PLASTICS IN THE OCEAN: MORE THAN A LITTER PROBLEM

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Prepared by
Center for Environmental Education

February 1987

n the cover: sea lion with
six-pack connector ring
round its neck.

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FOREWORD

This report was prepared by the Center for Environmental Education for the Environmental Protection Agency under Contract No. 68-02-4228. The original title was **USE AND DISPOSAL OF NONBIODEGRADABLE PLASTICS IN THE MARINE AND GREAT LAKES ENVIRONMENTS.**

Natasha Atkins directed the efforts by the Center for Environmental Education. Principal authors were Kathryn J. O'Hara and Suzanne Iudicello.

Please note that this reprint of the report does not contain copies of statutes applicable to marine debris and entanglement, which are referenced in the text as Appendix III.

During the preparation of this report several bills were introduced into the 99th session of Congress that dealt with aspects of the problem of plastic debris in the marine environment. While it is beyond the scope of the contract to summarize the content of these bills individually, we believe the following points are of interest:

- plastic rings used for carrying beverages ("six-pack" rings) are presently required to be degradable in eleven states, and Senate Bill 2596 requires that all such rings nationwide to be degradable;

- S. 2596 also calls for the Environmental Protection Agency to head an interagency review, together with industry, of the plastic debris problem and to make recommendations as to how these problems can be mitigated;

- another bill introduced in the Senate (S. 2611) calls for a bounty system to be established to encourage domestic fishermen to retrieve lost or discarded fishing nets;

- port facilities in the United States and abroad are presently inadequate for handling shipboard wastes and should be improved if Annex V of the MARPOL Treaty is ratified; and

- the Coast Guard has indicated that the U.S. is very near ratification of Annex V of the MARPOL Treaty.

For additional information on the problems concerning use and disposal of plastic debris in the marine environment, we refer the reader to the Congressional Record of 12 August 1986. We also would like to note that since the completion of this report in 1986 several more pieces of legislation have been introduced into the 100th Congress, which, due to time constraints, could not be listed in the report.

EXECUTIVE SUMMARY

Since its invention more than 40 years ago, plastic has become such an integral part of life that it is difficult to survey one's surroundings without finding plastic items in use: packaging and containers, household goods, furnishings, equipment and machines. But what happens to plastic that falls into disuse? Unfortunately, the durable characteristics that have made plastic so convenient for packaging, household products, and commercial equipment also make it a continuing, nondegradable and persistent presence in the environment. A growing body of evidence indicates that when discharged, lost or abandoned in the marine environment, plastic debris adversely affects the oceans and their inhabitants in a multitude of ways.

Environmental impacts arise from entanglement of marine animals in plastic debris and from ingestion of plastics by marine organisms. Plastic debris can cause potential threats to humans when divers become entangled or vessels become fouled in debris. The depletion of fishery resources, vessel damage, and aesthetic degradation resulting in lost tourism revenues or costly cleanup procedures all contribute to significant economic impacts caused by plastic debris.

Even though concern about marine pollution in general has been expressed since the 70's, the issue of plastic debris in the marine environment is a relatively new concern, and sources of hard data are meager. No central data collection source exists to document what types of plastic are out there, where it comes from, what it does, or who controls it. What legal authorities do exist to address ocean pollution are not plastic-specific, and have not been used to focus on the particular problem of entanglement of marine animals in plastic debris. Only one federal program exists that targets the problem directly. While federal wildlife managers and those engaged in management of the nation's refuges and seashores are aware of the magnitude of the problem posed by plastic debris, conservation agencies in coastal states seem unfamiliar with the issue, and are generally doing little or nothing to combat the tons of plastic litter that line their beaches. In a recently released plan setting out priorities for ocean research for the next five years, plastic debris and associated entanglement and ingestion by marine animals ranked among the last four items of a 50-issue list, and were categorized only as "low priority" national issues. It is against this backdrop that the authors have attempted to address the tasks posed by the scope of work: describe the types, sources, and impacts of nondegradable plastics in the marine environment and discuss the authorities relevant to the issue. In order to answer the questions raised, it was necessary to consult primary sources in addition to a literature search of what few authorities are available. Our review took us to lake beaches and seashores, to fishery supply houses and boat dealers, to uncompiled records of lost fishing gear and bags of beach litter. The picture, while anecdotal and incomplete, is of a growing problem that has yet to be tackled by natural resource managers at either the national or local level.

Environmental Impacts

Frequent reports of the mortality of marine mammals, sea turtles, seabirds and fish attributed to plastic debris have concerned scientists, conservationists, fishermen and others in recent years. Plastic in the marine environment may be a problem not only for individual animals, but may ultimately affect entire marine ecosystems.

While plastic debris has been shown to affect individual species, very little is known about the broader impacts on marine populations, communities or ecosystems. To date, extensive research has only been carried out on northern fur seal populations. But among those species that appear to have the greatest degree of interaction with marine plastic debris, many are endangered or threatened species namely, the Hawaiian monk seal, brown pelican, Kemp's ridley, hawksbill, leatherback, green and olive ridley sea turtles. The effects of plastic debris on these endangered and threatened species therefore should be closely monitored.

Among the species of marine mammals reported to become entangled, seals and sea lions appear to most affected, which is often attributed to their tendency to investigate floating debris. The most common items found on entangled pinnipeds are fragments of nets, and plastic strapping bands which are used to bind packages. For many pinnipeds the effects of entanglement on species survival are generally unknown. But for the northern fur seals of the Pribilof Islands in Alaska, recent studies indicate that this population is declining at an annual rate of 4 to 8 percent per year, largely due to entanglement. Types of fishing gear are also the most common plastic items found on entangled sea turtles, whereas birds have been reported to become entangled primarily in monofilament fishing line and six-pack connectors used to carry beverage cans.

Another major problem tied to plastic debris has been the issue of ghost fishing, or the ability of lost or discarded fishing gear to continue to catch finfish and shellfish indefinitely. Free-floating gill nets have been reported to catch large numbers of commercially valuable species of finfish and shellfish years after they have been lost. Estimates of this type of plastic debris from New England's Atlantic gillnet fisheries range from 30 miles of lost nets in 1985 to more than 18 miles lost thus far in 1986. Lost trawl webbing turned up on Alaskan beaches in 1974 in quantities of 272 kilograms per kilometer of beach, an amount that dropped to 172 kilograms 10 years later, but only after a significant decrease in the area's trawl fishery. In various fisheries that utilize traps constructed either partially or entirely of plastic, ghost fishing also poses a serious threat to fishery stocks. In New England, it is estimated that 20 percent of 2.5 million lobster pots are lost annually. Off Florida in the Gulf of Mexico, 25 percent of 96,000 stone crab traps were lost in 1984. It is estimated that more than 30,000 crab traps have been lost in Alaskan waters since 1960, at a rate of 10 percent per year of those set. Each of these pots and traps continues to capture fish and shellfish, resulting in a continuing cycle of baiting and capturing valuable commercial species that are never retrieved.

Along with the increasing reports of plastic debris in the marine environment there has been an increase in the documentation of plastic ingestion by marine animals. Certain animals may ingest plastics nonselectively while feeding on other organisms, while others mistake floating plastic for authentic food items. The ingestion of plastic bags and sheeting by sea turtles has become highly popularized and is attributed to deliberate consumption by turtles who mistake these items for jellyfish. To date, 50 species of seabirds have also been known to ingest plastic debris, most commonly raw polyethylene pellets, which are the raw form of plastic after it has been synthesized from petrochemicals.

Economics and Safety

In addition to the ecological impacts caused by plastic debris, there are also economic problems. Probably one of the most costly but least known impacts to fishermen is the loss of synthetic fishing gear. Since U.S. fishermen are not required to report fishing gear losses there is no way to assess this. Ghost fishing by lost fishing gear could be severely depleting fishery stocks, but quantitative data on this problem are also limited.

Plastic debris has also been reported to interfere with vessel operations, the most common instances involving plastic items that foul propellors and clog cooling water intake systems. The types of plastic debris involved in these incidents range from entire gill nets to garbage bags, sheeting and monofilament fishing line. Although this appears to be a problem nationwide, there is no source of documentation to determine the frequency of this occurrence. The fact that some boating supply companies have built devices on propellors to combat this problem, however, may give some indication that it is not merely a random occurrence.

Plastic debris may also pose a threat to human safety in the marine environment. Occasionally divers have become entangled in monofilament fishing line, but more frequently encounters involve gill nets. The disablement of vessels caused by plastic debris may also endanger human safety when power or steering control is lost; some have attributed fatalities at sea to vessel disablement during storms, whereas disabled vessels near inshore structures face the risk of collision. Research and military submarines have had similar near fatal encounters with lost gill nets.

Many coastal communities incur the costs of routine cleanup of debris, while others employ enforcement officers to patrol and control litter deposited by beachgoers. In certain areas, the deposition of large amounts of debris is coming from distant land-based or offshore sources. At Padre Island National Seashore in Texas, 90 percent of beach debris comes from the Gulf of Mexico and consists largely of plastic items associated with merchant shipping and oil industry activities, such as large pieces of plastic sheeting and domestic wastes in quantities and container-sizes suggestive of commercial activities. While this problem is costly in terms of cleanup, it may have an even greater impact on the coastal tourist industry. The economic impact suffered by coastal businesses as a result of marine debris was clearly demonstrated by the "floatable episode" of June 1976, when unusually large amounts of materials, primarily plastics, washed up on beaches in Long Island. The total cost of the cleanup was

$100 thousand, but an even greater economic loss was suffered by the coastal recreational industry due to the aesthetic degradation of beach areas.

Types and Quantities of Plastic Debris

The types of plastic debris described in this report are generally categorized in literature as either manufactured plastic articles or raw plastic particles. Manufactured plastic articles include those items that have been fabricated into consumer products such as fishing gear, packaging materials, bags, bottles and many other items. Raw plastic particles are typically in the form of small spherules or beads and are used to manufacture plastic products. Although there is enough available information in literature to draw some general conclusions about the primary types of plastic debris found in the marine environment, quantitative data are insufficient for estimating total amounts of particular debris in any major geographic area. Most of the quantitative estimates of debris reported in literature provide information on isolated concentrations in relatively localized areas. The lack of information on total quantities of specific debris in the marine environment points towards the need for future studies to address this aspect of the plastic debris problem.

Until recently the amount of lost or discarded fish netting was highly speculative, largely because gear losses are almost never reported. Although this subject is still in the beginning stages of analysis, various methods have been used in recent years to assess the types and quantities of lost or discarded netting including: estimation of the total amount of fishing net gear used in various fisheries and their relative probabilities of becoming lost; direct observations of net losses from fishing vessels; observations of derelict fishing nets at sea; and tabulation of accumulation rates of fishing gear on beaches. Each of these methods of analysis has provided some insight into the types and quantities of lost or discarded fishing nets in the marine and, to a lesser extent, Great Lakes environments.

Information on the types and quantities of lost commercial fishing gear that has not yet been reported in literature is found in the files compiled by the National Marine Fisheries Service under the Fishing Vessel and Gear Damage Compensation Fund of the Fishermen's Protection Act, and the "fishermen's contingency fund" established under the Outer Continental Shelf Lands Act. Both of these funds compensate fishermen for gear losses in federal waters of the United States. There is presently only one state program that maintains records and provides compensation for gear losses that occur in state waters.

Among the types of fishing gear that are known to affect the marine environment, gill and trawl nets appear to be of utmost concern. Some have concluded that gill nets are the most likely net type to become lost or damaged and discarded during fishing operations, principally because the amount of gill net used in the North Pacific far exceeds the amount of net used in all other fisheries analyzed: 170,466 km, or, if strung end to end, 4.2 times the length of the equator. Trawl nets, which are bag-shaped nets towed behind a vessel, are considered to be the second most likely net

type to become lost. There are an estimated 5,500 km of trawl net used by 12 major foreign and domestic trawl fisheries in the North Pacific.

Synthetic netting materials are also used in the construction of side panels for wood and metal traps employed in the various trap fisheries of the United States. Consequently, gear losses by these fisheries could well be contributing to the plastic debris problem in the marine environment. Furthermore, there appears to be a growing demand for plastic and plastic-coated wire traps in the U.S. commercial trap fisheries, since these traps are not only impervious to wood-boring organisms, but they also offer additional conveniences to fishermen.

There has been little attempt to quantify the amount of plastic buoys or rope lost by commercial fisheries operating in the marine environment. This may be because buoys and ropes are used in a variety of combinations. Although it is impossible to estimate the total number of buoys or amount of rope lost in North American waters, files kept by the Fishermen's Vessel and Gear Damage Compensation Fund suggest that total amounts are staggering. The following example is indicative: 295,000 floats lost per year in the North Pacific drift net fishery from 1978-1981. Similarly, lost or discarded monofilament fishing line is becoming an increasing problem, but the total amount of this plastic debris is unknown.

Two plastic items of debris which are associated with cargo shipping activities and are known to affect the marine environment as debris are plastic strapping bands and large pieces of plastic sheeting. Plastic strapping bands are used to bind items for shipping and are thought to be commonly removed off one end of a package without cutting them, and subsequently cast off a ship. Large sheets of plastic, used in cargo shipments to cover items during transportation, are also frequently reported as debris. Although there is no available documentation of the amount of this material generated as debris, plastic sheeting has been reported to be the most abundant litter item found on Padre Island National Seashore in Texas.

