EPA, NOAA, and Navy should vigorously implement the Marine Plastic Pollution Research and Control Act and other laws to reduce plastic pollution in the marine environment.

Recommendation 3A: Each agency should make compliance with requirements of the Marine Plastic Pollution Research and Control Act a high priority.

Recommendation 3B: The Coast Guard and other Federal enforcement agencies should make enforcement of regulatory requirements of the Marine Plastic Pollution Research and Control Act a high priority.

Recommendation 3C: NOAA should encourage regional fishery management councils to include requirements that fish and shellfish traps and pots have degradable panels or latches.

Recommendation 4: Research and Monitoring:

Federal agencies should carry out research to:

a) identify and quantify deleterious effects that marine debris causes for fish and wildlife, coastal communities, and vessels;

b) determine land-based sources of marine debris; and

c) assess potential uses for, by-products of, and effect of by-products of degradable plastic products.

Recommendation 4A: NOAA, the Fish and Wildlife Service, the Marine Mammal Commission and other agencies should expand

research and monitoring activities to determine more precisely impacts of persistent marine debris on fish and wildlife populations, particularly endangered, threatened, and depleted species.

Recommendation 4B: Federal agencies should work with state and local governments, universities, merchant vessel owners and operators, commercial and recreational fishermen, and local communities to quantify economic impacts caused by persistent marine debris.

Recommendation 4C: EPA, NOAA, Coast Guard, and other agencies should carry out research to determine contributions of land-based and vessel sources of plastic refuse to the overall problems, as well as ways to reduce plastic debris from all sources.

Recommendation 4D: NOAA should work with fishermen and equipment manufacturers to develop pragmatic ways to:

1) reduce loss of fishing equipment, particularly traps, trawl nets, and gill nets;
2) improve ways to recover lost fishing traps and nets; and
3) recycle used fishing nets and net fragments.

Recommendation 4E: The National Bureau of Standards should work with the ASTM (formerly known as American Society for Testing Materials) and other industry associations to develop standards and criteria for what constitutes "bio-degradable" and "photo-degradable".

Recommendation 4F: EPA, FDA and NOAA should work with plastic manufacturers to examine how degradable plastics react in the environment, including potential environmental effects as the plastic degrades.

Recommendation 5: Beach Clean-up and Monitoring:

Federal agencies should work cooperatively among themselves, as well as with state agencies, private industry, and environmental groups to remove marine debris from beaches and other parts of the marine environment. Federal agencies should encourage coordination with state and local authorities to conduct systematic monitoring of marine debris accumulation and impacts to assess compliance with regulations prohibiting disposal of plastics and controlling other solid waste discharges into U.S. waters.

Recommendation 5A: Federal agencies which manage coastal properties should step up actions to remove persistent marine debris.

Recommendation 5B: Federal agencies should support local volunteer beach clean-up efforts as well as the collection and interpretation of data on what the volunteers remove. Federal managers should encourage employees to participate in volunteer clean-ups.

Many Federal agencies are currently involved to varying degrees in each of the above recommendations. The following discussion summarizes current programs and expenditures in each activity and describes additional programs necessary to address Task Force recommendations.

Recommendation 1: Federal Leadership:

Federal agencies should provide national and international leadership for activities related to marine debris with international organizations, state and local governments, private industry and environmental groups.

Current Activities

Federal agencies are providing leadership to address persistent marine debris by:

-- leading efforts internationally to prohibit disposal of plastics in the ocean and reduce other types of marine pollution (State, Coast Guard, NOAA);
-- complying with requirements Annex V of MARPOL 73/78 prior to them taking effect (Coast Guard, NOAA, EPA);
-- conducting research on marine and coastal wildlife, and monitoring accumulation of debris (NOAA, FWS, MMC);
-- promulgating regulations to prohibit disposal of plastic into marine environments (Coast Guard, EPA);
-- removing debris from Federal lands with volunteers and employees (DOI, DOA);
-- coordinating and participating in volunteer beach clean-ups (DOI, NOAA), and
-- increasing public awareness of ways to reduce debris (NOAA, MMC).

Government officials in several departments are involved in this issue. The U.S. participates in numerous international fora on marine pollution, such as Marine Environment Protection Committee (MEPC) of the International Maritime Organization, U.N. Environment Program Regional Seas activities, and the Convention for the Conservation of Antarctic Marine Living Resources. U.S.

officials have taken active roles at MEPC by preparing technical reports and guidelines on implementation requirements of Annex V.

Much of the work on persistent marine debris is done by local operating units. Because most Federal agencies are decentralized, the government in toto has not previously looked at many routine operations, e.g., solid waste collection, as related to persistent marine debris. Because of the limited resources available, it is important that agencies not duplicate existing programs of other agencies.

The NOAA/MERP established and sponsors the Marine Debris Roundtable, an informal gathering of government, industry, and environmental organizations to discuss issues related to persistent marine debris. The Roundtable has met three times since its inception in 1986.

Environmental organizations, like the Entanglement Network and CEE, and industry trade associations, like the Society of the Plastics Industry, Inc., Gulf of Mexico Offshore Operators Committee, and Pacific fishing industry associations, have initiated numerous public education and beach clean-up activities. These organizations and others throughout the country are leaders in addressing the problem. Task Force members commend the efforts of all of these groups and individuals. It would be almost impossible for a Federally-run program to have had as good a response to the issue.

Additional Activities the Task Force Recommends

Recommendation 1A: Federal agencies should cease disposal of plastic materials into the ocean from all Federal vessels as soon as possible.

The best way to demonstrate Federal leadership is by setting an example. The U.S. Coast Guard and NOAA currently require their ships to return plastic refuse to shore for disposal. Most of their ships are at sea for relatively short periods. U.S. Navy ships remain at sea for several months, complicating these new requirements for disposal. The Navy is developing technology to improve storage of plastic debris aboard ship and is committed to handling wastes in a way that they no longer dispose of plastics in oceans.

> **Recommendation 1B:** Federal agencies should review their procurement and concession policies in coastal facilities to reduce the amount of plastic packaging containers, and other materials that are improperly disposed of and become persistent marine debris.

The Departments of the Interior, Agriculture, and Defense operate national parks and refuges, national forests, and military installations, respectively, along U.S. coasts. During their routine operations, they regularly use a wide range of plastic materials, some of which might become litter. Agencies should encourage proper disposal and solid waste management practices. If it can be shown that these materials become persistent marine debris, the Federal agencies should reduce the amount of plastic packaging, containers, and products.

Agencies provide different levels of service for users, both visitors and employees. For example, at recreation areas, concessionaires sell soft drinks, snacks, and picnicing/camping supplies. Federal agencies which manage such areas should encourage returnable or degradable packaging for specific products which become persistent marine debris in local areas.

Recomendation 1C: Federal agencies should continue to participate actively in international efforts to reduce persistent marine debris.

In November 1984, the U.S. sponsored the first international conference on plastic in the marine environment. This conference marked a turning point in understanding the problem, greatly increased awareness, and focused research efforts. It also underscored the fact that persistent marine debris is truly a worldwide problem. We need to share ideas on the problems it causes, how to study those problems, and how to do something about them. NOAA and the MMC are currently planning a second international conference on marine debris in April 1989 to address this issue further.

Since 1984, scientists and administrators have been attacking the problem in many other international fora. For instance, in 1975 the International Maritime Organization, Marine Environmental Protection Committee proposed Annex V to the International Convention to Prohibit Pollution from Ships (MARPOL). Fifteen nations, which represent over 50 percent of the world's shipping tonnage, have now agreed to abide by it. The U.S. has taken an active role in development and passage of Annex V of MARPOL 73/78. U.S. representatives to meetings of other international conventions, e.g., Convention on on the Conservation of Antarctic Marine Living Resources and working groups on UNEP regional seas conventions, have also worked to ensure that these conventions address persistent marine debris. In all of these, the goal of the U.S. is to increase awareness internationally so that others will become more involved.

Recommendation 1D: Federal agencies should encourage use of recycling plastic wastes by: 1) providing separate receptacles for different types of trash at coastal facilities; 2) purchasing and using recyclable products and materials whenever possible; and 3) providing technical support to state and local agencies and industry on recycling.

Two ways Federal agencies can encourage recycling are 1) to provide separate receptacles for different products to be recycled, i.e., paper, plastics, glass, metals, and wood, and 2) to purchase products that are recyclable. The demonstration project at the Port of Newport, Oregon proved that, once established, recycling can reduce costs of solid waste management at ports. Ports and other major facilities should examine opportunites to encourage employees and visitors to recycle solid wastes. Agencies should attempt to purchase products which are recyclable and to provide the necessary infrastructure to assure that they are recycled.

EPA is currently assessing the role of recycling in solid waste management and ways to encourage recycling as part of two studies -- the Municipal Solid Waste Management Task Force (ready in early 1989) and requirements of MPPRCA (ready in June 1989). EPA will evaluate various incentive systems for developing recycling markets as well as labeling strategies to identify recyclable plastic products.