The most diverse category of plastic debris found in the marine environment includes plastic packaging materials, bags, containers and a multitude of other items used for domestic purposes. Plastic domestic articles most commonly reported as marine debris include the following: bags, sheets, six-pack connectors used for carrying canned beverages, containers, bottles, tampon applicators and pieces of styrofoam.

The occurrence of small plastic particles in marine areas has been documented repeatedly in the past decade. Plastic pellets are the raw form of plastic after it has been synthesized from petrochemicals. These pellets are then transported in bulk to manufacturing sites, where they are melted down and fabricated into a multitude of plastic consumer goods. It is suspected that volumes of these pellets are discharged into rivers with the wastewater from plastic manufacturing processes, and eventually find their way into the marine environment. Plastic fragments, which are also of concern primarily because they are ingested by marine animals, result from the breakdown of larger manufactured plastic articles.

Sources of Plastic Debris

Although plastic debris may be generated both on land and at sea, it is generally believed that most of the debris in the marine environment comes from ocean sources. The amount of debris generated worldwide by ocean sources in the early 1970's was estimated to be about 6.4 million metric tons per year. While accidental loss of plastic items from ocean sources contributes to the problem of debris, deliberate disposal at sea is a greater problem. Deliberate disposal of such enormous quantities of waste may be explained in part by several factors. For example, alternative means of handling shipboard wastes such as grinders, compactors and incinerators are not only costly, but under certain circumstances highly undesirable. Furthermore, vessels that store garbage on board require adequate facilities on shore for disposal, but many ports both in the United States and abroad are ill-equipped for handling these wastes.

Commercial fishing operations are a major ocean source of domestic wastes and plastic fishing gear. Fishing gear may become lost accidentally due to gear failure caused by normal wear and tear, operational mistakes on the part of a fisherman, and storms. Gear conflicts among fishermen where both fixed and towed fishing gear are used in the same areas may also contribute to the accidental and, in some instances, deliberate loss of fishing gear. During gear mending procedures pieces of fishing gear are discarded, whereas entire nets, in particular gill nets, may be deliberately discarded when the total catch is too great to be hauled in. There are also reports of foreign fishermen cutting loose their nets when the U.S. Coast Guard has spotted them fishing in an illegal manner or location. However, extensive documentation of such deliberate gear losses is lacking.

In 1984, there were 24,000 commercial fishing vessels over 5 gross tons registered in the United States. According to the most recent (1977) regional breakdown, more than half operate in the North Pacific and a large portion of the remaining vessels operated in the Gulf of Mexico. Therefore, the amount of plastic debris generated by this source has been found to be greatest in the North Pacific, and would also be expected to be significant in the Gulf of Mexico.

The worldwide rate of disposal of domestic litter from merchant ships has been estimated at 110,000 metric tons, 0.7 percent of which is plastic. The amount of cargo-associated wastes including dunnage, shoring, pallets, wires and covers is estimated at 5.6 million metric tons per year. Merchant ships may also be a significant source of plastic pellets that have been reported in the marine environment. These pellets, used in packaging around larger objects in a ships hold or to reduce friction on a ship's deck during cargo transport, may escape during transit or unloading at port.

Other ocean-based sources of plastic debris include U.S. naval and research vessels, passenger vessels and, most importantly, privately owned recreational vessels. In 1984, 9.4 million recreational vessels were registered in the United States with the highest concentrations of these vessels in southern New England, the middle Atlantic, Chesapeake Bay and the Great Lakes.

Although the disposal of wastes from oil rigs and drilling platforms is strictly regulated, these structures are reportedly a major ocean source of plastic debris. The heaviest concentrations of these structures are off the Louisiana coast and offshore areas of Texas. In addition to the plastic debris generated by crew members on offshore structures in the Gulf, there are more than 1,000 vessels associated with exploration, development, serving, production and product transmission. All of these activities result in the generation of floatable or semi-buoyant trash and debris.

Land-based sources of plastic debris that are of particular concern include industries that synthesize plastic and manufacture plastic articles. Sediment samples from rivers, taken below outlet pipes of plastic factories, have contained concentrations of plastic pellets in the order of approximately 2,000 pellets per 2.5 cubic centimeters thus suggesting that plastic pellets are directly discharged into the river system by these industries.

In metropolitan areas, primarily along the North Atlantic coast, sewer systems that are combined with storm runoff systems generate large amounts of plastic debris via outfalls in marine areas during times of excess rainfall. Municipal wastewater treatment plants may directly discharge plastic debris from both primary and secondary sewage treatment plants. In the spring of 1976, an estimated 2,200 to 13,000 cubic feet per day of floatable materials had been dumped into the New York Bight area from raw discharges. Sewage sludge dumping in the ocean is also a potential source of plastic debris. Although plastic floatables in municipal sewage plants are routinely skimmed during treatment processes, approximately 5 percent escape screening and are dumped by barge along with treated sewage sludge. In the late 1970's an estimated 1,000 plastic tampon applicators were dumped with sewage sludge in the New York Bight every day.

Other land-based sources of plastic debris which have been identified include municipal solid waste disposal practices, docks and marinas, and littering by the public.

Regional Analysis

Much of the literature pertaining to the problems, types, and sources associated with plastic debris in North America focuses on the North Pacific where the National Marine Fisheries Service has directed its major Entanglement Program efforts. The subject of plastic debris has been documented to a much lesser degree for most other areas within the United States. In the Great Lakes region, for example, this issue has received very little attention. For purposes of identifying specific plastic debris problems and discovering possibly unique local solutions not documented in the literature, the research effort divided the United States into 10 coastal regions and the Great Lakes. Reports from federal wildlife refuge and seashore managers as well as discussions with other experts point out that plastic debris is clearly a nationwide problem. Overall, the most common types of problems being reported are the aesthetic degradation of coastal areas and the entanglement of wildlife. Of the various sources and types of plastic debris that cause entanglements, the two most commonly reported to cause problems of entanglement nationwide are monofilament fishing line and plastic six-pack connectors.

Although the occurrence of plastic debris is nationwide, and entanglements and beach degradation are reported from coast to coast, four coastal regions were identified to be of particular concern: Alaska, Massachusetts, the New York Bight, and Texas. As discussed above, fishing vessels in the North Pacific are a major source of plastic debris, and in keeping with this, experts in Alaska report that wildlife entanglement due to plastic debris items generated by ocean sources is a severe problem. On the other hand, the other three regions have severe problems with degradation of the aesthetic quality of their coastal areas. The types and sources of debris in these areas, however, differ. In Massachusetts, plastic items are generated by combined sewer outfalls in the Boston area. In the New York Bight plastic debris is coming predominantly from land-based sources. In Texas, large quantities of plastic debris come from offshore oil and merhant shipping activities.

Legal Authorities

There is a myriad of legal authority pertaining to ocean dumping and disposal of hazardous wastes, and regulating the taking of marine mammals and fish. Much of it may be applicable to controlling the kind of plastic debris that results in entanglement of marine organisms, but none of it addresses the issue specifically. This body of law can be divided into three types: laws that govern ocean dumping, including dumping of plastics; pollution laws that govern disposal of hazardous wastes and regulate water quality; fish and wildlife conservation laws that regulate how fish and marine animals may be taken by humans.

International authorities relevant include the London Dumping Convention, the MARPOL Protocol, the U.N. Regional Seas Program, the United Nations Law of the Sea, and other agreements similar in pattern to these major conventions. Each of these authorities is aimed at controlling dumping in the oceans. Certain substances are prohibited expressly, and others are permitted to be dumped under a regulatory scheme adopted by each of the nations party to the agreements. The major concern in relating these agreements to the entanglement issue is whether or not dumping of plastics is covered under the prohibitions. The key issue in using the London Dumping Convention to control dumping of nets is whether or not a net is discarded purposefully, or incidentally in the course of normal fishing operations. The MARPOL Protocol, on the other hand, does expressly denote fishing nets among prohibited disposals, and additionally covers accidental disposals. However, Annex V, which contains the language relevant to plastics, must be ratified by at least 15 nations whose fleets jointly constitute 50 percent of the gross tonnage of the world's shipping. To date, 14 nations have ratified the Annex, but their combined tonnage falls short of the requirement. The U.S. has not ratified the Optional Annex V. A major concern with all these agreements is that enforcement is difficult and left to the discretion of each signatory nation.

U.S. domestic legislation governing ocean or inland dumping is typified by the Rivers and Harbors Act of 1899, the Act to Prevent Pollution from Ships, the Marine Protection, Research and Sanctuaries Act (MPRSA), and the Clean Water Act. In addition to these major authorities, there are several other laws which may be applicable in narrow circumstances. Pertinent considerations in determining whether these laws

are applicable to entanglement include the extent of their jurisdiction, and whether or not plastics are covered substances under the definitions of each law. The major authority is the MPRSA or "Ocean Dumping Act." However, its applicability may be limited in that it regulates transportation for the purpose of dumping, rather than dumping itself. The second type of authority, aimed at land-based disposals, can be found in the Resource Conservation and Recovery Act, which regulates disposal of solid waste and prohibits dumping of hazardous waste. The key question with regard to plastics and entanglements is whether netting and other plastic debris can be defined as "hazardous" under the law. The final group of U.S. authorities examined is wildlife conservation law. Under these laws, such as the Marine Mammal Protection Act, the Endangered Species Act, the Migratory Bird Treaty Act, and the Fishery Conservation and Management Act, it is the taking of marine mammals and birds that is prohibited, rather than the disposal of materials that lead to entanglement. Under each of these authorities, entanglement would constitute a violation as an illegal "taking." As with other legislation, enforcement is difficult, since the prohibited activity takes place at sea.

Each of the states has enacted legislation on the state level to implement federal pollution control laws such as the Clean Water Act and the Resource Conservation and Recovery Act. The provisions of these laws are substantially the same as the federal law, though may be more restrictive. In addition, a series of laws known as "bottle bills" can be viewed as a solution to one segment of the entanglement problem. These laws in many states prohibit the sale and distribution of beverage containers that are connected by plastic rings or similar devices unless the connectors are bio- or photodegradable.

Programs

There are very few existing programs that address, or have the potential to address, the problems of plastic marine debris, even in areas where the problems are significant. The only federal agency that has a program specifically relating to entanglement is the National Marine Fisheries Service. Some existing federal programs, such as the National Sea Grant College Program, and the Chesapeake Bay program which resulted from a 5-year EPA study, are potentially relevant to the problem of plastic marine debris. Some states have programs that relate directly to legislation, for example beach cleanup programs and recycling programs. A limited number of private entities, including corporate and non-profit organizations, have specific programs relating to entanglement or other aspects of marine debris.

Conclusion

Evidence is emerging that the disposal of plastic debris in the marine environment is a serious problem for a number of species and for communities and user groups that depend on the marine environment. Even when the information is anecdotal, as it is in many cases, a synthesis of such anecdotal reports suggests that the biological and economic impacts may be significant.

Unfortunately, there have been few directed studies concentrating on particular regions or particular populations of animals. There are two areas of special concern in which further research is needed: endangered and threatened species for which entanglement has been documented, and regional areas where high concentrations of plastic debris have been reported.

Management agencies, at the federal, state and local levels, are not yet fully aware of the magnitude of this issue, and have not directed their efforts toward investigating the biological and economic impacts associated with marine plastic debris in a systematic manner.

The major sources of plastic debris in the marine environment have been identified. However, because of legal interpretation, enforcement problems, and the need for public education, effective means to control the use and disposal of plastics have yet to be implemented.

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INTRODUCTION

While the U.S. plastics industry has been in existence for over a century, the commercial development of today's major plastic materials first came about in the period of 1930-1940. Shortages of rubber and other materials during World War II brought plastics into great demand. Newer plastics such as polyethylene and polypropylene proved to be excellent substitutes for traditional materials such as wood, paper, metal and glass. When large scale plastic production commenced, reduced costs set the stage for a whole new era. By 1960, aproximately 6.3 billion pounds of plastic resin were produced in the United States. The early 1970's saw more than a three-fold increase in plastics production with over 20 billion pounds. In subsequent years plastic production continued to increase to the present value of over 47.9 billion pounds. In terms of volume, plastics are now one of the most important materials used in America today (The Society of the Plastics Industry 1986).

But even more notable is the growth in applications of plastic materials in the United States. In 1985 more plastics were produced than metal, glass, paper and leather while the use of plastics has surpassed that of these and other popular materials. In comparison to the value of shipments of other major industries, "miscellaenous plastic products" now ranks among the top ten biggest manufacturing industries in the country along with petroleum, automotives, electronics and industrial chemicals (The Society of the Plastics Industry 1986). Major markets for plastics now include transportation, packaging, building and construction, electrical and electronic goods, furniture and furnishings, consumer and institutional supplies, industry and machinery. In essence, plastics have become incorporated into virtually every industrial and commercial sector of America.

But what of the plastics that fall into disuse? The presence of plastic items that have been lost or disposed of in the marine environment has become of increasing concern among scientists, fishermen, conservationists and others. Unfortunately, one of the major characteristics of plastic that has made it so successful has been the basis for this concern—plastic is nonbiodegradable.

In recent years, there has been a growing body of evidence that nonbiodegradable plastic materials, as debris, are adversely affecting marine ecosystems in a multitude of ways. This report analyzes the issue of the use and disposal of nonbiodegradable plastics in the marine and Great Lakes environments of the United States. For the purposes of this report, the term "marine" encompasses the waters of the Great Lakes.

Part I of this report details information available in literature on the types and quanities of plastic debris found in the marine environment. The sources of these items of plastic debris are discussed in Part II. Part III examines the environmental and economic impacts and problems for human safety attributable to plastic debris and Part IV analyzes the problem caused by plastic debris on a regional basis.

Part V examines international, federal, and state authorities relevant to the disposal of plastics in the marine environment, focusing on the particular issues of entanglement of marine species in discarded plastic materials, or ingestion by marine biota of plastic debris. For purposes of the analysis, each law is examined as to its purpose; its authority, including responsible party or agency, provisions, and jurisdiction; its application to entanglement, including express provisions, constructions and interpretation by the courts, and possible new interpretations; its relationship to other laws; and its limitations, including further issues for review.

PART I

TYPES AND QUANTITIES OF PLASTIC DEBRIS

Plastic items that affect the marine environment as debris are generally categorized in literature as either manufactured plastic articles or raw plastic particles (Coleman and Wehle 1984). Manufactured plastic articles include those items that have been fabricated into consumer products such as fishing gear, packaging materials, bags, bottles and many other items. Raw plastic particles are typically in the form of small spherules or beads from which plastic products are manufactured. For purposes of this report types of manufactured plastic are further categorized as either fishing gear, cargo-associated wastes from merchant ships, and a wide variety of plastic items available for domestic purposes.

Although there is enough available information in literature to draw some general conclusions about the types of plastic debris found in the marine environment, quantitative data are insufficient for estimating total amounts of particular debris in any major geographic area (e.g. North American coastal waters or the Great Lakes). Most of the quantitative estimates of debris reported in literature provide information on only isolated concentrations in relatively localized areas. These distinct concentrations of plastics are subject to a multitude of controlling factors including tides, winds and currents (Wong, et al 1974, Shaw and Mapes 1979, Van Dolah et al 1980, Galt 1985, Merrell 1985, Reed and Schumacher 1985). Moreover, the types, as well as the quantities of plastic debris found in an area may be closely related to the identity and proximity of potential sources of debris. For instance, in areas of Alaska adjacent to major fishing grounds, the majority of reported debris items have been pieces of lost or discarded fishing gear (Merrell 1980, 1984, 1985). In heavily populated metropolitan areas such as New York, however, domestic wastes generated from land based sources are most prevalent (Swanson et al 1978).

Therefore, the quantitative information presented in this section is intended to indicate only localized concentrations of plastic debris. The lack of information on total quantities of specific debris in the marine and Great Lakes environments points towards the need for future studies to address this aspect of the plastic debris problem.

Fishing Gear

Nets

The introduction of synthetic fibers for manufacturing fishing gear is considered to have been one of the most important technological advances for the modern fishing industry (Kristjonsson 1959). Not only are plastic nets and lines lighter and more bouyant, but they are also stronger, more durable and ultimately cheaper than the formerly used natural fibers such as hemp, linen, cotton, manila and sisal (Uchida 1985). While nylon was the first of these plastics to be developed in Japan in 1949, the success with which it was received by the fishing industry stimulated the introduction of additional synthetics (Japan Chemical Fibers Association 1971). Subsequently, a spectrum of synthetic fibers, such as vinylon,

vinylidine, vinyl chloride, polyethylene, polyester, and polypropylene was developed. According to the Japan Chemical Fibers Association there are also over 10 different combinations of mixed fiber twines each of which may consist of up to four distinct materials.

The development of synthetic fibers was met with such success by the fishing industry that by 1964 almost all fishing nets were made entirely of synthetic fibers. By 1968, the Japanese production of synthetic fiber fishing nets was 18,000 tons, 5,600 tons of which were exported. Today, the majority of netting and ropes available from U.S. fishing supply companies are advertised as either nylon, polypropylene, or polyethylene.

Until recently, the amount of lost or discarded fish netting was highly speculative, largely because gear losses are almost never reported (Uchida 1985). Presently, this subject is still in the beginning stages of analysis. But various methods have been used in attempting to assess the types and quantities of lost or discarded netting including: estimation of the total amount of fishing net gear used in various fisheries and their relative probabilities of becoming lost (Uchida 1985); direct observation of net losses from fishing vessels (Low et. al. 1985); observation of derelict fishing nets at sea (Jones and Ferrero 1985, Carr et al 1985); and tabulation of accumulation rates of fishing gear on beaches (Merrell 1980, 1984, 1985).

A study conducted by Uchida (1985) was directed at the major net fisheries operating in the North Pacific Ocean. By calculating the amount of net gear available to these fisheries, this analysis provided an idea of the extent to which derelict fishing gear may become a component of marine debris. The gill net, which is essentially a wall of netting designed to entangle fish or other taxa such as crustaceans and mollusks, was concluded to be the most likely net type to become lost or damaged and discarded during fishing operations. This conclusion was based, in part, on the fact that the amount of gill net used in the North Pacific far exceeds the amount of net used in the other fisheries analyzed. The total length of all gill nets used by the 15 major North Pacific gill net fisheries is 170,466 km: when strung end to end this amount of gill net would extend a distance 4.2 times the length of the earth's equator.

The most extensive gill net fishing operations in the North Pacific are the drift gill net fisheries of Japan, Taiwan and Korea which primarily target species of squid, salmon and billfish. Every night during the fishing season each vessel operating within these fleets sets a drift gill net extending from 9 to 27 km in length (Eisenbud 1985), which is allowed to drift at sea and is recovered the next day. The combined distance of all nets set each night for these fisheries is estimated to be about 33,000 km (20,503 miles), for a total of 1,714,725 km (1,065,510 miles) each year.

In U.S. territorial waters, drift gill nets are used by the Japanese salmon mothership fishery. Each of the 172 catcher boats operates a drift gill net, 12 to 15 km long (Uchida 1985). The total length of these gill nets set in this fishery is 2,580 kilometers per day.

Trawl nets, which are bag-shaped nets towed behind a vessel, are considered to be the second most likely net type to be lost primarily because they are prone to snagging on the bottom (Uchida 1985). There are

an estimated 5,500 km of trawl net used by 12 major foreign and domestic trawl fisheries in the North Pacific.

Direct observation of net losses from fishing vessels has been carried out off Alaska where the most dominant fisheries are foreign and domestic trawl fisheries for groundfish species. In 1984, an estimated 322 trawlers were operating off Alaska, 93 of which were of U.S. origin (Low et al 1985). Based on observer reports from foreign vessels it was estimated that 65 nets or portions of net were lost in one year. The amount of netting material per trawl in the foreign fisheries ranges between 1,400 to 4,900 square meters but there is no reliable estimate of the total quantity of trawl gear damaged or lost.

Sighting net debris at sea is even more difficult. Net fragments are often undetectable from a ship if weather conditions are poor or if distance from a ship is great (Jones and Ferrero 1985). Since gill nets in particular are designed to be transparent in water, it is almost impossible to spot these items unless corks or buoys are attached. Gill nets without markers have only been recorded when they have been retrieved during active fishing operations. Therefore, it is believed that sightings of net debris are underestimations of the true amount of this debris present in an area. During 973.2 hours of searching covering 8,759 nmi in a major fishing area of the North Pacific where sightings of gill nets were expected there were only 3 sightings of trawl net fragments and 9 sightings of gill net fragments. The trawl net pieces were each about 2 m and the gill net fragments ranged from 0.5 to 150 m in size. Observations along two shipboard transects in the North Pacific between Alaska to Honolulu, Hawaii and then on to Japan found only 3 pieces of gill net, 1 trawl fragment and an unidentified piece of netting (Dalhberg and Day 1985).

Although the net debris described above consists primarily of sightings of fragments, larger pieces or entire nets have been found at sea. DeGange and Newby (1980), aboard a salmon research vessel, observed a 3,000 m lost gill net in the Western North Pacific. The crew of this vessel managed to retrieve 1500 m of this net, leaving the remainder afloat. Off Agattu Island, a vessel retrieved an abandoned gill net which measured approximately 15 km (Jones and Ferrero 1985).

Some fisheries, such as the New England groundfish gill net fishery, anchor nets from 900 to about 1,100 meters in length on the bottom to catch demersal species. Once lost, these anchored nets stay submerged. Therefore a more appropriate technique for at-sea observations is from a submersible vessel. In 1984 the submersible Johnson Sea-Link II made 13 dives to survey prime fishing sites in the Gulf of Maine for lost gill nets (Carr et al 1985). More than 100 acres of major gill net fishing grounds were covered by the submersible and 10 lost gill nets were sighted. In 1985, 14 more dives were made in this area covering over 173 acres; only one lost gill net was found (Carr 1986).

The only real standardized beach study of net debris was conducted in Alaska (Merrell 1980, 1984, 1985). During the 4 years of surveys on Amchitka Island, trawl net fragments were found to be the most common item, constituting 76-85% of the weight of all plastic litter collected. In 1974, 272 kg of trawl web was found per kilometer of beach. Merrell also demonstrated that the amount of net debris on a beach can be reduced if

disposal is minimized: in 1982, the weight of trawl web decreased to 172 kg/km and this was attributed to a decrease in trawling activity in this area.

Fragments of lost or discarded fishing gear have also been analyzed on islands in the Hawaiian Archipelago in areas of critical habitat for the endangered Hawaiian monk seal. On Lisinaki Island, 73 net fragments which were large enough to entangle Hawaiian monk seals were counted on the beaches during a 6-month period (Henderson 1984). Many fragments of netting and other types of fishing gear are thought to foul on the 100 m wide reefs ranging from small pieces less than 1 square meter to entire nets weighing over 100 kg.

Information on the types and quantites of lost commercial fishing nets that has not yet been reported in literature is found in the files compiled by the National Marine Fisheries Service (NMFS) under the Fishing Vessel and Gear Damage Compensation Fund of the Fishermen's Protection Act. This fund provides monetary compensation to U.S. fishermen engaged in a fishery subject to U.S. management, while in the Fishery Conservation Zone. Originally, the fund was intended to compensate fishermen for vessel and gear losses incurred by foreign fishing activities. In reality, however, fishermen may receive compensation for such losses caused by any vessel and for any damage even if the actual causal factor is unknown (Bean 1984). The fund is financed by fees imposed on foreign fishing vessels permitted to fish in the U.S. Fishery Conservation Zone.

Fisherman who file for compensation under this fund must include a full inventory of all property involved in the casuality, including the number and description of all components lost, damaged or destroyed. During the past three years, from 1983 to February 1986, a total of 329 individual cases have received compensation under the Fishing Vessel and Gear Damage Compensation Fund (Table 1). Of the cases involving nets, most were reports of lost or damaged gill nets by fishermen in New England.

In order to obtain information on the quantity of fishing gear reported lost to the Fishermen's Vessel and Gear Damage Compensation Fund, files for fiscal year 1985 to present (March 1986) were examined. In 1985, 136 cases were available for review. Twenty-one cases involved gill net losses reported by fishermen engaged in the groundfish gill net fishery in New England (Table 2). A total of 525 gill net units were reported lost, each measuring 91 meters in length. Therefore a total of 48 km (157,500 feet or 30 miles) of gill net were lost in one year. An additional 15 cases were reported by groundfish gill net fishermen in 1986 (Table 2). The total amount of gill net units for this period was 320, totalling over 29 kilometers (96,000 feet or 18.18 miles).

There is presently only one state program that maintains records and provides compensation for gear losses that occur in state waters: the Fishermen's Gear Compensation Fund administered by the Louisiana Department of Natural Resources, Division of State Lands. From 1979 to date, over 3,200 claims for lost or damaged equipment have been received, the majority of which are for shrimp trawls which utiliize nets varying in length from ten to seventy feet (Wagner pers. comm). Estimates of the amount of lost as opposed to damaged gear were unavailable.

Table 1. Cases filed under the Fishermen's Vessel and Gear Damage Compensation Fund for 1983 through February 1986.

Region	Gear Type	Number of Cases	Amount Paid
Alaska	pot/trap (fixed)	24	226520.18
Northeast (ME to MD)	gill net (fixed)	57	138134.73
	long line (mobile)	2	9175.50
	pot/trap (fixed)	2	615511.17
	trawl (mobile)	124	10546.63
Northwest (WA to OR)	pot/trap (fixed)	49	424046.03
	trawl (mobile)	2	16317.06
Puerto Rico	pot/trap (fixed)	1	3291.96
Southeast (VA to TX)	gill nets (fixed)	2	1121.32
	longline (mobile)	3	891.21
	pot/trap (fixed)	57	219749.23
	trawl (mobile)	2	2312.19
Southwest (CA)	gill net (fixed)	2	8216.07
	pot/trap (fixed)	1	0.0
Total		329	1675833.27

Table 2. Cases reported to the Fishermen's Vessel and Gear Damage Compensation Fund involving gill net losses in New England for 1985 through March 1986.