Before recycling can effectively reduce plastics in the solid waste stream and marine environment, an appropriate infrastructure to purchase used material and convert it to sellable products needs to exist. EPA should encourage development of a recycling infrastructure by providing private

industry, and state and local government with technical information and assistance.

> **Recommendation 1E:** NOAA should coordinate and disseminate information related to persistent marine debris. NOAA should call at least two meetings of appropriate Federal agencies each year to discuss each agency's education, regulatory, and research programs.

Task Force members recognize problems associated with coordinating Federal activities which are locally oriented. Nevertheless, they also see the need to continue the dialogue among agencies which participated on this interagency task force. Rather than establishing a formal coordinating task force, most members felt that NOAA should take responsibility for calling meetings where Federal agencies could share information, ideas, resources and leadership. This would be in addition to continuing to host the Marine Debris Roundtable.

> **Recommendation 1F:** NOAA should continue to sponsor the informal Marine Debris Roundtable.

Because public involvement is so critical to the success of efforts to curtail persistent marine debris problems, Federal agencies need to cooperate with environmental groups, representatives of trade associations, and international organizations to address marine debris.

> **Recommendation 1G:** The Administration should support the NOAA/Marine Entanglement Research Program by including it in the Administration's FY 1990 budget and thereafter.

NOAA/MERP funds ($750 K) are the sole line item specifically addressing marine debris in Federal appropriations. Since fiscal year 1985, it has been funded by Congress, but not included in the Administration's budget submission to Congress. The Task Force believes that NOAA/MERP is an effective catalyst for increasing public awareness/education and research programs on persistent marine debris. At least five additional years of research, monitoring, education, and mitigation will be needed to resolve certain basic research needs and to implement actions for mitigating current problems and preventing future ones.

> **Recommendation 1H:** Persistent marine debris should be included as an element in the 5-Year Federal Plan for Ocean Pollution Research, Development, and Monitoring.

The National Ocean Pollution Planning Act (NOPPA, PL 95-273 as amended) requires that a Board be established, chaired by NOAA, to coordinate marine pollution research, development, and monitoring activities funded by the Federal government. The major responsibilities of the Board are to ensure coordinated interagency planning and review of marine pollution programs and to review requests for appropriations to determine their consistency with priorities of the 5-year Federal plan for Ocean Pollution Research, Development and Monitoring. The law directs the National Ocean Pollution Planning Office to update the Federal Plan every three years. The most recent plan was completed in 1985. The next plan is expected in September 1988.

Recognizing marine debris as a distinct category of marine pollutant in the Federal plan will establish a formal mechanism to address interagency planning and coordination, and assure that persistent marine debris problems are considered with other types of marine pollution. This should aid in the future elimination

of unintentional duplication of effort and allow maximum use of available resources and funds.

Benefits of Federal Leadership

Federal agencies should be setting an example with regard to addressing persistent marine debris for private industry and citizens, as well as state and local governments. The best way to set an example is to: 1) handle waste materials properly; 2) participate in beach clean-ups; and 3) discuss the problems and ways to combat them at every opportunity--at home and abroad.

Private industry must actively develop new degradable plastics and ways to improve handling of solid wastes. But, they need to be certain of agencies' requirements. Revising Federal procurement practices to require degradable plastic packaging would demonstrate an agency's serious intentions to reduce debris.

Another way to demonstrate the Administration's effective leadership would be to support programs which address marine debris, such as NOAA/MERP, Coast Guard marine enforcement, and public land beach clean-ups. All of these activities are necessary to demonstrate commitment to learning about and resolving problems associated with persistent marine debris.

Recommendation 2: Public Awareness/Education Program: Concerned Federal agencies should work with each other, state and local governments, private industry, and environmental groups to develop comprehensive educational materials on problems caused by marine debris and ways to solve them.

Current Programs

The Departments of Commerce (National Oceanic and Atmospheric Administration), and the Interior (Take Pride in America Task Force) are currently operating public education campaigns to address persistent marine debris (Table VII-1). The Department of Commerce program focuses solely on marine debris while programs at Interior and Transportation primarily address the abuse of public lands, natural and cultural resources, and marine pollution, respectively.

NOAA-affiliated universities and MERP provide national leadership to states and private sector using available resources in education and communication. These programs generally focus on specific groups. For instance, the NOAA public awareness/education program developed and delivered video presentations explaining what fishermen in the Gulf of Mexico, Pacific and Atlantic could do to reduce the amount of trash, including plastics, that they now throw overboard. NOAA also developed information kits for elementary public school teachers and a general interest video tape explaining the problem. In conjunction with the Center for Environmental Education and the Society of the Plastics Industry, NOAA developed a series of printed public service announcements which trade and recreational fishing journals have published. They have also produced radio and television materials to increase public awareness of causes and solutions to the problem.

The Department of the Interior's Take Pride in America program emphasizes stewardship of public lands and resources. It features celebrities in public service announcements for print and television as well as providing general information

Table VII-1. Expenditures for Public Awareness/Education Programs Related to Persistent Marine Debris

	FY 87 (thousands of dollars)
NOAA/MERP	$152k
NOAA/OAR	$150K
DOI/Take Pride	
Total expenditure	$80-150
Proportion for marine debris	NA
DOT/Coast Guard	NA
EPA	NA

packages. Many local groups are operating under the Take Pride banner. A component of Take Pride should include marine debris. Steps are being taken to accomplish this. For example, the Marine Litter Campaign in Alaska is using Take Pride banner to increase access to media. The Minerals Management Service (DOI/MMS) formed a Gulf of Mexico Take Pride Task Force (Take Pride Gulf Wide) to address marine debris problems there. DOI/MMS employees in New Orleans "adopted" beaches during the national Coast Week beach clean-ups and the Louisiana "Sweep of the Beach". Texas General Land Office also has a very successful adopt-a-beach program. Such efforts should become an integral part of the proposed public awareness campaign to ensure the message about the marine debris problem reaches marine user groups with whom solutions ultimately rest.

Additional Activities the Task Force Recommends

> **Recommendation 2A:** Federal agencies should cooperatively support a major public awareness campaign by providing seed money and seeking funds from the private sector.

Federal agencies should examine their public awareness/education programs to determine appropriate and efficient ways to address marine debris problems. NOAA, U.S. Coast Guard, EPA and DOI are currently developing a series of independent, but related, programs and public service announcements to explain marine debris problems and new regulations which will be in place by 1989. NOAA has proposed a major 3-year public awareness campaign which would cost between $250,000 and $500,000. The Center for Environmental Education and the Society of the Plastics Industry, Inc., as well as the Department of the Interior, EPA, and the Coast Guard are jointly working to develop this campaign. NOAA and other agencies should seek funds from

other interested groups such as fishermen's associations, plastic manufacturers, and merchant shippers to support this program.

> **Recommendation 2B:** The U.S. Coast Guard, U.S. Navy, and other Federal agencies should include materials relative to persistent marine debris problems in all educational materials for employees and candidates for licenses.

Professional mariners, U.S. Navy personnel, Coast Guard personnel and employees at Federal facilities all receive training which could include ways to reduce plastic use and proper disposal techniques. Merchant vessel officers and crews are required to take examinations to obtain competency licenses and certificates. The examinations should include information and questions on regulations and proper handling of plastic materials. Information on the problem and needed solutions also should be provided with fishing licenses, and permits issued to fishermen by NMFS.

> **Recommendation 2C:** Federal agencies should use all appropriate media to explain the message on problems that marine debris causes and proper disposal methods for disposal of solid wastes. Federal agencies should support formation of an interagency information exchange on existing educational materials.

The telecommunications revolution in the U.S. has spawned a vast array of technology to inform citizens about problems and, equally important, ways to resolve them. Almost all schools, fishing boats, and merchant vessels now have video cassette recorders. NOAA/MERP, in conjunction with fishing industry association, the Center for Environmental Education and the Society of the Plastics Industry, Inc., has supported the

production of several video tapes for commercial fishermen, merchant fleets, and plastic manufacturers and processors. The Offshore [oil and gas] Operators Committee in the Gulf of Mexico has assisted in the production of a video tape on marine debris for employees of offshore oil rigs.

Task Force members recognize that producing videotapes and other educational material can be expensive. Copying and distributing materials can be less costly.

> **Recommendation 2D:** The U.S. Coast Guard should begin a public education campaign on the requirements of the Marine Plastic Pollution Research and Control Act as soon as possible to assure that owners and operators of all vessels, ports, and the boating public are aware of requirements prior to their entering into force.

New regulations implementing the MPPRCA will, for the first time, prohibit mariners from disposing of plastic materials into U.S. waters. Some vessels will be required to have placards explaining the regulations. Some will also have to develop waste management plans.

The U.S. Coast Guard public awareness/education program will emphasize vessel safety for recreational boaters as well as navigation, vessel maintenance, and operation for merchant seamen and Coast Guard personnel. Locally organized volunteers in the Coast Guard Auxiliary distribute a variety of information to recreational boaters through classes, pamphlets, and announcements posted at marinas and boat launches. The Coast Guard should include information on reducing marine debris by proper disposal in this material.