Case No.	Location	Number of Net Units Lost*	Amount Paid
		1985	
2	Chatham, MA	11	2,224.97
4	S. Portland, ME	27	4,462.00
9	Chatham, MA	15	2,775.00
10	Chatham, MA	11	1,969.00
11	Chatham, MA	14	2,776.00
16	Chatham, MA	15	3,034.05
20	N. Hampton, NH	20	3,511.65
30	Chatham, MA	9	1,820.43
31	Kennebunk, ME	12	2,113.80
32	Gloucester, MA	40	5,910.00
38	Scituate, MA	28	4,383.00
39	Gloucester, MA	66	11,322.60
70	Amesbury, MA	33	4,558.50
71	N. Hane, NH	13	2,319.29
75	Portland, ME	8	1,302.97
107	Portsmouth, NH	63	13,104.00
120	N. Hane, NH	22	3,745.29
122	Newburg, MA	35	5,433.75
125	Essex, MA	39	7,200.00
127	Brewster, MA	24	5,803.14
134	Scituate, MA	21	3,912.55
Total		**525**	**95,695.80**
		1986	
12	unknown	18	3,344.90
6	Chatham, MA	7	1,912.50
5	unknown	15	unknown
33	N. Hampton, NH	22	4,207.86
3	Portland, ME	15	2,887.90
30	unknown	12	3,282.00
48	Nashua, NH	45	6,068.26
26	W. Yarmouth, MA	33	6,696.50
25	N. Chatham, MA	9	1,185.00
21	Chatham, ME	12	4,840.00
40	Gloucester, MA	32	6,005.00
38	Scituate, MA	17	3,655.00
49	E. Hardwich, MA	10	2,374.36
32	Matsfield, MA	30	5,198.25
17	Hampton, NH	31	5,688.79
Total		**246**	**47,881.06**

*** 1 unit of net equals 500 feet.**

Traps

Synthetic netting materials are also used in the construction of side panels for wood and metal traps employed in the various trap fisheries of the United States (Smolowitz 1978b, High and Worlund 1979). Wooden traps used in the New England lobster fishery, for example, have synthetic panels typically of nylon or polpropylene (Blackmore pers. comm.). According to Ketcham Traps, a supplier of lobster trap building materials in New Bedford, Massachusettes, an average of 4 square feet of netting is required for a standard size (36"x21"x12") wood trap (Purtell pers. comm.). In 1984, a reported 2.5 million traps were used in the New England lobster fishery (Fogarty pers. comm.). It is estimated that 20% or more of these traps are lost each year (Smolowitz pers. comm.).

King crab traps are also constructed of synthetic webbing or plastic-coated wire (Smolowitz 1978b, High and Worlund 1979). King crab fishermen in Alaska report losing approximately 10% of their pots each year and more than 30,000 king crab traps have been estimated to have been lost since 1960 (High and Worlund 1979). Consequently gear losses by these fisheries could well be contributing to the plastic debris problem in the marine environment.

Furthermore, there appears to be a growing demand for plastic and plastic-coated wire traps in U.S. commercial trap fisheries. These traps are not only impervious to wood-boring organisms, but they also offer additional conveniences to fishermen (Smolowitz 1978b). Plastic-coated and wire traps are lighter and easier to handle out of water than wood traps, and are heavier and more reliable in water. Some plastic traps are made to be collapsible and easily stacked, therefore conserving vessel deck space. In addition, coatings on wire traps minimize corrosion and may extend "trap life" beyond 10 years and plastic traps never corrode. Lobster fishermen report that plastic-coated traps are as efficient as other types and the trend to use these traps, at least in this fishery, is well underway.

Another example is the stone crab trap fishery in the Gulf of Mexico. Although traps used in this fishery have traditionally been made of wood many commercial fishing supply companies now advertise plastic stone crab traps (Figure 1). In the 1979-80 stone crab fishing season an estimated 297,600 traps were used by crab fishermen (Gulf of Mexico Fishery Mangement Council, 1981). At the same time only 5 to 10 percent of all traps were reported to be metal or plastic (Gulf of Mexico Fishery Mangement Council, 1979). However, the number of traps in this fishery has been increasing (Gulf of Mexico Fishery Management Council, 1981) and major trap losses are known to occur in this fishery every year. In one area of this fishery along the west coast of Florida 25 percent of the 96,000 traps in use were reported lost (Gulf of Mexico Fishery Management Council, 1984b). Therefore, if plastic traps come into widespread use, this fishery may also contribute to the plastic debris problem.

Plastic Buoys and Ropes

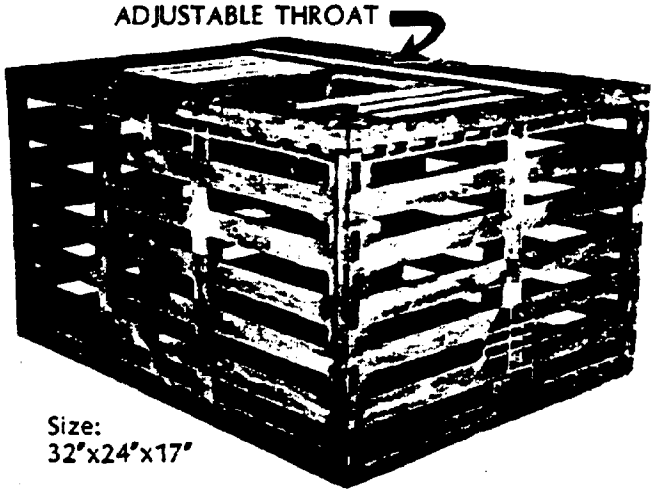
There has been little attempt to quantify the amount of buoys or rope lost by commercial fisheries operating in the marine environment. This is possibly attributable to the complex nature in which these items are used. For example, more than 2.5 million gill net floats are used in North

Figure 1. Advertisement of plastic traps that could pose a threat to fishery resources due to "ghost fishing."

PLASTIC TRAPS

PLASTIC!

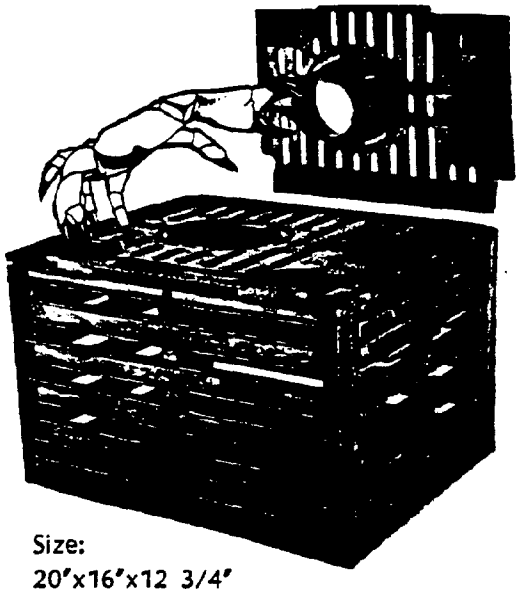
LOBSTER TRAPS
(KNOCKED DOWN)



Size:
32"x24"x17"

TRAP WITH WOOD LATH LID.....$ 36.75 each
TRAP WITHOUT WOOD LATH LID...$ 34.75 each
WOOD LATH LID.....$ 2.00 each

THE LOBSTER TRAPS ARE SOLD "KNOCKED DOWN" FOR LOWER SHIPPING CHARGES TO YOU.



Size:
20"x16"x12 3/4"

PLASTIC CRAB TRAPS
(KNOCKED DOWN)

These new plastic traps have been designed for the commercial fishing industry. The traps are virtually maintenance free and feature removable bait boxes.

TRAP w/REMOVABLE BAIT BOX....$ 24.00 each

THE CRAB TRAPS ARE SOLD "KNOCKED DOWN" FOR LOWER SHIPPING CHARGES TO YOU.

Atlantic & Gulf
FISHING SUPPLY CORP.
591 S.W. 8th Street • Miami, Florida 33130

pacific fisheries each year (Merrell 1984). In 1982, Japanese salmon catcher boats used 15,000 floats on each of their 172 drift gill nets which were fished every day. During 1978-81 an average of 296 km of gill net was lost annually along with approximately 295,000 floats.

Gill net floats were found to be the most common plastic litter item on Amchitka Island, Alaska, during beach surveys conducted for the period 1972-1982 (Merrell 1984). A dramatic decrease in the number of floats found on these beaches (from 126/km in 1974 to 59/km in 1982) was attributed to a decrease in gill net fishing activity off Alaska during this time period.

Floats used to suspend trawls, and inflatable buoys used in the king crab trap fishery as surface markers, were found on Amchitka Island in 1982 densities of 5.4 trawl floats and 2 inflatable buoys per kilometer of beach (Merrell 1984).

Merrell (1980, 1984, 1985) also reported on the amount of synthetic fiber rope found on Amchitka Island beaches. Most of the rope found was presumed to be from trawl fisheries although some was attached to buoys from crab traps. During 1974 to 1982 the weight of rope found decreased 60% (from 36 to 14 kg/km) and cumulative length decreased 30% (from 802 to 565 m). The total number of pieces, however, remained similar with 25.9 pieces per km in 1974 and 24.5 pieces per km in 1982.

The number of buoys and ropes mentioned above were found on a single isolated beach. It is impossible to estimate the total number of these items lost in North American waters. Files kept by the Fishermen's Vessel and Gear Damage Compensation Fund suggest that total amounts of lost bouys and rope are staggering. In the states of Oregon and Washington a total of 1042 buoys and over 142 km (465,906 feet) of rope were reported lost (Table 3). King crab fishermen who reported trap losses used 2-3 buoys per trap. Therefore, the previous estimate of 30,000 king crab traps lost since 1960 (High and Worlund, 1979) may represent more than twice as many lost buoys inthe king crab fishery alone. The 34 stone crab fishery claimants reported a loss of 16,611 traps (Table 4). Each trap used in the stone crab fishery in the Gulf of Mexico is marked with a single buoy. Consequently, the loss of 16,611 traps represents a loss of an equal number of lost buoys. Each buoy is connected to a trap by a synthetic line averaging 91 m (50 feet) (Swingle pers. comm.). Therefore, the loss of 16,611 traps also represents a loss of approximately 253 km (830,550 feet or 157 miles) of rope.

Monofilament Fishing Line and Other Plastics Related to Fisheries

Lost or discarded monofilament fishing line is also becoming an increasing problem (Merrell and Fowler 1986). However, the amount of monofilament line used by fishermen, and the potential for such gear to be lost or discarded, is unknown.

Plastic bags for bait, ice and salt sold to commercial as well as recreational fishermen, are also known to become lost or discarded and contribute to the problem of debris. According to one fishing gear

Table 3. Cases examined of traps and buoys lost in the states of Oregon and Washington for 1985 reported to the Fishermen's Vessel and Gear Damage Compensation Fund.

Fishery	Number of Traps Lost	Number of Buoys	Amount of Rope (feet)
Black Cod	22	12	26,400
Black Cod	62	14	43,200
Black Cod	53	9	41,160
Black Cod	60		36,000
Subtotal	**197**	**35**	**146,760**
Sablefish	98	78	94,800
Sablefish	60	22	44,922
Sablefish	320	16	38,400
Sablefish	41	20	4,800
Subtotal	**519**	**136**	**182,922**
Dungeness	74	148	22,200
Dungeness	73	368	24,090
Dungeness	28	112	10,080
Subtotal	**175**	**628**	**56,370**
King Crab	18	54	51,084
King Crab	12	60	9,180
King Crab	21	105	13,974
King Crab	12	24	5,616
Subtotal	**63**	**243**	**79,854**
TOTAL	**954**	**1,042**	**465,906**

Table 4. Cases examined for stone crab traps lost in 1985 as reported to the Fishermen's Vessel and Gear Damage Compensation Fund.

Case No.	Number of Traps	Amount Paid
40	316	6,715.00
41	614	11,229.95
45	438	6,679.50
51	179	3,155.00
79	853	12,504.98
80	634	9,294.44
89	935	14,025.00
91	656	11,947.50
92	543	8,280.75
93	222	4,420.10
95	137	1,500.15
97	258	3,934.00
98	398	6,069.50
99	256	3,840.00
100	400	6,100.00
101	257	3,919.25
102	280	4,981.68
103	192	3,148.24
104	805	13,286.21
108	240	3,600.00
110	721	10,995.25
111	907	13,831.75
112	257	unpaid
113	983	17,236.50
114	957	15,579.96
116	481	7,830,68
117	316	6,368.75
118	65	977.60
119	350	4,137.88
121	1130	16,950.00
124	430	6,557.50
126	256	3,840.00
128	171	2,607.75
135	974	21,953.96
TOTAL (34 cases)	**16,611**	**267,498.08**

supplier, about 50,000 boxes of frozen herring wrapped in plastic are sold each year to the longline and troll fleet of southeast Alaska (Paul 1984). Some have noted these types of bags to be numerous on coastlines in the United States (Neilson 1985).

Cargo Associated Wastes

Two plastic items of debris which are associated with cargo shipping activities and are known to affect the marine environment as debris are plastic strapping bands and large pieces of plastic sheeting.