Benefits of Public Awareness/Education Program

Task Force members unanimously agree that the most important undertaking should be a public education campaign. Increasing awareness of a problem is the best way to minimize corrective costs such as clean-up. It should greatly enhance implementation of MARPOL Annex V. Until the public is fully aware of problems that improper disposal causes, there will be little incentive to change the way they have traditionally disposed of plastic. However, measuring benefits of a nationwide effort can be difficult, and will require a long-term monitoring program.

Reports of Federal land managers who have actively promoted the Take Pride in America program indicate that costs to maintain clean facilities were reduced as much as fifty percent. Cities participating with Keep America Beautiful, a private nonprofit organization which organizes local public education campaigns against litter, have reduced litter by as much as 80 percent (Wilson, pers. comm. 1988). Reducing litter along roads and in public places lowers costs associated with picking it up. Therefore, using these other programs as an example, one can assume that there will be substantial economic benefits. Additionally, there are the benefits of aesthetically pleasing beaches, fewer marine animals harmed, and fewer vessels needing to spend time and money on repairs related to persistent marine debris.

Recommendation 3: Vigorously Implement All Laws Related to Marine Debris:

The Department of Transportation, EPA, NOAA, and Navy should vigorously implement the Plastic Pollution Research and Control Act and other laws to reduce plastic pollution in the marine environment.

Current Programs

Title II of the Marine Plastic Pollution Research and Control Act of 1987, directs, among other things:

-- the Secretary of Transportation to issue regulations implementing Annex V of MARPOL 73/78;

-- the Administrator of EPA, in consultation with the Secretary of Commerce, to study adverse effects of improper disposal of plastic items in the marine environment and the solid waste stream;

-- the Secretary of Commerce to report to Congress on the effects of plastic materials on the marine environment;

-- the NOAA Under Secretary, EPA Administrator, in consultation with the Secretary of Transportation, to begin a public education program, including a Citizens' Pollution Patrol, regarding harmful effects of plastic marine pollution; and

-- the EPA Administrator, in consultation with the NOAA Under Secretary, and other Federal and state agencies, to develop a restoration plan for the New York Bight, which

includes a report on persistent marine debris in the Bight area.

The U.S. Coast Guard has developed a schedule to promulgate final regulations implementing the MPPRCA by December 31, 1988. It expects to issue the Advanced Notice of Proposed Rulemaking (ANPR) in June 1988. It expects to publish proposed regulations in July 1988, and final regulations in November 1988.

President Reagan signed MPPRCA in December 1987. Congress authorized additional monies for only the New York Bight restoration plan and studies. Congress established deadlines for each of the studies and reports. EPA, NOAA, and Coast Guard officials are currently working on all of required studies. However, Congress has not yet appropriated any funds to carry out the MPPRCA. Agencies are carrying out the law's requirements with existing resources (Table VI-2).

MPPRCA requires the Navy to comply with MARPOL Annex V within five years. The Navy initiated a broad program to eliminate the discharge of plastic from ships at sea and the discharge of any floatable waste in the special ocean areas such as the Baltic and Mediterranean Seas. The program encompasses three major efforts:

1) changes in operational procedures that can be accomplished immediately to reduce the amount of plastic discarded overboard;

Table VII-2. Expenditures for Implementing MPPRCA and Other Laws Related to Marine Debris

	FY 87 (thousands of dollars)
US Coast Guard	
Promulgate regulations	$250
DOC/NOAA	
Report: effects, marine plastics	$50
NOAA public education	$30
EPA	
Report on improper disposal of plastics in the environment	$500 (FY88)

2) feasibility analyses to find substitutes for plastics used aboard ship and the requirement to substitute other materials where feasible; and
3) development, procurement, and installation of hardware aboard ship (such as compactors, pulpers, and plastics processors) to manage and dispose of wastes properly.

While all three efforts are in progress, items 2 and 3 will take longer to complete. Completion dates and costs of all three efforts are difficult to predict at this time. However, Navy compliance with this law will cost over one (1) million dollars per ship.

Additional Activities the Task Force Recommends

Recommendation 3A: Each agency should make compliance with requirements of the Marine Plastic Pollution Research and Control Act a high priority.

Task Force members suggested several specific topics the Coast Guard should consider in Annex V regulations:

-- Requiring fishermen to report lost nets, traps, and buoys which are made of plastic or other synthetic materials;

-- Addressing solid waste disposal problems in ports, particularly in remote areas; and

-- Referring to other relevant regulations, such as Department of Agriculture rules governing food wastes on vessels which have been in foreign ports.

Recommendation 3B: The Coast Guard and other Federal enforcement agencies should make enforcement of regulatory requirements of the Marine Plastic Pollution Research and Control Act a high priority.

The Coast Guard has requested for FY89, 23 additional billets and $500K for enforcement of Annexes I, II, and V of MARPOL 73/78. The Coast Guard will use approximately $100K for enforcement of Annex V.

Recommendation 3C: NOAA should encourage regional fishery management councils to include requirements that fish and shellfish traps and pots have degradable panels or latches.

Each year, U.S. lobster, crab, and finfish fishermen lose thousands of traps and pots. Manufacturers are increasingly shifting from wood and cotton webbing traps to plastic or plastic coated traps. Lost traps and pots, called "ghost traps", can continue to capture marine resources for several years. The Magnuson Fisheries Conservation and Management Act authorizes NOAA, through the fishery management councils, to require appropriate measures to conserve living marine resources. Degradable panels or latches would reduce the amount of commercially valuable fishery products which these "ghost traps" capture but are never harvested. The fishery management councils should add requirements to fishery management plans for degradable panels and/or latches that will release captured animals after several months.

Benefits of Implementing MPPRCA and other Relevant Laws

U.S. Coast Guard regulations implementing MPPRCA will prohibit disposal of plastic materials from all vessels platforms into

navigable waters or the U.S. exclusive economic zone and require that adequate reception facilities be available in all U.S. ports and marinas. This will greatly reduce the amount of vessel generated plastic refuse entering the oceans. The reports that EPA, NOAA, and the Coast Guard are preparing will further identify problems caused by persistent marine debris and solutions to those problems including a report on compliance with Annex V. This will reduce the probability of beach closings due to occurrence of trash on beaches.

Recommendation 4: Research and Monitoring:

Federal agencies should carry out research to:

a) **identify and quantify deleterious effects that marine debris causes for fish and wildlife, coastal communities, and vessels;**
b) **determine land-based sources of marine debris; and**
c) **assess potential uses for, by-products of, and effects of by-products of degradable plastic products.**

Current Activities

Since its inception in FY 1986, the NOAA/MERP has devoted approximately 50 percent of its total appropriation ($750K annually) to research on impacts of marine debris, quantification of marine debris, and reviews of potential technology for photo- and bio-degradable substitutes. It funded scientists within NOAA as well as other Federal agencies, state agencies, academia, and contractors.

The DOI/Fish and Wildlife Service, Marine Mammal Commission, and other programs within NOAA also support research on the extent of fish and wildlife interactions with marine debris. U.S. Fish and

Wildlife Service employees routinely note when they find animals at National Wildlife Refuges which are entangled with plastic materials. In their maintenance and monitoring activities, scientists have noted the presence of ingested plastics or signs of entanglement. Many private researchers and volunteers also provide reports of marine wildlife interactions with plastics.

Information on economic effects caused by plastic debris on coastal communities or vessels is lacking. The Task Force identified several reports on these problems, but could not locate systematic evaluations or studies on the extent of impacts regionally or nationwide.

Further research is necessary to help direct mitigation efforts towards those areas where problems are greatest and to assess the effectiveness of those mitigation actions that are undertaken.

Scientists and beach clean-up volunteers have studied litter on beaches and tried to determine its origin. Origins of fishing nets and a few other items are readily apparent. However, many items littering beaches are commonly used by many people. Therefore, their specific origins are difficult to determine by indirect sampling. Regulations being prepared under the MPPRCA will control only vessel and platform sources of persistent marine debris. We need to improve our knowledge of land based sources of persistent debris found in coastal environments.

Table VII-3. Expenditures for Research

	FY 87 (thousands of dollars)
NOAA	
MERP	$266
other NMFS	$154
OAR	$ 15
DOI/Fish and Wildlife Service	
directed research only	$78
Marine Mammal Commission	$5
US Navy (shipboard treatment of wastes)	$500
EPA	
land-based sources	*

*Included in Table VI-2 as cost of implementing MPPRCA

Additional Activities the Task Force Recommends

Recommendation 4A: NOAA, the Fish and Wildlife Service, Marine Mammal Commission and other agencies should expand research and monitoring activities to determine more precisely impacts of persistent marine debris on fish and wildlife populations, particularly endangered, threatened, and depleted species.

Existing information from research on effects of plastic debris is inconclusive as to effects of persistent marine debris on most wildlife species although it suggests that significant effects may be possible for at least some species. Marine debris has been determined to have caused deaths of a number of endangered, threatened, and depleted species. However, the effects of marine debris on most wildlife populations are virtually unknown.