Plastic strapping bands are used to bind items individually or in boxes (Figure 2). According to Cyklop Strapping Corporation, one of the major worldwide strapping manufacturers, plastic strapping has replaced steel straps because it is lightweight, it does not rust, it is less dangerous when cut, and it is about half as expensive as steel (Sommers pers. comm.). Plastic straps are primarily made of polypropylene, although recycled polyester terephthalate (PET) and, to a lesser extent, nylon straps are also produced. Polyester strapping has a breaking strength of 500 to 1,100 pounds and is used for shipping items that require high strength and high tension (Plastic Bottle Information Bureau 1986). Strapping materials are produced in a variety of widths and are sold in 2 forms: "hand grade" strapping which is secured manually with a buckle or metal strap, and "machine grade" strapping sealed with heat.

According Cyklop, strapping materials are used extensively by the beverage container, corrugated box, and other industries. The U.S. Post Office also uses a great deal of strapping. Sommers estimated that the total amount of strapping materials sold in the U.S. are 75 million pounds/year of polypropylene, 50 million pounds/year of PET (Sommers stated that these estimates may be off by $\pm$ 20 million). It is not possible to convert these figures to total length, however, because of the variety of lengths per roll depends on the width of the strapping.

Plastic strapping becomes a problem as debris when these bands are removed off the end of a package without cutting them, and subsequently cast off cargo ships (Cawthorn 1985). Merrell (1984, 1985) reported plastic straps on Amchitka Island which were used in trawl fisheries to bind boxes of frozen fish, nets, and other items for shipment. Strapping bands were the second most abundant item found in beach surveys of plastic debris. In 1982, the average density of straps were 58 straps per kilometer of beach. In 1974, an average of 71 straps was found per kilometer. The reduction in straps from 1974-1982 coincided with the decrease in trawl fishing effort off Alaska during this period.

Neilson (1985) reported finding 2,055 plastic strapping bands during an organized beach cleanup that covered 350 miles along the coast of Oregon.

Large sheets of plastic, used in cargo shipments to cover items during transportation, are also frequently reported as debris. One pound of this sheeting will cover 28 square feet of beach (King 1985). Although there is no available documentation of the amount of this material generated as debris, plastic sheeting has been reported to be the most abundant litter item found on Padre Island National Seashore in Texas.

Figure 2. Plastic strapping band found in Alaska. Photo: T.R. Merrell

Domestic Plastics

The most diverse category of plastic debris known to affect the marine environment includes plastic packaging materials, bags, containers and a multitude of other items used for domestic purposes. Essentially, the items that fall into this category include all plastic articles that are not fishing or cargo-associated wastes. Much of the plastic litter that has been observed on beaches and at sea is made up of these everyday items (Paul 1984). Plastic domestic articles most commonly reported as marine debris include the following: bags, sheets, six-pack connectors used for carrying canned beverages, containers, bottles, tampon applicators and pieces of styrofoam.

Over the past decade the use of plastics in packaging has more than doubled: in 1975 nearly 5.6 billion pounds of plastics were used in packaging, in 1985 this figure increased to about 12.8 billion pounds. Production of plastic bottles in 1984 exceeded 17.4 billion units, 7.3 billion of which were food and beverage bottles containers. The remaining were primarily for household chemicals (2.9 billion) medicinal and health (2.8 billion) and toiletries and cosmetics (2.3 billion). An additional 5.8 billion pounds of polyethylene, polypropopylene and other thermoplastics were used in the production of flexible packaging including household and institutional refuse bags and film. The amount of trash bags produced in 1984 alone used 902 million pounds of plastic (The Society of the Plastics Industry 1986). It is virtually impossible, however, to determine just what amount of domestic plastic items are either accidentally or intentionally discarded in the marine environment.

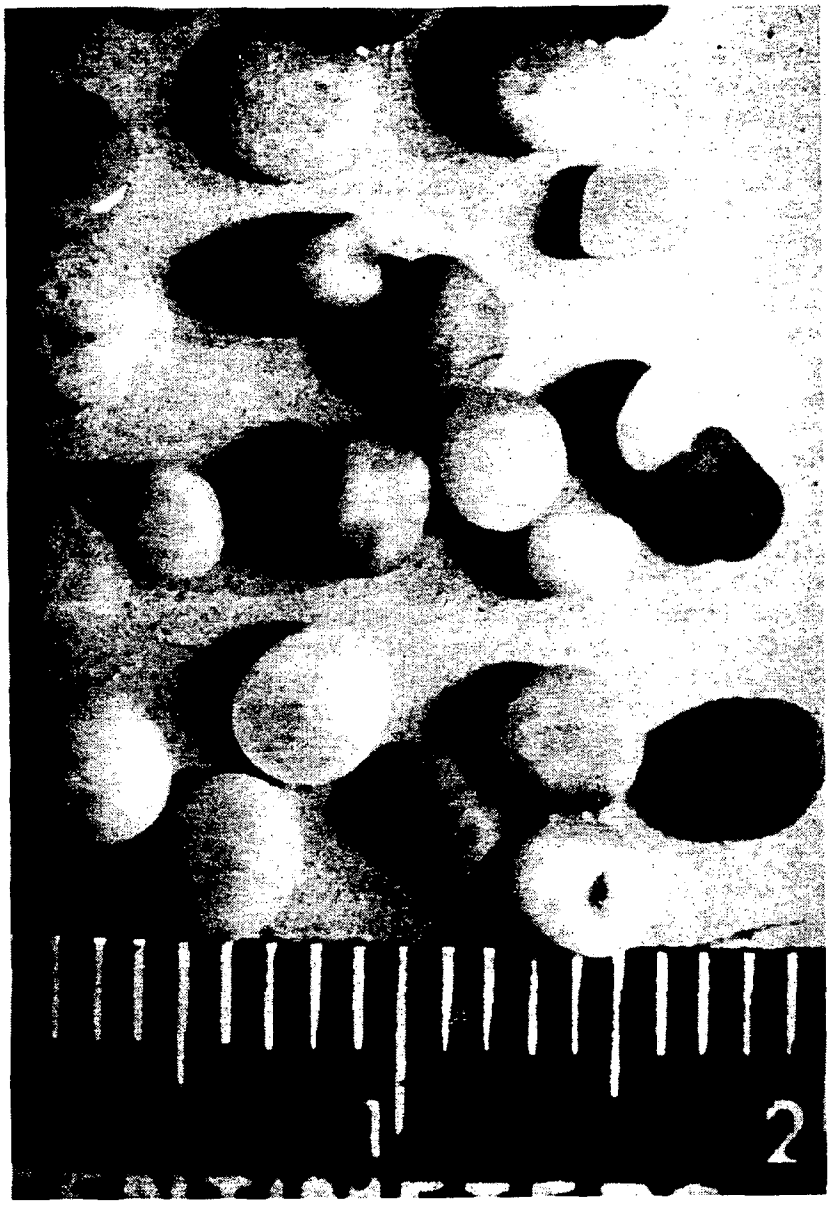
Plastic Pellets and Fragments

The occurrence of small plastic particles in marine areas has been documented repeatedly in the past decade (Carpenter et al 1972, Carpenter and Smith 1972, Colten et al 1974, Hays and Cormons 1974, Morris 1980, Van Dolah et al 1980, Gregory 1979, 1983). The two major types of these particles are raw plastic pellets and small plastic fragments.

Raw plastic pellets (Figure 3) are the raw form of plastic after it has been synthesized from petrochemicals (Day et al 1985). In 1985, 47.9 billon pounds of plastic resin were produced in the United States (The Society of the Plastics Industry 1986). Pellets are transported in bulk to manufacturing sites, where they are melted down and fabricated into a multitude of plastic consumer goods. Pellets found in marine areas are typically described as being spherical or cylindrical and range in size from 0.2-6 mm in diameter (Coleman and Wehle 1984, Hays and Cormon 1974, Colton et al 1974). The chemical composition of plastic pellets reported to occur in the marine environment has included polystyrene, polyethylene and polypropylene (Hays and Cormons 1974, Morris 1980).

Raw plastic pellets have been found both on beaches and at sea. In the United States, concentrations of 1,000 - 2,000 pellets were found in handfuls of sediments taken along a river bank in the vicinity of a plastic manufacturing plant (Hays and Cormons, 1974). Concentrations at sea were reportedly 3,500/km2 in the Sargasso Sea (Carpenter and Smith 1972). Colten et al (1974) noted a widespread distribution of particles in the coastal, slope and Gulf stream waters between Florida and Cape Cod. Van Dolah et al

Figure 3. Raw plastic pellets. Photo: R. Day



(1980) documented an extension in the range of plastic particles into the offshore waters of the South Atlantic. In the Pacific, Wong et al (1974) found a maximum of 34,000/km^2.

Plastic fragments, on the other hand, result from the breakdown of larger manufactured plastic articles. Guillet (1974) and Gregory (1978, 1983) reported that weathering of polyethylene and styrofoam occurs naturally and eventually leads to disintegration. However, Gregory (1983) noted that it would require 3-50 years for complete disintegration to occur on a beach, and much longer at sea.

Merrell (1984, 1985) reported plastic fragments larger than 5 mm to be the most numerous plastic item on Amchitka Island, Alaska. The number of plastic fragments found per kilometer of beach increased progressively from 33.5 in 1972, 64.0 in 1973, 137.4 in 1974 and 305 in 1982. He found that this increase in plastic fragments correlated with a decrease in overall numbers of other larger items of plastic litter, which were apparently disintegrating.

PART II

SOURCES OF PLASTIC DEBRIS

As can be ascertained from the previous section, the types of plastic debris found to occur in the marine environment encompass a broad range of objects. While certain items can be easily traced to particular sources, others may be generated from several different and sometimes unspecifiable sources. Although plastic debris may be generated both on land and at sea, it is generally believed that most of the debris in the marine environment comes from ocean sources (Coleman and Wehle 1984).

Ocean Sources

The worldwide rate of disposal of garbage from ocean sources in the early 1970's was estimated to be about 6.4 million metric tons per year (National Academy of Sciences 1975). Morover, according to the Academy this litter is concentrated unevenly in the Northern Hemisphere. Although more recent estimates are not available, the disposal of wastes from ocean sources is an increasing problem and continues essentially because it is inexpensive and convenient (Merrell and Fowler 1986). Alternative means of handling shipboard wastes such as garbage grinders, compactors and incinerators are not only costly, but under certain circumstances highly undesirable. Small vessels do not have the space for large waste-processing equipment. For larger vessels, such equipment is often either not durable enough to handle shipboard shock and vibration, or is considered to be a potential safety hazard such as incinerators (Koss pers. comm.).

Furthermore, vessels that store garbage on board require adequate facilities on shore for disposal. But many ports both in the United States and abroad are ill-equipped for handling these wastes (Horsman 1982, Merrell and Fowler 1986). Consequently, in many situations garbage, including plastics, is routinely disposed of overboard.

Accidental loss of plastic items from ocean sources also contribute to the problem of debris. The following section describes the means by which plastic is either discarded deliberately or lost accidentally from ocean sources at sea.

Commercial Fishing Industry

Commercial fishing operations are known to be a source of plastic debris in the form of domestic wastes and fishing gear. The National Academy of Sciences (1975) estimated that the average rate of domestic waste, including plastics, generated by vessel crews is 0.8 kg per person per day. Using this figure, the Academy arrived at two estimates of total amounts of domestic wastes generated by fishing fleets. The first, based on a worldwide fishing fleet of 120,000 vessels over 5 gross tons, with an average crew of 20 per vessel, was calculated as follows:

$$(120{,}000 \text{ vessels}) \times (20 \text{ persons/vessel}) \times (240 \text{ days}) \times (0.8 \text{ kg/person-day})$$

$$= 460{,}000 \text{ metric tons/year}$$

The Academy arrived at a second estimate of 220,000 metric tons, using fishery catch statistics. The Academy's final calculation of total domestic wastes generated by the world fishing fleet was an average of these two figures, or 340,000 metric tons per year.

No similar calculations have been made for fishing fleets in U.S. waters specifically. In 1984 there were 24,000 commercial fishing vessels over 5 gross tons registered in the U.S. The total number of fishing vessels was 127,400 (O'Bannon pers. comm.). Therefore, using the Academy's variables above the amount of debris generated by U.S. commercial fishing vessels could be:

(24,000 vessels)x(20 persons/vessel)x(240 days)x(0.8 kg/person-day)

= 92,160 metric tons/year

This amount does not include wastes generated by foreign fisheries operating within U.S. waters.

The most recent regional breakdown of the location of U.S. vessels over 5 gross tons is available for 1977 (Table 5). At this time more than half (7,643) of the vessels operated in the North Pacific and a large portion of the remaining vessels (5,328) operated in the Gulf of Mexico. Therefore, the amount of potential debris generated by commercial fishing operations would be assumed to be greatest in these regions.

The Academy also estimated that the world's commercial fishing fleet generates one thousand metric tons of plastic fishing debris including nets, lines and buoys every year.