Recommendation 4B: Federal agencies should work with state and local governments, universities, merchant vessel owners and operators, commercial and recreational fishermen, and local communities to quantify economic impacts caused by persistent marine debris.

Persistent marine debris causes direct and indirect economic losses for vessel operators and local beach communities. Debris can entangle propellers, block intake ports, and interfere with operations causing vessels to be out of service for varying periods. Local beach communities spend millions of dollars each year removing litter to maintain attractive beaches. Heavily littered beaches detract from recreational users' perceptions of their visits and the value of their experience. Businesses in some communities claim to have lost revenues as a result of littered beaches. The extent of these economic losses caused by

persistent marine debris are not known, but should be documented and monitored to assess the effectiveness and, as necessary, to provide the basis for redirecting mitigation efforts.

> **Recommendation 4C:** EPA, NOAA, Coast Guard, and other agencies should carry out research to determine contributions of land-based and vessel sources of plastic refuse to the overall problems, as well as ways to reduce plastic debris from all sources.

Coast Guard regulations implementing the MPPRCA should provide a critical first step towards elimination of vessel and platform generated plastic refuse in the marine environment. The regulations have no effect on debris generated by land-based sources, about which we have minimal quantitative data.

> **Recommendation 4D:** NOAA should work with fishermen and equipment manufacturers to develop pragmatic ways to:
> 1) reduce loss of fishing equipment, particularly traps, trawl nets, and gill nets;
> 2) improve ways to recover lost fishing traps and nets; and
> 3) recycle used fishing nets and net fragments.

Fishermen lose nets and traps when marker lines break and nets snag on the bottom. Lost traps and trawl and gill nets entangle a variety of marine wildlife, including marine mammals, sea birds, sea turtles, fish, and shellfish. MPPRCA and MARPOL Annex V will prohibit fishermen from intentionally discarding synthetic nets into the ocean. However, these regulations do not penalize fishermen for losing nets and traps accidentally.

The Driftnet Monitoring, Assessment, and Control Act of 1987 (Title IV of Public Law 100-220) addresses problems associated

with actively fishing as well as lost gill nets in the North Pacific Ocean. Specifically it requires NOAA to:

1) improve monitoring programs to quantify levels of gill net fishing by foreign nationals;
2) enter into agreements for effective enforcement of international treaties and domestic regulations;
3) evaluate feasibility of gill net marking, registry, and identification systems;
4) evaluate feasibility of a gill net bounty system; and
5) evaluate feasibility of a cooperative gill net fishing vessel tracking system.

NOAA conducted a workshop on fisheries generated marine debris to discuss ways to encourage fishermen to recover lost nets and dispose of them on shore (see Appendix A). Participants at the workshop concluded that "incentive systems", such as requiring fishermen to post returnable deposits on nets, marking nets with personal identification codes, and establishing a bounty system for returning lost nets, are neither warranted nor practical at this time. Many participants expressed concern over institutional arrangements necessary to implement such systems. Nevertheless, NOAA should continue to work with fishermen, fishery management councils, and net and trap manufacturers to reduce the amount of fishing gear lost in the marine environment by determining the rates and circumstances whereby nets and traps are lost. Such data should help provide a basis for identifying and correcting particularly severe problems.

Recommendation 4E: The National Bureau of Standards should work with the ASTM (formerly known as the American Society for Testing Materials) and other industry associations to

develop standards and criteria for what constitutes "bio-degradable" and "photo-degradable".

Eleven states now have requirements that six-pack yokes be degradable. Five states require fish pots and traps to have degradable panels or latches. Yet, no uniform standards exist to specify what "degradable" means. The term "recyclable" also is commonly used in different ways. Scientists do not fully understand how plastic materials degrade in marine environments or potential environmental implications of degradation products.

Recommendation 4F: EPA, FDA and NOAA should work with plastic manufacturers to examine how degradable plastics react in the environment, including potential environmental effects as the plastic degrades.

As manufacturers begin producing photo- and bio-degradable products, Federal agencies need to evaluate what happens to the plastic in the marine environment. For instance, will it sink, break-up, or dissolve? If algae grows on it, will degradation slow? Is microbial action necessary for degradation? Will it emit toxic substances as it degrades? Are there potential impacts when degradable plastics are disposed of in landfills? We need to determine answers to these and many other questions before we require that specific products be degradable solely on the basis of the problems that they cause as marine debris. The Task Force considered recommending that certain products, e.g., tampon applicators, ice bags, and six-pack yokes, be made degradable through regulations. The Task Force believes that such recommendations are premature until assessments of the effectiveness of MPPRCA regulations and analyses required by MPPRCA have been completed. State and local governments are addressing plastic product refuse as part of their solid waste

handling activities. Furthermore, EPA and industry should develop more information about actual degradation processes in the marine environment and environmental and economic impacts of specific products.

Benefits of Research and Monitoring Programs

Federal research programs should determine more completely where marine debris originates, how to reduce it, and the extent of its effects on fish, wildlife, and humans. By increasing research efforts, scientists can provide information which will lead to remedies to resolve the myriad of problems associated with persistent marine debris. More information is needed to assure that any additional mitigation and education activities effectively address problems. Thus, research will help set priorities for government as well as non-governmental efforts to address the most critical problems.

Little information is currently available on economic effects of marine debris for coastal communities, vessel operators, wildlife observers, or fishermen. State and local governments should determine economic effects of debris on their communities. Each of these industries is an important component of regional economies. Marine debris can affect all of them. Making good decisions to mitigate potential harmful effects will require additional information.

Recommendation 5: Beach Clean-up:

Federal agencies should work cooperatively among themselves, as well as with state agencies, private industry, and environmental groups to encourage removal of marine debris from beaches and other parts of the marine environment. Federal agencies should

encourage systematic monitoring of marine debris accumulation and impacts to assess compliance with regulations preventing disposal of plastics refuse and other persistent materials into U.S. waters.

Current Activities

The Federal government has two important roles in cleaning beaches. First it has a responsibility to remove persistent marine debris from Federal property which 1) recreational visitors use and 2) is important habitat of protected species. Second, it assists with volunteer efforts by helping organize projects, and collecting information about what volunteers remove (Table VII-4).

Each park, wildlife refuge, and national forest funds its clean-up program out of its operations budget. Clean-up costs vary significantly, for example:

-- Gateway National Recreation Area (New York and New Jersey) spent over $500 thousand in FY 1987 on beach clean-ups.

-- Padre Island National Seashore (Texas) spends $200,000 to $400,000 per year removing only the drums which wash ashore as well as additional funds to maintain clean beaches in heavily used recreational areas.

Table VII-4. Expenditures for Beach Clean-ups

	FY 87 (thousands of dollars)
NOAA	
OAR	50
MERP	10
DOI	
National Park Service	950*

* Estimated portion of NPS operation and maintenance budgets at coastal facilities spent on clean-up of persistent marine debris.

-- Assateague Island National Seashore (and other Federal lands) rely heavily on volunteers, such as the Assateague Mobile Sports Fishermen Association for trash removal from remote portions of the beach.

There are no comprehensive funding figures for removal of marine debris from Federal, other public, or private lands. Since clean-up costs are part of normal maintenance budgets, only estimates of costs of clean-ups can be cited.

Federal employees throughout the country participate as volunteers in local beach clean-ups. The Gulf of Mexico Regional Office of the Minerals Management Service staff "adopted" a portion of Louisiana beach to clean during 1987 Coast Week. The Massachusetts beach clean-up coordinator is a National Marine Fisheries Service employee. Numerous NOAA agents helped coordinate local clean-ups.

No Federal program exists for systematically collecting nation-wide data on extent of marine debris. NOAA/MERP is exploring with the National Park Service a pilot program to establish reference areas for monitoring debris accumulation along stretches of several beaches and monitor deposition throughout the year. These data provide an important opportunity to monitor and evaluate effectiveness of regulations implementing Annex V. If this program is successful, it could be expanded to include certain wildlife refuges and marine sanctuaries in future years.

The Center for Environmental Education (CEE) prepared and distributed data cards for volunteers to use in three states during 1987 Coast Week beach clean-ups. CEE plans to provide cards and process data from all volunteer clean-ups in 1988. NOAA/MERP is considering partial support of this data base.

Additional Activities the Task Force Recommends

> **Recommendation 5A:** Federal agencies which manage coastal property should step-up actions to remove persistent marine debris.

Federal land management officials realize that persistent marine debris creates problems on property which they manage for human visitors as well as wildlife.

> **Recommendation 5B:** Federal agencies should support local volunteer beach clean-up efforts as well as the collection and interpretation of data on what the volunteers remove. Federal managers should encourage employees to participate in volunteer clean-ups.

Beach clean-ups provide the most comprehensive information about quantities of persistent marine debris. They are the least expensive way to collect data. At this time, systematic surveys of the ocean's surface and bottom are prohibitively expensive, although systematic surveys and monitoring programs to determine deposition rates and identify sources are included in Recommendation 4 (Research and Monitoring) above.