There are many reasons why fishing gear may become lost accidentally. Gear failure caused by normal wear and tear may cause nets, lines and buoys to separate from a fishing unit. If marker buoys are lost, submerged nets and traps may not be retrievable. Operational mistakes, such as setting traps too deep, may also cause accidental gear loss. Towed or dragged gear is highly suspectible to becoming hung on bottom structures (Uchida 1985). Another form of accidental loss of gear may be caused by storms which may either relocate gear or destroy gear. In 1985, for example, approximately 25,000 spiney lobster traps were estimated to have been lost in the Florida Keys due to Hurricane Kate (Sigo 1986).

Gear conflicts may result in significant amounts of accidental gear loss especially in areas where both fixed or stationary gear, such as traps or set gill nets, are being used in the same areas as towed or dragged gear, such as trawl nets or draggers. In New England, the increase in both commercial and recreational fishing pressure in the groundfish fishery has intensified the problem of gear conflicts. Since bottom gill nets and trawlers are fishing for groundfish within the same prime fishing grounds, gill net losses are not uncommon (Carr et al 1985). On the other hand, recreational fishing by dragging hooks over the bottom causes the fouling of gill nets and the loss of hooks and lines.

Table 5. Regional distribution of U.S. commercial fishing vessels for 1977.

	VESSELS (by tonnage)			
Region	**5 tons or more**	**less than 5 tons**	**other**	**total**
New England	929	15,221	230	16,380
Middle Atlantic	573	11,261	61	11,895
Chesapeake	2,058	18,765	275	21,098
South Atlantic	1,463	6,417	255	8,135
Gulf	5,328	10,929	44	16,301
Pacific	7,643	14,937	496	23,076
Great Lakes	217	446	55	718
Mississippi (and tributaries)	----	9,654	201	9,855
Hawaii	101	----	----	101
TOTAL*	**18,312**	**87,630**	**1,617**	**107,559**

***Exclusive of duplication**

Source: U.S. Dept. Commer. 1984. Fishery Statistics of the United States, 1977. Statistical Digest No. 71.

There is also an ongoing conflict among draggers and lobster trap fishermen in New England. Draggerman have stated that they are finding it increasingly difficult to make a tow without coming in conflict with lobster pots (Stevens 1985). In 1985, lobstermen had lost more than $120,000 worth of gear and this figure was predicted to double by the time all reports were in.

Gear conflicts among fishermen may also contribute to the deliberate, rather than accidental, loss of fishing gear. For example, in the Gulf of Mexico where stone crab trap fishermen and shrimp trawlers are in competition for the same fishing area, incidents have occurred where trawl gear has become fouled on barbed wire that has been secured to cinder blocks and stone crab traps in the conflict area (Gulf of Mexico Fishery Management Council 1984a).

During gear mending procedures pieces of nets or other fishing gear are deliberately discarded. Although a large portion of debris may be generated in this way, there is a need for more information on the frequency of this occurrence (Gerrodette 1985). Entire nets, in particular gill nets, are also deliberately discarded at times when the total catch is too great to be hauled in (Anonymous 1985, Uchida 1985). In addition, there are also reports of foreign fishermen deliberately cutting loose their nets to avoid U.S. fishing infractions when spotted by the Coast Guard (Stevens, 1985). However, extensive documentation of such deliberate gear losses is lacking.

Merchant Shipping Industry

The world's merchant shipping fleet is suspected to be a major source of cargo-associated wastes as well as domestic wastes. The amount of cargo-associated wastes including dunnage, shoring, pallets, wires and covers was estimated at 5.6 million metric tons per year based on a fleet of 19,600 ocean-going vessels greater than 1,000 gross tons and a cargo waste rate of 285 tons/ship/year.

The annual worldwide rate of disposal of domestic litter from crew members has been estimated at 110,000 metric tons, 0.7 percent of which is plastic (National Academy of Sciences 1975). This annual rate was calculated as follows:

$$(9{,}101 \text{ ships/day}) \times (40 \text{ crew/ship}) \times (365 \text{ days})$$

$$= 140{,}000{,}000 \text{ crew (per year)}.$$

Each crew member was estimated to generate 0.8 kg of litter per day. Thus:

$$140{,}000{,}000 \text{ crew/year} \times 0.8 \text{ kg/day}$$

$$= 110{,}000 \text{ tons/year}.$$

According to Horsman (1982) each person aboard a merchant ship dumps 0.3 plastic containers at sea every day. Horsman assumed that the average number of crew members on a merchant ship is 30 and calculated from the Lloyd's Register of 71,000 ships in 1979, that 639,000 plastic containers are disposed of daily by the world fleet.

Although there are no estimates of the total amount of waste generated specifically within North American waters, according to the U.S. Department of Transportation there are currently 734 merchant ships (over 1,000 gross tons) registered in the United States (U.S. Maritime Administration pers. comm.). Although many of these vessels are transoceanic, presently 178 ships are listed to operate solely within North American waters. However, many more foreign, in addition to U.S. ships operate within U.S. waters and ports.

Merchant ships may also be a significant source of the plastic pellets that have been reported in the marine environment (Day et al 1985). Since plastic pellets are shipped worldwide, escapement of pellets may occur during landing and unloading. Pellets are also used in packaging around larger objects in ships' holds and therefore may escape during handling. To reduce friction for moving large objects, some ships use pellets on their decks which are then washed overboard (Anonymous 1981b, as cited Day et al 1985).

The United States Navy

The United States naval and research vessels also contribute to the plastic debris problem. There are approximately 600 vessels in this fleet with an estimated population of 285,000 (Parker, pers. comm.). The total amount of waste including plastic, rubber, metal, wood, paper, glass, cloth and garbage is 1.38 kg (3.04 lbs)/man/day, 0.005 kg (0.01 pounds) of which is plastic (Parker and Yang, 1986).

The U.S. Navy acknowledges that wastes are typically thrown overboard on many of their vessels (Koss, pers. comm.). Even ships with compactors use plastic bags to dispose of compacted trash at sea. Although Navy regulations require that all trash must be negatively buoyant, this would be difficult to control for lightweight plastics. Naval technicians, however, are presently developing alternative and feasible means for handling shipboard wastes. They are also investigating a type of biodegradable bag which is used by the Royal Navy.

Passenger Ships

Large passenger ships also constitute a source of debris. The National Academy of Sciences (1975) estimated that passenger ships serving U.S. ports generate 28 thousand metric tons of litter per year, 1.8% (504 metric tons) of which is plastic. Each person onboard a passenger ship is estimated to generate approximately 0.03 kg of plastic litter per day.

Recreational Vessels

Privately owned recreational vessels also contribute to the debris problem. In 1984, the Department of Transportation reported that 9.4 million recreational vessels were registered in the United States (Table 6). Figure 4 shows that regions of southern New England, the middle Atlantic, Chesapeake and Great Lakes have the highest concentrations of recreational vessels per square mile of land.

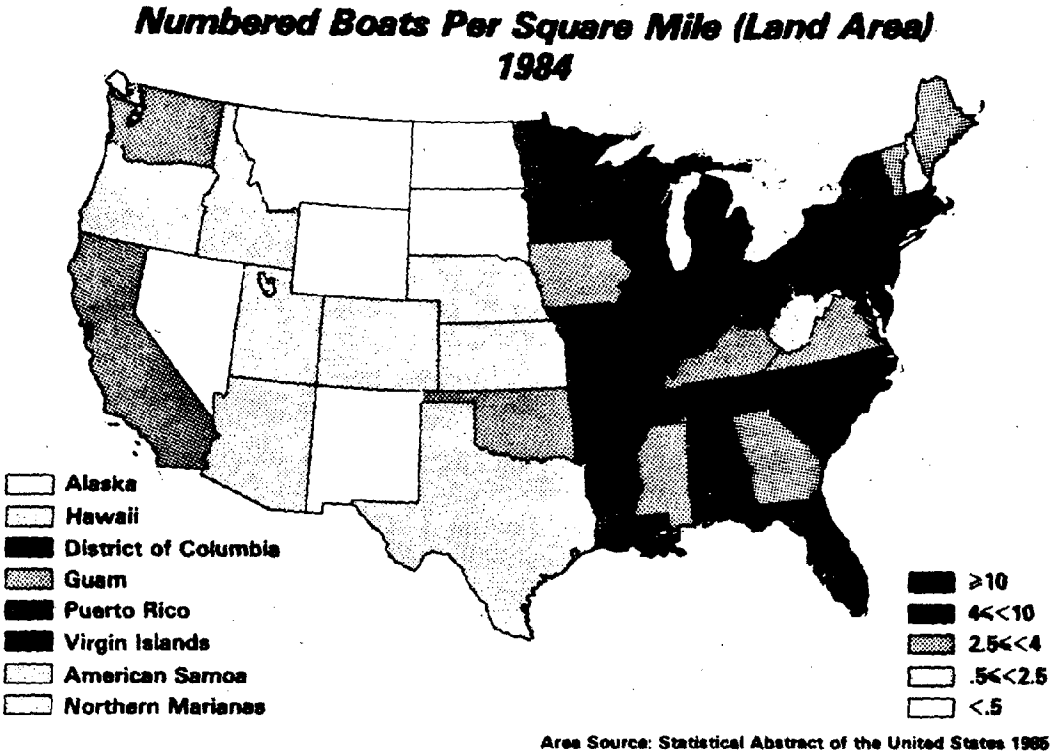
Table 6. Number of recreational vessels in the United States for the years 1983 and 1984.

NUMBERING DATA BY STATE				
		TOTAL BOATS NUMBERED		SCOPE OF CURRENT BOAT NUMBERING SYSTEM
		1983	1984	
TOTAL	RANK 1984	9,165,094	9,420,011	
Alabama	14	227,657	229,890	All motorboats, sailboats, and rental boats
*Alaska	47	17,082	24,608	All motorboats used on federal waters
Arizona	31	107,333	112,047	All watercraft
Arkansas	11	293,928	309,831	All motorboats with exceptions 2/
California	3	605,387	619,087	All motorboats; sailboats over 8 feet in length
Colorado	35	64,367	66,016	All motorboats and sailboats
Connecticut	33	66,881	72,591	All motorboats; sailboats 19 and a half feet or more in length
Delaware	39	36,167	37,402	All motorboats
Dist. of Col.	53	4,524	3,391	All watercraft
Florida	5	526,495	517,365	All motorboats
Georgia	15	219,876	225,812	All motorboats; sailboats 12 feet or more in length
Hawaii	50	12,604	13,112	All motorboats and sailboats over 8 feet in length
Idaho	34	64,703	67,471	All motorboats
Illinois	12	270,043	275,470	All motorboats and sailboats over 12 feet in length
Indiana	22	174,479	173,006	All motorboats
Iowa	21	185,129	175,470	All watercraft with exceptions 3/
Kansas	32	81,919	83,305	All motorboats and sailboats
Kentucky	30	114,767	114,546	All motorboats
Louisiana	10	303,044	312,119	All motorboats
Maine	29	116,419	117,842	All motorboats
Maryland	25	142,515	142,795	All motorboats
Massachusetts	20	161,137	184,140	All motorboats
Michigan	1	654,143	665,540	All motorboats
Minnesota	2	622,872	629,291	All watercraft with exceptions 4/
Mississippi	28	123,249	122,237	All motorboats
Missouri	9	302,730	328,440	All motorboats; sailboats over 12 feet in length
Montana	40	32,981	34,395	All motorboats
Nebraska	36	50,994	54,913	All motorboats
Nevada	44	30,273	31,288	All motorboats
*New Hampshire	51	6,579	9,242	All motorboats used on federal waters
New Jersey	26	138,367	140,884	All motorboats; all other boats more than 12 feet in length
New Mexico	41	30,919	34,114	All motorboats and sailboats
New York	8	327,700	331,742	All motorboats
North Carolina	17	192,432	202,908	All motorboats except boats with electric motors
North Dakota	42	38,134	33,723	All motorboats
Ohio	7	334,423	338,184	All watercraft
Oklahoma	19	202,641	193,022	All watercraft
Oregon	27	138,131	140,003	All motorboats and sailboats 12 feet in length or greater
Pennsylvania	16	209,241	217,293	All motorboats
Rhode Island	45	23,876	31,231	All motorboats
South Carolina	23	209,615	168,323	All motorboats
South Dakota	43	29,305	33,091	All motorboats
Tennessee	18	192,018	196,446	All motorboats and sailboats
Texas	4	594,868	599,591	All motorboats
Utah	37	47,152	51,781	All motorboats and sailboats
Vermont	46	28,737	29,774	All motorboats
Virginia	24	145,085	148,999	All motorboats
Washington	13	135,642	253,980	All motorboats used on federal waters
West Virginia	38	54,468	38,742	All motorboats
Wisconsin	6	425,905	436,221	All motorboats and sailboats over 12 feet in length
Wyoming	49	19,386	19,831	All motorboats
Guam	54	680 1/	690 1/	All motorboats
Puerto Rico	48	23,013	23,083	All motorboats
Virgin Islands	52	2,872	3,425	All motorboats
America Samoa	56	73	78 1/	All motorboats
N. Marianas	55	134	190 1/	All motorboats

* States not having an approved numbering system as of 31 December 1984, and where the Coast Guard is the numbering authority.
1/ Estimate
2/ Arkansas excludes boats with motors of 10 HP or less used only during daylight.
3/ Iowa excludes inflatables under 7 feet in length and canoes/kayaks under 13 feet in length.
4/ Minnesota excludes non-motorized boats 9 feet in length and under, duckboats during duckhunting season, and riceboats during harvest season.