Benefits of Federal Support of Beach Clean-ups

Beach clean-up cannot be the complete answer. Along with prevention and education programs, it is an important way to mitigate effects of persistent marine debris. Properly documented clean-ups will also provide data for evaluating effectiveness of prevention and education activities aimed at marine and land-based sources of debris.

Removing debris from Federal lands where endangered and threatened species encounter marine debris, such as the Hawaiian Island National Wildlife Refuge, should help protect these species. Fish and Wildlife Service officials routinely manage habitat for protection of endangered species. This recommendation applies to all Federal agencies with coastal properties.

Some persistent marine debris poses a danger to human health and safety. Cleaning it up reduces potential for injury. Maintaining clean beaches attracts more visitors, thereby increasing expenditures within local economies.

When over 23,000 volunteers nationwide turn out to remove trash from beaches, someone is raising the publics' awareness of marine debris. Beach clean-ups provide a way to get volunteers, particularly young people, actively involved and it allows them to see the results of their efforts at the end of the day. Volunteer beach clean-ups encourage proper stewardship of public lands and waters. People who clean up beaches are likely to protect beaches and other public lands. Minimal Federal support of these activities accomplishes many objectives -- data on extent of debris, public awareness, and physical removal of trash.

In 1987, Padre Island National Seashore had two major clean-ups in which NPS spent $2000 to promote the clean-ups; accrued $95,000 in NPS costs (for trash bags, personnel, etc.); and received 8,000 hours of volunteer work. Work is usually valued at $7 per hour, therefore, that puts the value of the volunteer labor at approximately $56,000. However, the amount saved by using volunteer labor cannot be measured at $56,000 because the work would not have been done had volunteers not done it.

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APPENDICES

APPENDIX A:

LETTER FROM THIRTY U.S. SENATORS

United States Senate
WASHINGTON, D.C. 20510

April 2, 1987

The Honorable Ronald Reagan
President of the United States
The White House
Washington, D.C. 20500

Dear Mr. President:

We are writing to request your assistance in developing a coordinated strategy to resolve the increasingly serious and complex problems resulting from the presence of plastic debris in the marine environment.

Plastic debris is accumulating in the oceans and coastal waters of the United States and other nations at an alarming rate and in a wide variety of forms that reflects the extensive use of plastics throughout the world. Everything from small plastic pellets used in packaging, to monofilament fishing lines and net fragments, to packing bands, bottles, six-pack connectors, bags, and large sheets of plastic are found floating in the water and littering our beaches. This plastic debris does not degrade readily and persists for many years with potentially devastating impacts on the living marine resources and our commerce, safety, and enjoyment of the marine environment.

It is estimated that 50,000 northern fur seals die each year after becoming entangled in discarded plastic packing bands, causing the population to decline by 8 percent per year. Endangered and threatened sea turtles, pelicans, and sea birds become entangled and die in plastic debris and ingest the debris with other food or mistake it for jellyfish or other prey items with a fatal result. Human safety is also jeopardized by plastic debris. Vessels have been disabled when their propellors and other gear are fouled with plastic ropes, netting, bags, sheets, and fishing line, and divers as well as research and military submarines have become entangled in lost and abandoned gill nets. Finally, our nearshore waters and beaches are despoiled by plastic debris with adverse impacts on aesthetics and the tourist industry upon which so many of our coastal communities depend.

The list of the sources of marine plastic debris is nearly as disturbingly long as is the inventory of the types and quantities of debris. Merchant and military ships, commercial and sport fishing vessels, recreational boats, sewage treatment and storm water facilities, and a host of other shoreline activities all contribute to the problem through discard, discharge, loss, or abandonment of plastic materials. Similarly, those diverse activities are subject to a variety of federal research, educational, and regulatory programs under a number of statutes within the jurisdiction of the Departments of Commerce, Defense, Interior, and Transportation, the Environmental Protection Agency, the Department of State as they relate to international affairs, and other federal agencies. Not surprisingly, the result has been a fragmented approach to the problem.

We believe there is a pressing need to focus and coordinate the various efforts of the federal government to develop solutions to the marine plastic debris problem. For this purpose, we respectfully suggest that you establish a high level, interagency task force to conduct an expedited assessment of the problem and potential solutions. Ideally, the task force would be able to generate within the next several months a report setting forth an action plan of measures to reduce or eliminate marine plastic debris and its adverse effects, as well as such research and development efforts and additional legislation as are warranted. The action plan should provide for evaluation of the feasibility of utilizing degradable or other materials to accelerate decomposition, instituting bounties and other incentives for retention and retrieval of debris, increasing public education campaigns, and other measures. It should also identify existing mechanisms, such as the coastal zone management and sea grant programs that could provide a national network for a concerted attack on the problem. Such an assessment would complement current programs and would be of substantial assistance to us as we seek to formulate a comprehensive solution.

Marine plastic debris offers a challenging opportunity to mobilize the resources, talents, and best efforts of the federal government in developing a coordinated strategy to resolve the problem. We look forward to working with the members of your task force in developing and implementing that strategy.

With best wishes,

Sincerely yours,

ERNEST F. HOLLINGS

TED STEVENS

BOB PACKWOOD

JOHN C. DANFORTH

LLOYD BENTSEN

JOHN F. KERRY

PETE WILSON

JOHN McCAIN

WILLIAM S. COHEN

DANIEL K. INOUYE

PAUL S. TRIBLE, JR.

DONALD W. RIEGLE, JR.

ALBERT GORE, JR.

FRANK H. MURKOWSKI

SPARK M. MATSUNAGA

CARL M. LEVIN

BROCK ADAMS

BARBARA A. MIKULSKI

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LAWTON CHILES

JOHN C. STENNIS

HOWELL T. HEFLIN

DANIEL J. EVANS

BILL BRADLEY

EDWARD M. KENNEDY

TERRY SANFORD

ALFONSE M. D'AMATO

PAUL S. SARBANES

JOHN BREAUX

WARREN B. RUDMAN

APPENDIX B:

REPORT OF THE WORKSHOP ON INCENTIVE SYSTEMS AND DERELICT FISHING

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APPENDICES AVAILABLE UPON REQUEST

REPORT

On a national workshop on fisheries-generated marine plastic pollution

I. INTRODUCTION

Fishermen, marine researchers, educators, plastics manufacturers and government representatives--more than 80 in all--met in Portland, Oregon February 9-11, 1988, for "Oceans of Plastic," a workshop to address problems caused by fisheries-generated plastic debris and derelict fishing gear. The workshop examined ways to reduce marine plastic debris and explained new laws intended to halt plastic pollution in the ocean.

Discussion during the three days indicated that many commercial fishermen, faced with a threat to waters that generate their livelihood, have assumed leadership in fighting marine plastic debris and their industry does not at this time need special government regulation. Fishing industry representatives said the best incentive for fishermen to reduce their contribution to the plastic debris problem is education, coupled with assistance in shoreside solid waste disposal. Although some workshop participants expressed doubts about whether education alone can rectify the problem, most agreed educational efforts will help reduce marine plastic debris.

Plastics in the ocean cause serious problems, but they represent only a portion of the solid waste dilemma nationwide. Annex V of the International Convention to Prevent Pollution from Ships (called MARPOL), which takes effect December 31, 1988, prohibits dumping plastics into the ocean. Some waste plastic will be burned at sea, but the rest will come ashore. In many coastal communities, particularly those in which landfill space is limited, the new law will be a burden.

The Portland workshop, sponsored by the National Oceanic and Atmospheric Administration and conducted by Sea Grant, was planned to accomplish the following objectives:

1. contribute to the understanding of fisheries-generated marine plastic debris.

2. investigate ways to reduce the amount of fisheries-generated marine debris.

3. identify effective ways--including possible incentives--to reduce derelict fishing gear.

4. contribute to the nation's marine debris educational program.

Frank discussion on a broad range of topics resulted in general and in most cases unanimous agreement on many points. These points were condensed in an open session at the end of the workshop, during which participants

agreed upon specific language to carry their ideas to Washington, D.C. This language, which provides the framework for this report, appears in bold print throughout the document.

II. THE MARINE PLASTIC POLLUTION ISSUE–BACKGROUND:

Persistent plastics in the ocean have aroused concern of fishermen, mariners, biologists, beach-goers and others who have contact with the marine environment. Problems caused by this synthetic jetsam range from the aesthetic, when tons of scrap plastic pile on a well-loved beach, to the life-threatening, when propellers foul in derelict plastic fishing gear. Waste plastic threatens marine life, too; fish, birds and mammals ingest or become entangled in it, although little quantitative data exists with which to assess the magnitude of this problem.

Isolated efforts to combat marine plastic pollution--including those by individual fishermen, fishermen's associations and beach groups--have been ongoing for a number of years. But those familiar with the debris problem felt a more comprehensive approach was needed. In April 1987 the issue became focused in Washington, D.C. after 30 U.S. senators signed a letter to the President. The letter outlined the impact of plastic waste on marine resources, formally sounding the alarm against a formidable environmental hazard.

The President forwarded the letter to the Domestic Policy Council, which in turn called upon federal agencies, under the leadership of NOAA, to cooperate to combat marine plastic debris with efforts such as this workshop. At the same time, national legislators initiated a number of bills aimed at reducing marine plastic pollution. Two of those bills became law at the end of 1987.

After ratifying Annex V of the International Convention to Prevent Pollution from Ships (MARPOL), Congress passed Public Law 100-220, which contains two relevant acts: the Plastic Pollution Research and Control Act and the Drift Net Impact, Monitoring and Control Act.

The first piece of legislation addresses the general plastic debris problem. It implements MARPOL, the international convention that prohibits all ocean discharge of plastics, and charges the U.S. Coast Guard with writing appropriate regulations. Further, the act charges the Environmental Protection Agency and the National Oceanic and Atmospheric Administration with tasks aimed at reducing marine plastic waste.

The Coast Guard is further charged with reporting on the level of compliance with the new law one year after it becomes effective and biannually thereafter for a period of six years.

The drift net law is narrower in scope. It addresses the portion of the high seas gill net fishery of the North Pacific, primarily foreign-based, that employs nets more than 1.5 miles long. Among its other provisions, the law requires a feasibility study of a net bounty system, which would encourage retrieval of lost gill nets, and a study of a net marking system, which would

allow the U.S. government to readily identify high seas gill net gear. (For more background, see workshop chairman Robert Schoning's opening remarks in the appendix to this report.)

III. MARINE PLASTIC POLLUTION–THE FISHING INDUSTRY'S ROLE:

"THE DOMESTIC COMMERCIAL AND RECREATIONAL FISHERIES CONTRIBUTE DEBRIS TO THE OCEAN IN VARIOUS WAYS, BUT THEY CLEARLY ARE NOT THE MAJOR CONTRIBUTORS."

According to data compiled from beach surveys around the country, marine debris comes from a variety of sources: inadequate municipal treatment systems, beach users, the oil and gas industry, recreational boating, commercial fishing and cargo vessel traffic of all types. Types of beach debris vary among geographical regions. The only area where derelict plastic fishing gear comprises the predominant beach debris is the northern North Pacific, where there are few coastal towns and plenty of fishing boats.

Regardless of the source, the problem is substantial. In 1987, 26,500 volunteers gathered 700 tons of trash from 1,800 miles of U.S. coastline in 19 of 21 marine coastal states. These annual beach clean ups, hosted on a state-by-state basis, typically last only one day.

Contents of sample bags were segregated by type and counted; this data was combined with information from inventory cards completed by clean up volunteers. Researchers extrapolated the following statistics from the data: Nationwide, between 40 and 60 percent of beach debris is plastic. Another 10 to 20 percent is expanded polystyrene foam. In other words, between 50 and 80 percent of materials washing ashore don't degrade in the environment.

Plastic debris specific to the fishing industry ranges from galley waste--including food wrappings and packages--to web scraps cut during mending and thrown overboard. Derelict fishing gear--nets, trawls, pots, lines--is lost in bad weather or in accidents. Because of the expense and potential hazard, fishermen are generally careful to prevent gear loss. Exceptions noted included gear willfully abandoned by foreign vessels discovered in closed areas and domestic gear left on fishing grounds during brief, intense season openings in which recovery of set gear would violate regulations or waste valuable fishing time.

"MEANINGFUL EFFORTS ARE ONGOING IN REDUCING DERELICT GEAR IN MANY FISHERIES AROUND THE COUNTRY."

Industry representatives noted that each fishery uses specialized gear and anecdotal evidence indicates that different gear types present different problems if lost or abandoned. For instance, lost gill nets are reported to collapse and ball up under their weight and through motion of ocean currents within a matter of weeks. Lost shrimp and crab pots without degradable escape panels, however, are said to continue to "ghost fish" for some time, perhaps years.

Harvest policies influence the derelict gear problem. Several examples were cited. In Puget Sound, a gill net fishery runs at the same time as a Dungeness crab fishery, leading to pot loss through entanglement. In brief season openings, which are familiar in Alaska waters, fishermen may set more gear than they can retrieve before the closing.

Discussion highlighted differences in opinion--and the lack of solid, scientific information--about the magnitude of effects of derelict gear on marine ecosystems. It is clear that birds and mammals become entangled and die. It is clear that derelict fishing gear continues to fish to some degree. What is the long-term impact on resources? Nobody knows for sure.

It also became obvious during discussion that the plastic debris pollution issue and the foreign high seas gill net fisheries issue have become confused, possibly because P.L. 100-220 addresses both. Because U.S. fishermen use a great variety of gear, including gill nets, problems caused by plastic debris, derelict fishing gear and mammal entrapment in active gear should be separated.

"PROBLEMS RELATED TO REDUCTION OF FISHING INDUSTRY DEBRIS IN THE OCEAN MAY VARY SIGNIFICANTLY AMONG DIFFERENT GEOGRAPHICAL AREAS AND FISHERIES AND SHOULD BE CONSIDERED ACCORDINGLY."

"THE NORTH PACIFIC FISHING INDUSTRY HAS DEMONSTRATED LEADERSHIP IN FINANCING ACTIVITIES TOWARD REDUCING ITS CONTRIBUTIONS OF PLASTIC TO THE OCEAN, RECOVERING AND RETURNING PLASTIC TO SHORE, PROPER DISPOSAL OF PLASTIC AND DEVELOPMENT OF NEEDED PERTINENT KNOWLEDGE."

The fishing industry tackled the marine debris issue before Congress passed recent laws. In the North Pacific, domestic and foreign-based fishermen have spent their own funds for educational materials. In October, these fishermen sponsored an international conference in Kailua, Hawaii to examine and share information about plastic debris pollution and to recommend and adopt steps to reduce fisheries-generated marine debris and derelict gear.

"THERE ARE STRONG INDICATIONS THAT SEGMENTS OF THE FISHING INDUSTRY WILL CONTINUE TO PROVIDE LEADERSHIP AND SUPPORT IN ADDRESSING OCEAN DEBRIS PROBLEMS, PARTICULARLY THOSE RELATED TO INDUSTRY ACTIVITIES."

During a roundtable discussion, fishing representatives said they support the idea of taking a leadership role to deal with the marine plastic debris issue. Some fishermen, such as those in the North Pacific, should continue leadership they've already assumed; fishermen in other areas agreed they should unite and face the issue head-on to demonstrate that government regulation isn't necessary.

There were, however, some reservations expressed. Some industry representatives noted that they are leading the fight against marine debris, and it has placed them in a high-profile position, making the fishing industry a potential political target. Assumption of leadership can be

misconstrued as an assumption of responsibility for the entire marine debris problem. Industry representatives expressed the importance and advantages of taking leadership, but said they preferred leading a broad-based effort among all groups that use the ocean.

IV. MARINE PLASTIC POLLUTION–SOLUTIONS:

The bulk of the workshop time was spent discussing potential solutions--ranging from government-initiated financial incentive programs to education and technology--to the marine plastic pollution problem. Following are summaries of these discussions.

A. Financial incentive systems

This workshop session began with panel presentations. Xan Augerot of Washington Sea Grant explained various types of financial incentive systems for consideration. These systems were evaluated by Jon Sutinen, a resource economist with the University of Rhode Island. Casey Jarman of the University of Hawaii Richardson Law School addressed legal structures affecting enactment of those systems. Background papers written by these individuals are included in the appendix to this report. Following panel presentations, industry representatives responded.

"A VARIETY OF ECONOMIC INCENTIVE-TYPE PROGRAMS FOR REDUCING GEAR DISCARD AND LOSS AND ENCOURAGING SUBSEQUENT RECOVERY WERE DISCUSSED AT LENGTH, BUT SIGNIFICANT SHORTCOMINGS WERE EVIDENT WITH EACH, BASED ON PRESENT UNDERSTANDING AND DIFFERENCES IN THE CONDUCT OF SPECIFIC FISHERIES. BECAUSE DOMESTIC COMMERCIAL FISHERIES VARY GREATLY IN TYPE, COST, EXTENT AND FREQUENCY OF GEAR LOSS, OPERATION METHOD AND AREA AND AMOUNT OF LOGISTICAL SUPPORT REQUIRED, ANY REGULATORY APPROACH GOVERNING DISPOSAL AND RECOVERY OF FISHING EQUIPMENT WARRANTS FURTHER STUDY."

1. Pollution rights

This type of incentive system, in which a user buys a permit to pollute at a certain level, isn't applicable to the marine debris issue because the Plastic Pollution Research and Control Act prohibits dumping plastics into the ocean.

2. Net deposit

A net deposit system, as presented at the workshop, would be patterned after bottle bill legislation. Fishermen would pay a deposit on gear at the time of purchase. A refund would be made to anyone who returned the gear to a refund location.

"INCENTIVE-TYPE APPROACHES REQUIRING ADVANCE DEPOSITS WHEN PURCHASING GEAR AND PROVIDING REFUNDS UPON RETURN WERE OPPOSED BECAUSE OF DIFFICULT BOOKKEEPING INVOLVED AND BECAUSE OF THE EXTENDED PERIODS OF TIME DEPOSITS WOULD BE OUT-OF-POCKET, PRESUMABLY IN A GOVERNMENT ACCOUNT."