Source: U.S. Dept. Transportation. 1985. Boating statistics 1984. United States Coast Guard. COMDTINIST M16754 IF.

Figure 4. Density of recreational vessels in the United States by state for 1984.



Source: U.S. Dept. of Transportation. 1985. Boating statistics 1984. United States Coast Guard. COMDTINIST M16754 IF.

In calculating the amount of waste generated by this source in 1972, the National Academy of Sciences (1975) estimated that 3 million vessels (out of a total of 6 million U.S. registered vessels in 1972) were in states that border marine areas, and that 1 million (33%) of these vessels were used in marine (as opposed to fresh) waters. The amount of litter generated by these vessels was assumed to be dependent on the number of passengers per vessel and the amount of time these vessels operate out of the year. Each of these passengers was estimated to generate 0.453 kg of trash, including plastic, per day. Using the Academy's variables, the amount of trash generated by all marine recreational vessels in the United States per year is calculated to be:

(1,000,000 boats) x (76 person-days/year/boat) x (0.453 kg/person-day)

= 34,000,000 kg or 34,428 metric tons per year

Using the Academy's calculations, for the 9.4 vessels registered in 1984, 4.7 million (one half) of these vessels presumably operated in coastal states and 1.5 million (33%) were used in marine waters. Therefore, we calculate the amount of trash generated by U.S. recreational vessels to be:

(1,500,000 boats) x (76 person-days/year/boat) x (o.453 kg/person-day)

= 51,642,000 kg or 51,642 metric tons per year.

Since the regions of southern New England, the middle Atlantic, Chesapeake and Great Lakes have the highest concentrations of recreational vessels these areas may also be subject to the greatest amount of debris from this source.

Petroleum Industry

Although the disposal of wastes from oil rigs and drilling platforms is strictly regulated (Burgbacher 1985) these structures have also been reported to be an ocean source of plastic debris (Amos 1985, King 1985). The debris may be in the form of domestic wastes generated by crew as well as industrial wastes from various operational activities. The greatest concentration of offshore rigs and drilling platforms within U.S. waters is in the Gulf of Mexico. In 1985, there were 3,056 oil and gas platforms in the Outer Continental Shelf and 1,000 platforms within the Gulf of Mexico (U.S. Dept. Interior 1985). The heaviest concentrations of these structures are off the Louisiana coast and offshore areas of Texas. As of October 1985, 175 mobile drilling rigs and 67 platform rigs were in operation (Burgbacher 1985).

The National Academy of Sciences (1975) estimated that there are 50-person crews working 365 days a year for drilling rigs. Based on this information the 175 active rigs would have 8,750 person-days per year (175 rigs x 50 person crews). Each platform was estimated to have 30 person-days per year. Thus, the 67 platforms would have 2,010 person-days per year (67 platforms x 30 person-days). Thus the total number of person-days per year in the Gulf is 10,760. This figure agrees with Burgbacher's (1985) statement that there are approximately 10,000 oil company personnel located offshore at any one time.

The daily amount of domestic litter generated by each employee is estimated to be 0.8 kg for personel aboard production platforms and 1.07 kg for those on board drilling rigs (NAS 1975). Therefore, we calculate the total amount of litter generated per year by drilling rigs and platforms in the Gulf of Mexico to be:

Rigs: (175 rigs)x(50 crew)x(365 person-days/yr)x(1.07kg)

= 3,417,312 kg or 3,417 metric tons

Platforms: (67 platforms)x(30 person-days/yr)x(0.8kg)

= 1,608 kg or 1.6 metric tons

Data on the plastic component of this litter were not available.

In addition to the number of employees calculated above, there are an 27,000 contract employees offshore every day (Burgbacher 1985). Moreover, there are numerous related activities that contribute to the problem of plastic debris. The oil structures in the Gulf are serviced by more than 1,000 vessels including cargo boats, standby boats, field service boats and crew boats. Seismic programs, which are conducted from a moving seismic vessel towing a cable with a sound source attached, involve an additional small number of vessels. These offshore operations associated with exploration, development, serving, production and product transmission all result in the generation of floatable or semi-buoyant trash and debris in the Gulf (U.S. Dept. Interior 1985).

A large portion of the plastic debris attributed to the oil and gas activities in the Gulf are the large pieces of plastic sheeting used to cover certain shore items and small chemical pails (Burgbacher 1985). Although these items are reported to be contained on ships and disposed of on shore, occasionally such containers are overfilled which increases the chance for loss of sheeting in transit. Other items of plastic debris attributable to oil and gas activities are seismic marker buoys, five-gallon plastic drums, computer write protection rings (these come from magnetic tapes used to record data by seismic research vessels and are removed from the reel to protect data), drilling pipe thread protectors, diesel oil and gas filters polypropylene hawsers and even plastic hardhats (King 1985, Amos 1985).

Land Based Sources

In some cases plastic debris generated by land-based sources is characteristic of, and easily identified to a particular source. In other cases, however, the sources of certain debris items generated on land are not as clearly defined. The following section provides an overview of some land-based sources of plastic debris including plastic manufacturing and processing plants, sewage systems, landfills, dock and marina structures and littering by the general population.

Plastic Manufacturing and Processing Activities

Industries that synthesize plastic and manufacture plastic articles have been typically suspected to be the primary source of the plastic pellets which have been reported as a worldwide contaminant of the oceans (Morris 1980). Sediment samples taken within rivers below outlet pipes of factories manufacturing plastics in the U.S. have contained concentrations of plastic pellets in the order of approximately 2,000 pellets in 2.5 cubic centimeter samples suggesting that plastic pellets are directly discharged into river systems by these industries (Hays and Cormons 1974). The presence of these pellets in distant locations at river mouths and coastal beaches, but in the general vicinity of these industries suggests that pellets are carried by river systems into coastal waters.

Sewage Operations

Several operations associated with municipal sewage and wastewater treatment and disposal have been identified as sources of plastic debris. These include combined sewer outfalls, wastewater discharges, and ocean dumping of sewage sludge (Swanson et al 1978). The types of plastics debris associated with these sources are primarily plastic tampon applicators, condoms, thin pieces of plastic sheeting from sanitary napkins and disposable diapers.

In metropolitan areas, primarily along the North Atlantic coast, sewer systems that are combined with storm runoff systems generate large amounts of plastic debris via outfalls in marine areas (Swanson et al 1978). During times of excess rainfall each system may become flooded, resulting in the escapement of sewage and floatable plastics and the discharge of these materials in storm runoff which drains into marine areas.

Some municipal wastewater treatment plants discharge plastic debris directly from both primary and secondary sewage treatment plants. While many sewage treatment plants in metropolitan areas, such as New York, have been upgraded for secondary treatment (Tiedemann 1983), some of these plants are not fully secondary and do not remove all floatables including plastic (Swanson et. al. 1978, Tiedemann pers. comm.). In addition raw unfiltered sewage is sometimes discharged because of plant breakdown or construction activities. In May and June of 1976, an estimated 2,200 to 13,000 cubic feet per day of floatable materials had been dumped into the New York Bight area from raw discharges by wastewater treatment plants. What followed has been termed the "floatables episode" in June 1976, when unusually large amounts of plastic and other types of debris washed up on New York beaches. Although sewage treatment plants were not solely responsible for this incident, the amount of plastic debris from these sources was thought to be considerable.

Sewage sludge dumping in the ocean is also a source of plastic debris especially in the New York Bight (Swanson et al 1978). Although plastic floatables in municipal sewage plants are routinely skimmed during treatment processes, approximately 5% escape screening and are dumped along with treated sewage sludge. In the late 1970's, an estimated 1,000 plastic tampon applicators were dumped with sewage sludge in the New York Bight per day. Today the amount is considerably higher (Tiedemann pers. comm.).

Solid Waste Disposal Practices

Another source of plastic debris is from municipal solid waste disposal practices (Swanson et al 1978). Three to four billion tons of solid waste are produced in the United States every year (NACOA 1985). In New York City, 7.4% of all wastes by weight in the solid waste stream from residential and commercial sectors was found to consist of plastics (Environmental Defense Fund 1985). For purposes of comparison, 9.2% of the waste stream was metal, and only 5.7% was glass.

In some areas garbage is emptied at collection sites onto barges and then is transported to landfills located along coastal waterways. Fresh Kill landfill on Staten Island New Jersey, for example, receives 700 tons of trash a day. Since this garbage is not contained on the barges, lightweight litter items such as paper and plastics are frequently blown off into the water. Escapement into surrounding waters often occurs during unloading as well (Tiedemann pers. comm.). Until recently litter that had escaped into coastal waterways adjacent to Fresh Kill was dredged and dumped at sea.

Degradation of Docks and Marinas

Large chunks of styrofoam occurring as marine debris are often identified as pieces of floatation used for docks and marinas (Neilson 1985). During a beach cleanup of Oregon's coast 2,100 volunters collected 48,898 chunks of styrofoam larger than a baseball within three hours. High concentrations of styrofoam at the mouths of rivers with houseboat moorages upstream suggested that these were the most likely source of this debris.

Littering By the General Population

Although some have concluded that "picnickers" contribute relatively little debris in comparison to ocean sources (Scott 1972), in some areas such as Los Angeles County, California, where beachgoers leave behind approximately 75 tons of trash each week, the general population's contribution to the debris problem could be substantial (Cahn 1984). However, in areas where there are both heavy vessel traffic and highly populated beaches it is often difficult to determine the primary source of domestic debris.

PART III

IMPACTS OF PLASTIC DEBRIS

In recent years, there has been an increase in reports of mortality of marine mammals, sea turtles, seabirds and fish attributed to plastic debris. This problem, generally referred to as "entanglement" may be a problem not only for individual animals, but may ultimately affect entire marine ecosystems.

In addition to the ecological impacts of plastic debris, there are also economic problems associated primarily with fishing gear losses, damages caused by debris, and costs to coastal communities due to cleanup operations or lost revenues from tourism. In some areas plastic debris has threatened human safety.

Entanglement of Wildlife in Plastic Debris

Broadly interpreted, entanglement is defined as the "unintentional harassment, injury and mortality of organisms through physical means by objects of foreign material in the marine environment" (Wallace 1985). This foreign material may be identified both as items of debris and as "active" fishing gear under supervision by fishermen. Entanglement of animals in active fishing gear, when such animals are not targeted by a particular fishery but are caught accidentally, is also referred to as "incidental take" or "bycatch". Since incidental take generally does not involve lost or discarded debris it will be omitted from this discussion, even though it is a major cause of mortality for many marine animals (Coleman and Wehle 1983, Heimonen 1985).

In recent years, the term "entanglement" appears to have been adopted in literature to refer to any interaction with lost or discarded marine debris, when in actuality, with respect to marine animals, it consists of two distinct interactions: 1) the actual act of becoming entangled in debris, and 2) the ingestion of debris. While some authors have included both of these types of interactions in their overall interpretation of "entanglement," for purposes of this report "entanglement" and "ingestion" will be dealt with separately. Here the term "entanglement" will be used to describe interactions of marine animals with debris that involve plastic items encircling body parts. "Ingestion" will be used to describe interactions that involve animals that have consumed plastic items.

Entanglement in plastic debris may occur when an animal comes into either accidental or intentional contact with an item of debris and becomes ensnared in this debris. Although some entanglements have been attributed to random encounters with debris during normal activities, there appear to be a number of factors that affect an animal's chances of becoming entangled.

Some of these accidental entanglements have been attributed to the inability of an animal to "see" plastic debris, especially fishing gear that is designed to be nearly transparent in water (Balazs 1985). Accidental entanglement may also result when an animal is attracted to prey that congregate around floating objects or to prey entrapped in lost nets that

continue to fish. Consequently, while attempting to feed on the prey, animals may become entangled in debris.

Other encounters with debris may be deliberate. The propensity of pinnipeds and especially young pups to investigate floating debris has been repeatedly attributed to their curious and playful nature (Henderson 1984, 1985, Scordino 1985, Stewart and Yochem 1985, Calkins 1985). Unfortunately such curiosity may often lead to entanglement. The following section will discuss information reported in literature on entanglements of animals in marine debris.

With the intent of identifying the scope, if not the magnitude of entanglement and ingestion of plastic debris by marine wildlife, anecdotal and exemplary findings involving single animals are included as a demonstration suggesting that these problems could well be broader in range.

Marine Mammals

The list of pinniped species reported to be entangled in plastic debris includes northern fur seals (Fowler 1982, 1985, Scordino 1985), Cape fur seals (Shaughnessy 1980), New Zealand fur seals (Cawthorn 1985), California sea lions, northern elephant seals and harbor seals in California (Stewart and Yochem 1985), Hawaiian monk seals (Henderson 1984, 1985) and Stellar sea lions (Calkins 1985).