3. Inventory

In an inventory system, all gear purchased and taken aboard a vessel would be recorded. If a fisherman didn't return gear to a refund location within a specified time, he or she would pay a "deposit." If the gear was eventually returned, the deposit would be divided among the gear retriever, the shoreside disposal agent and, if the gear was marked, the original owner. The inventory system required, however, might be too burdensome to be feasible.

"THE SIGNIFICANTLY EXPANDED BUREAUCRACY AND ASSOCIATED GOVERNMENT RECORD-KEEPING ARE MAJOR DETERRENTS TO SOME FINANCIAL INCENTIVE CONCEPTS."

Jon Sutinen evaluated financial incentive systems on the basis of eight criteria: effectiveness, permanence, behavior modification, cost effectiveness, fairness, degree of interference with individual decision-making, political effectiveness and enforcement considerations. Nearly all of the financial incentive systems, particularly the deposit system, received high marks from Sutinen when judged on these points (see appended discussion paper).

The proposed systems did not, however, receive high marks from fishermen. Fishing industry representatives objected to any regulatory program that would add to the cost of operation or levy fines for inadvertent gear loss. They also objected to the idea of a new bureaucracy created to oversee a new regulatory system--a system that would keep track of deposits on gear and/or gear identification for an estimated 130,000 commercial fishing vessels.

B. Bounty system

Under a bounty system, fishermen would receive financial reward for bringing ashore their old gear and any gear they find. Such a system could be funded from the federal treasury or other sources. The recently passed Drift Net Act requires a feasibility study of bounties for possible application to the high seas drift net fishery.

"THERE ARE POTENTIALLY POSITIVE SUCCESSFUL APPROACHES TO ENCOURAGING RECOVERY OF DERELICT FISHING GEAR AND RETURNING IT TO PORT WITHOUT INVOKING PENALTIES FOR INADVERTENT LOSSES. THE INDUSTRY SUPPORTS THE CONCEPT OF AT LEAST REIMBURSING AN INDIVIDUAL FOR COSTS INCURRED IN COLLECTING AND RETURNING DERELICT GEAR AND POSSIBLY PROVIDING A SMALL REWARD FOR SUCH ACTION, BUT FURTHER REFINEMENT OF THIS CONCEPT IS NECESSARY."

"THERE IS NO ENDORSEMENT OF ANY BOUNTY OR FINANCIAL INCENTIVE-TYPE APPROACH AT THIS TIME BECAUSE OF THE VARIETY OF SIGNIFICANT AND REAL PROBLEMS FACING EACH, BASED ON AVAILABLE KNOWLEDGE OF THE APPROACHES AND THE FISHERIES. FURTHER, SUCH MAJOR CHANGES IN ADDRESSING THE OCEAN DEBRIS PROBLEM, BY SELECTING ONE OF THE LESSER CULPRITS, WITHOUT THE SUPPORT OF INDUSTRY, WOULD BE DEVASTATING TO CURRENT OR FUTURE COOPERATION AND EFFECTIVENESS."

C. Educational incentives

"THE SINGLE MOST WIDELY SUPPORTED APPROACH TO ADDRESSING THE PROBLEM OF REDUCING FISHING INDUSTRY PERSISTENT DEBRIS WAS EDUCATION OF ALL SEGMENTS OF THE PUBLIC AND USER GROUPS AND SUPPORT AND ENCOURAGEMENT OF PRODUCTIVE ONGOING EFFORTS, BASED ON MEASURABLE SUCCESS ALREADY OBTAINED THROUGH SUCH ACTIONS. A CLEARINGHOUSE FOR INFORMATION NATIONALLY AND INTERNATIONALLY IS ENCOURAGED."

During discussion of financial incentive and bounty systems, a semantical gap between the fishing industry and government administrators became apparent. Fishermen interpret the word "incentive" broadly, as does Webster's New World Dictionary: "...something that stimulates one to take action, work harder, etc."

Instead of a new government program, fishing industry representatives recommended education and information as incentives for fishermen to help reduce marine plastic debris. As one Northeast fishery leader said, "I'm of a mind that if we have any funds ... rather than impose sheaves of regulations that are going to be unenforceable, impractical, let's put our funds in education."

Other regional fisheries representatives reinforced the idea that education is the best answer to marine plastic pollution at this time. As one speaker noted, "The worst way to get a fisherman to do anything is to tell him he's got to do it."

During the evaluation of approaches to abating marine plastic debris it was noted that educational programs are popular because they are politically attractive, don't cost much and meet other favorable criteria including lack of interference with individual decision-making. However, it was also noted that education and publicity efforts often have only modest effectiveness and lack permanence.

Other workshop speakers had more favorable views of educational programs. The year-old Marine Refuse Disposal Project in Newport, Oregon is an example of a successful education and information campaign. This pilot project was funded by the National Marine Fisheries Service Marine Entanglement Program in anticipation of passage of the MARPOL Annex V legislation. The project is in two interrelated parts:

1) making sure port facilities are adequate to handle plastics that port users return, and

2) making mariners aware of the serious nature and effects of plastic debris and encouraging action.

The majority of Newport fishermen now voluntarily dispose of their plastic trash in port. Trash bins near the docks make this easy. The project's director said program success stems from motivations that education and

awareness foster. Fishermen have not only become involved in overcoming the marine debris problem, they feel ownership in this task and in their accomplishments.

Newport fishermen participate in a variety of activities that help generate this feeling of ownership. They appear in television ads, lead groups of kids on bay clean-up activities and wear sweatshirts and hats with the "Don't teach your trash to swim" logo. Most importantly, they talk to their peers on marine radio, in bars and restaurants and on the docks.

One trawler was overheard saying to another as their boats drew together to transfer a crew member, "Is that YOUR garbage in the water? We don't do that anymore here."

Part of the project's success may be attributed to its approach.

"If you want this marine debris problem to be solved, you have to offer the fishermen something," the project director said. "Something simple and inexpensive (such as coffee and donuts on the docks) but sincere and welcome. Then ask for their help."

Although the pilot project is nearly over, the program was designed to be self-perpetuating. Garbage bins are on the docks, fishermen are aware.

"THE RECENTLY COMPLETED NEWPORT, OREGON MARINE REFUSE DISPOSAL PROJECT WAS DEEMED HIGHLY SUCCESSFUL, WITH POTENTIAL FOR ADOPTION BY OTHER DOMESTIC PORTS. DISTRIBUTION OF WRITTEN HIGHLIGHTS OF THE PROJECT TO OTHER DOMESTIC PORTS IS ENCOURAGED."

"THE SUPPORT AND INVOLVEMENT OF THE FISHING INDUSTRY IN REDUCING MARINE DEBRIS PROBLEMS CAN BEST BE ENCOURAGED AND OBTAINED BY POSITIVE APPROACHES RATHER THAN BY THREATS OF INCREASED OPERATIONAL COSTS AND PUNITIVE ACTIONS ASSOCIATED WITH SOME FINANCIAL INCENTIVE PROGRAMS."

D. Technology

In addition to the array of incentives discussed, technology also will play a role in reducing plastics in the ocean. Options include: using degradable plastic for packaging as well as fishing gear; recycling plastics; and marking nets at the time of manufacture to identify owners at some point in the future.

1. Degradable and recyclable plastic

"THERE IS ONGOING AND PROPOSED RESEARCH ON MODIFYING PLASTIC MATERIAL TO MAKE IT MORE ADAPTABLE TO DISPOSAL AND RECOVERY."

Plastics industry representatives said research has led to development of some degradable plastics. They also indicated that most plastics are recyclable. Research to further develop and refine both technologies continues. Although some degradable plastic packaging products are on the market and some recycling is conducted, this is an area for growth.

"EFFORTS TO IMPROVE BIODEGRADABILITY OR DISPOSABILITY OF FISHING GEAR SHOULD AVOID MAKING MATERIALS MORE COSTLY, OR LESS SAFE, EFFICIENT OR SERVICEABLE."

Although few question the wisdom of degradable six-pack yokes, fishing gear designed to break down in the environment is another matter. Degradable escape panels of natural materials have been available for crab, shrimp and lobster pots for some time, but degradable synthetic net hasn't been developed yet and probably won't be for a number of years. Still, interest in such a product remains strong. The Stevens Institute of Technology's Polymer Processing Institute recently received a $187,000 Saltonstall-Kennedy grant to develop materials for fish traps and pots that will degrade in sea water.

Fishermen are concerned about the concept of netting that disintegrates. They say such materials may make on-board operations unsafe and are likely to significantly increase the cost of gear. About half-way through the workshop, one Northwest fisheries leader expressed uneasiness about what he'd heard so far. "Can you imagine what would happen to me if I went back and told my fishermen that they were going to have to pay a 10 percent surcharge for (gear) identification and then they were going to have to pay a deposit on a net that's going to biodegrade in two years?"

A fishing gear manufacturer said biodegradable synthetic netting or line would be acceptable only if:

1. new materials are as strong as those now used.
2. it's affordable.
3. it biodegrades only if lost.

A plastics researcher said that although there are ways to make plastics degradable, little is known about behavior of plastic in the ocean environment. Researchers must know more about the material to determine when and how it will degrade, and that information must be passed to fishermen, before biodegradable or photodegradable nets and lines are a viable option.

"THE PLASTICS INDUSTRY IS COOPERATING IN ADDRESSING SPECIFIC NEEDS OF THE FISHING INDUSTRY IN USING AND DISPOSING OF PLASTIC MATERIALS, BUT MORE WORK NEEDS TO BE DONE."

2. Net-marking

The concept of marking nets for registration and identification purposes arose in the early 1980s in response to concerns about gear abandoned in the high-seas drift net fishery. Northwest Marine Technology has a grant from the NMFS to develop a method to mark nets during manufacture. A researcher for that company said he's confident the technology is available, but the question is one of politics. Is net-marking desirable? The fishing industry says not on an individual vessel owner basis. Fishermen are worried about liability for problems caused by long-lost gear. Marking on a country-by-country basis may be acceptable.

"SERIOUS CONCERNS WERE EXPRESSED ABOUT THE CONCEPT OF REQUIRING NETTING TO BE INDIVIDUALLY MARKED AT PURCHASE SO IT CAN BE TRACKED THROUGHOUT ITS LIFE AND SO A REFUND MAY BE PAID TO ANYONE WHO RETURNS IT. THERE IS MUCH TRADING, LOANING AND SELLING OF PIECES OF WEBBING AND THE SUBSEQUENT POTENTIAL LIABILITY FOR DAMAGE OR HARM TO WILDLIFE OR HUMANS AFTER INADVERTENT LOSS IS FRIGHTENING. FURTHER, LOGISTICAL AND ADMINISTRATIVE PROBLEMS AND POTENTIAL FOR ABUSE WOULD BE MASSIVE."

"THE DOMESTIC FISHING INDUSTRY SHOULD NOT BE SUBJECTED TO PROGRAMS RELATING TO MARKING OR IDENTIFYING GEAR TO ADDRESS A PROBLEM CAUSED BY FOREIGN FISHING VESSELS."

"THE CONCEPT OF MARKING FISHING EQUIPMENT DURING MANUFACTURE FOR FUTURE IDENTIFICATION OF PARTS OR THE WHOLE WARRANTS CAREFUL EVALUATION."

V. MARINE PLASTIC POLLUTION–EDUCATIONAL NEEDS:

"A VARIETY OF BROADLY BASED EDUCATION PROGRAMS HAVE RESULTED IN INCREASING AWARENESS AND CONCERN, WITH POSITIVE, RELATED ACTIONS AND INVOLVEMENT BY A BROAD SEGMENT OF THE PUBLIC NATIONWIDE. IT IS RECOGNIZED THAT SUCH PROGRAMS ARE COST-EFFECTIVE AND SHOULD BE CONSIDERED BY PRODUCERS AND USERS AS WELL AS GOVERNMENT."

If there was one point upon which all workshop participants agreed, it was that more education about the marine plastic debris issue is needed. Different user groups need different types of education.

In addition to information about the Newport refuse project, and the consequences of plastic pollution, individual fishermen need accessible, pertinent information about the Plastic Research and Control Act before it takes effect on December 31, 1988. Other members of the fishing community, such as fish processors and fishing port administrators, will be affected by the new law, too, and also need information.

As new technology becomes available to cope with or prevent marine plastic problems, a mechanism for delivering that information in a timely manner should be established. At the workshop, the idea of a national clearinghouse was endorsed. The clearinghouse might consist of a well-defined network of all of the entities involved: Sea Grant, National Marine Fisheries Service, the U.S. Coast Guard, the Environmental Protection Agency, state and local governments, port authorities, fishermen's associations, environmental groups and others.

Representatives of various government agencies expressed the desire that educational programs be spearheaded by fishermen and other user groups. Sea Grant and other agencies should provide support but should not take leadership away from the fishing industry or others who already are addressing this issue.

Since the fishing industry isn't the only group with a stake in clean oceans, other user groups need access to information and to this national clearinghouse. Workshop participants suggested sharing information about beach surveys and beach clean ups nationwide to make efforts and resulting data more homogeneous.

"BEACH CLEANUP PROGRAMS SUCH AS ADOPT-A-BEACH' AND 'GET THE DRIFT AND BAG IT' HAVE GENERATED GREAT NATIONAL PUBLIC INTEREST AND INVOLVEMENT IN COLLECTING DEBRIS IN MARINE AREAS AND THE CONCEPT AND PARTICIPATION ARE RAPIDLY EXPANDING."

VI. MARINE PLASTIC POLLUTION AND THE SOLID WASTE DILEMMA:

"SHORESIDE WASTE DISPOSAL OF MARINE DEBRIS IS ONE OF THE MOST PRESSING AND PERPLEXING PROBLEMS FACING THE FISHING INDUSTRY IN IMPORTANT REMOTE FISHING COMMUNITIES."

In each workshop session, discussion returned time and again to an obstacle that exacerbates the marine plastic debris problem and is bound to interfere with smooth implementation of the Plastic Pollution Research and Control Act: lack of adequate solid waste disposal facilities ashore.

At the end of this year, when boats are required to bring ashore all plastic garbage, the effects on coastal communities will be profound. Consider the case of Dutch Harbor, the port for the town of Unalaska, Alaska. A tiny fishing village of 1,800 tucked into the rocky, Aleutian landscape, Dutch Harbor serves 800 Bering Sea fishing boats--foreign and domestic--with more than 4,000 port calls each year. The town's landfill will be full in two years, and a new site hasn't been identified. In Unalaska as well as many other small ports, the shift of the solid waste burden from the fleet, often home-ported elsewhere, to the municipality, will be substantial.

Even communities whose landfills aren't nearing capacity may be pressed to accommodate trash brought ashore by merchant vessels, cruise ships, military ships and fishing boats. Some larger vessels are like floating cities, each day generating hundreds of bags of trash that are now dumped overboard. A specific example mentioned during discussion was a military vessel reported to produce 500 bags of trash per day. In some ports, especially in small, remote towns, the cost of dumping trash is prohibitive, providing a blatant disincentive for compliance with the new law. Furthermore, it would discourage fishermen from bringing ashore debris left by others and picked up in nets. City government in one Alaska coastal community reportedly considered raising landfill fees to $200 per ton.

Solutions to this waste disposal problem are too involved to address in the context of marine plastic debris; the entire nation must at some point find creative ways to deal with all the trash--particularly non-degradable types--produced by a consumptive society. In the short-term, however, there are some steps that could help fishermen comply with the new law, such as improved, safer technology for onboard incineration of plastics and other

trash, expanded plastics recycling, a switch to alternative packaging materials such as paper, and financial assistance to help ports deal with ramifications of MARPOL Annex V.

Finally, widespread distribution of the plan initiated by the Port of Newport in the pilot project mentioned earlier in this report may help coastal towns prepare for the coming flood of marine-generated plastic waste.

"CONSIDERABLY MORE INFORMATION IS NEEDED CONCERNING THE RELATIVE MERITS OF PRESENTLY KNOWN APPROACHES TO INCINERATION AT SEA, RECYCLING OF MATERIAL BROUGHT ASHORE AND SHORESIDE DISPOSAL OPTIONS. MUCH PROGRESS, HOWEVER, HAS BEEN MADE ON THE LATTER TWO."

VII. SUMMARY

Although some people believe fishermen need financial inducement to comply with the Plastic Pollution Research and Control Act, fishing industry representatives who attended the conference made convincing arguments against instituting a new regulatory program targeting fishermen. Some segments of the industry have initiated their own programs to help clean up the ocean, and other fishermen have indicated interest in following suit. Efforts to mitigate marine debris should for the present be aimed toward educational programs, for fishermen and all who use the ocean. If compliance reports called for by the new law indicate educational efforts are inadequate, regulatory programs should be pursued only with the involvement of the industry.

VIII. RECOMMENDATIONS

1. Distribute nationally summaries of the highly successful Newport Marine Refuse Disposal Project for application and use, and support funding of similar projects in other selected ports.

2. Develop a national repository and clearinghouse for collection and dissemination of information on the marine debris problem.

3. Maximize development of voluntary approaches to attack the marine debris problem through involvement of the domestic commercial and recreational fishing communities and general public through expansion of current successful programs. If voluntary approaches prove inadequate in reducing fisheries-generated marine debris and derelict fishing gear, explore with fishing industry leaders the possible development of incentive programs to minimize release of fishing gear and to maximize recovery and appropriate disposal of such gear.

4. Encourage the plastic industry to work more aggressively and directly with the fishing industry to address general as well as specific plastic-oriented problems associated with individual fisheries.

5. Explore practical ways to dispose of plastic debris and derelict fishing gear ashore, particularly in isolated fishing communities such as in Alaska. Explore technologies such as on-board incineration and recycling to reduce the impact of fisheries generated debris on shore-based disposal facilities. Encourage use of alternative packaging materials, such as paper, aboard vessels.

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