Fragments of nets and plastic strapping bands have been reported to entangle almost all species of seals with the greatest frequency. Trawl net fragments, the most frequently observed item on northern fur seals, are usually of a mesh size large enough to slip over the head of a seal (20-25 cm.) (Scordino 1985). Smaller meshes seem to have a lower entanglement potential unless they have tears in the webbing. The average fur seal may encounter two to ten pieces of potentially entangling netting every year (Fowler and Merrell 1986). The size of plastic strapping bands found on fur seals varies between 38-96 cm. in circumference and 0.3-1.6 cm. in width (Scordino 1985) with smaller circumference bands being observed more frequently on seals (Fowler et al 1985). While net fragments may, in some cases, derive from encounters with active fishing gear, plastic strapping bands are recognized solely as items of debris (Stewart and Yochem 1985).

The effects of entanglement on the survival of pinniped species is generally unknown, but for the northern fur seal, entanglement is believed to be a major cause of mortality (Fowler 1982, 1985, Fowler et al 1985, Fowler and Merrell 1986). The Pribilof Islands of Alaska have a population of about 871,000 northern fur seals, 80 percent of the estimated total population of this species (Fowler and Kozloff 1985). Studies indicate that the fur seal population of the Pribilofs is less than half of that observed 30 years ago, and current trends indicate that this population is declining at annual rate of 4 to 8 percent per year (Fowler and Merrell 1986).

Although subsistence hunting still occurs on the Pribilofs, there is strong evidence to suggest that entanglement is the major factor for this decline. The history of entanglement of northern fur seals presents a

prime example of the influence of synthetic commericial fishing gear and other items on an animal population (Fowler and Merrell 1986). Small numbers of seals were observed entangled in rubber bands and rope in the early 1900's. An increased frequency of entanglement, however, was noted in the early 1960's, at a time when fishing effort increased in the North Pacific and Bering Sea and synthetic fiber fishing gear was coming into widescale use. Based on sightings of young males, 0.4% of the Pribilof population are currently entangled in debris. An almost equal percentage of fur seals have been observed with cuts, bruises or scars indicative of previous entanglements.

Seals entangled in debris may be affected in many ways. If a seal is not immediately immobilized by being entangled, the debris could ultimately prevent normal activities required for survival. The majority of entangled northern fur seals have had items of debris around their necks (Scordino 1985) (Figure 5). This kind of entanglement, if constricting, may directly impair swimming or feeding abilities. Entangling debris also increases drag during swimming (Feldkamp 1983). Consequently, an entangled seal must use more energy to swim and therefore must consume more food compensate. However, the drag caused by entangling debris would inhibit the high speed required for pursuit of prey items and may therefore lead to starvation. Young entangled fur seals, (two and three years old), reportedly have reduced growth rates compared to unentangled seals, and only 10% are expected to survive (Fowler 1985, Fowler et al 1985). Entangled female seals may take twice the amount of time to forage for their pups, if they are able to return at all (Fowler pers. comm.). In addition, although the observation of scarred seals suggests that some of these animals may be able to rid themselves of this debris (Scordino 1985), others may not be as fortunate and while they grow their synthetic "collars" can cause lacerations and open wounds susceptible to infection. Open wounds are more frequently observed on older seals which may have encountered debris at an earlier age.

The observations of entangled seals on the Pribilof Islands has been thought to represent "only the tip of the iceberg" (Fowler pers. comm.). While entangled seals are usually observed with only small fragments of net and pieces of debris, these seals are believed represent only those individuals that have survived entanglement. The limited numbers of observations of entangled seals at sea have involved larger net fragments, in which most of the seals were found dead (Fowler and Merrell 1986). It is not known how many seals may become entangled and die, and subsequently drop out of these larger nets at sea without ever being observed (Fowler pers. comm.). Therefore, earlier mortality estimates of 50,000 Northern fur seals per year attributed to observations of entanglements on shore (Fowler 1982) may actually be conservative (Fowler et al 1985).

Although many species of cetaceans have been reported entangled in nets or trap lines, this has generally been attributed to collisions with active fishing gear. However, there are cases in which entanglement has been attributed to debris. For example, DeGange and Newby (1980) found two dead Dall's porpoises in a 3500 m derelict gill net off Amchitka Island, Alaska.

Figure 5. Northern fur seal entangled in synthetic trawl net in the Pribilof Islands, Alaska. Photo: C. Fowler

Sea Turtles

Sea turtles, because of their physical as well as biological characteristics, are prone to entanglement (Balazs 1985). Specific reports of sea turtle entanglements include green, loggerhead, hawksbill, olive ridleys and leatherback turtles. Monofilament fishing line was reported by Balazs to be the most common type of debris to entangle turtles, followed by rope, trawl net, gill nets, and plastic sheets or bags. Fishing-related debris was involved in approximately 68% of all cases. As is the case for mammals, entangled sea turtles are unable to carry out basic behaviors such as feeding, swimming, and surfacing to breathe, and constricting debris may cause lesions or even necrosis of flippers. Leatherbacks and green turtles are especially prone to entangling their front flippers and heads in rope. Trawl net fragments floating at the surface have been described to "act like magnets" for sea turtles, which are attracted to sargassum mats and other natural floating masses that offer shelter and concentrated food sources.

Birds

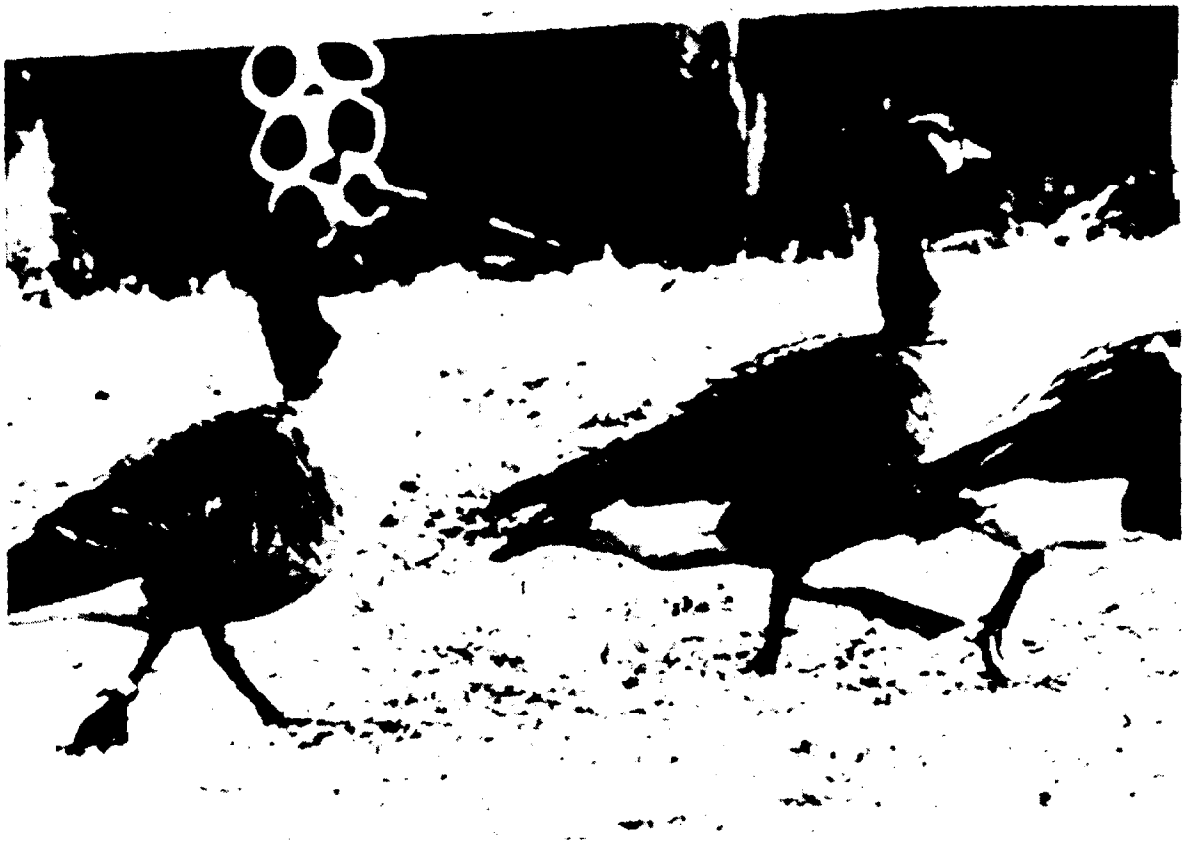
Information on entanglement of birds in marine debris consists primarily of anecdotal accounts in literature. This issue tends to be overshadowed by the magnitude of seabird mortality in active fishing gear. The Japanese salmon gill net fishery, for instance, is reported to kill over 250,000 seabirds in U.S. waters each year during a two-month fishing season (King 1985). Seabirds are attracted to the fish caught in nets, so that derlict nets, which continue to catch fish, will also entangle seabirds. One hundred or more dead seabirds have been found entangled in large pieces of derelict gill nets found at sea (Jones and Ferrero 1985). Smaller net fragments, including the webbing from lobster pots, have also been reported to entangle birds (Bourne 1977).

Birds also become entangled in monofilament fishing line and everyday domestic debris. The entanglement of brown pelicans, a protected species, in monofilament is a major problem in both California (Gress and Anderson 1983) and Florida. For many of these pelicans and other birds, if the monofilament does not immobilize them immediately, it often becomes snagged in trees and the birds are unable to break free. Other items, such as plastic six-pack rings, get stuck on birds' necks when they attempt to dive or feed through the rings (Figure 6). Many birds actively collect pieces of nets and fishing line for nest material (Bourne 1977) which can lead to the strangulation of both adults and juveniles. Although many of these incidents are considered to be rather infrequent (Fowler and Merrell 1986) there is no means by which this information is collected and monitored. There is clearly a need for networks or reporting systems such as those that already exist for sea turtles and marine mammals.

Fish and Crustaceans

A major issue tied to the debris problem in recent years has been ghost fishing, the ability of certain lost or discarded fishing gear to continue to catch finfish and shellfish species indefinitely. Unfortunately, it is a difficult problem to study and there are few quantitative data on the subject. The problem of ghost fishing was initially recognized when lost bottom-set gill nets used in the cod fishery

Figure 6. Canada goose entangled in plastic six-pack ring on Lake Erie in Ohio. Photo: Ohio Division of Watercraft.



Iceland were reportedly catching fish months or even years after becoming lost (Smolowitz, 1978a). Ghost fishing by discarded domestic and foreign fishing gear may pose a real problem to U.S. fishing stocks.

Gill nets deployed at the surface and suspended by floats have been reported to catch fish after being lost or abandoned. 1,500 meters of a 3,500 m. gill net retrieved in the North Pacific contained 99 seabirds, 2 salmon shark, 1 ragfish and 75 recently entangled salmon (DeGange and Newby 1980). For every fresh salmon in the net there were also at least 2 decaying or skeletal remains of additional salmon. It was estimated that the net had been adrift for a month and may have traveled a distance of 100 kilometers or more. Another lost gill net found off Agattu Island in 1981 measured 15 kilometers. In addition to the 350 seabirds and 2 salmon sharks caught in this net, there were also salmon, many of which were decaying (Jones and Ferroro 1985). While the retrieval of this net lasted 3 hours, 175 salmon were counted within only 35 minutes.

Ghost fishing by submerged nets, which cannot be easily observed, may be another serious problem (Figure 7). Gillnets set on the bottom have been reported to catch fish and crustaceans years after they are lost (High 1985, Carr et al 1985). In New England, observations from a submersible reported finding that even lost gill nets, which generally become twisted and tangled on the ocean bottom, still continue to ghost fish (Carr et al 1985, High 1985). In Lake Superior, approximately 1/2 mile of nylon gill net was retrieved during a study, and although the net was mostly rolled up in a ball, it contained approximately 100 lbs of fish, many of which were too rotten to identify (Groll pers. comm.). The estimated age of this net was 15 years.

The threat of ghost fishing in various trap fisheries is also of major concern. Once a trap becomes lost it may continue to fish indefinitely or until the trap deteriorates (Figure 8). Once fish or crabs of appropriate sizes enter a baited trap they are unable to escape. If the trap is lost they will die as a result of starvation or cannibalism thus serving as bait to attract new species, which could go on indefinitely. Unbaited traps also attract certain species as a means of shelter (High 1985, Smolowitz 1978b). Some have even hypothesized that certain crustaceans, such as lobster, may be conditioned to enter unbaited traps relating these objects to major food sources in heavily fished areas (Smolowitz 1978b). Lost king crab traps have been reported to contain as many as 100 live marketable sized crabs per trap (Smolowitz 1978a). Black cod or sablefish pots recovered after one month have been found to contain up to 32 snow crabs and an average of 12 sablefish per pot. Other experiments involving dungeness crab pots demonstrated the effectiveness of lost pots to retain legal sized crabs (High 1976).

Each lost inshore lobster trap in New England has been estimated to catch 2.5 pounds of lobsters a year. Each larger offshore trap catches 6 pounds of lobsters per year. Although these figures may not seem significant alone, in 1978 annual trap losses were reported at 525,000 and 18,000 traps for the inshore and offshore fisheries, respectively. This amounts to a total of 1,420,500 pounds of lobster in a single year, and does not take into account the cumulative effects of lost traps over several years.

Figure 7. Submerged groundfish gill net "ghost fishing" one year after being lost in New England. Photo: A. Carr

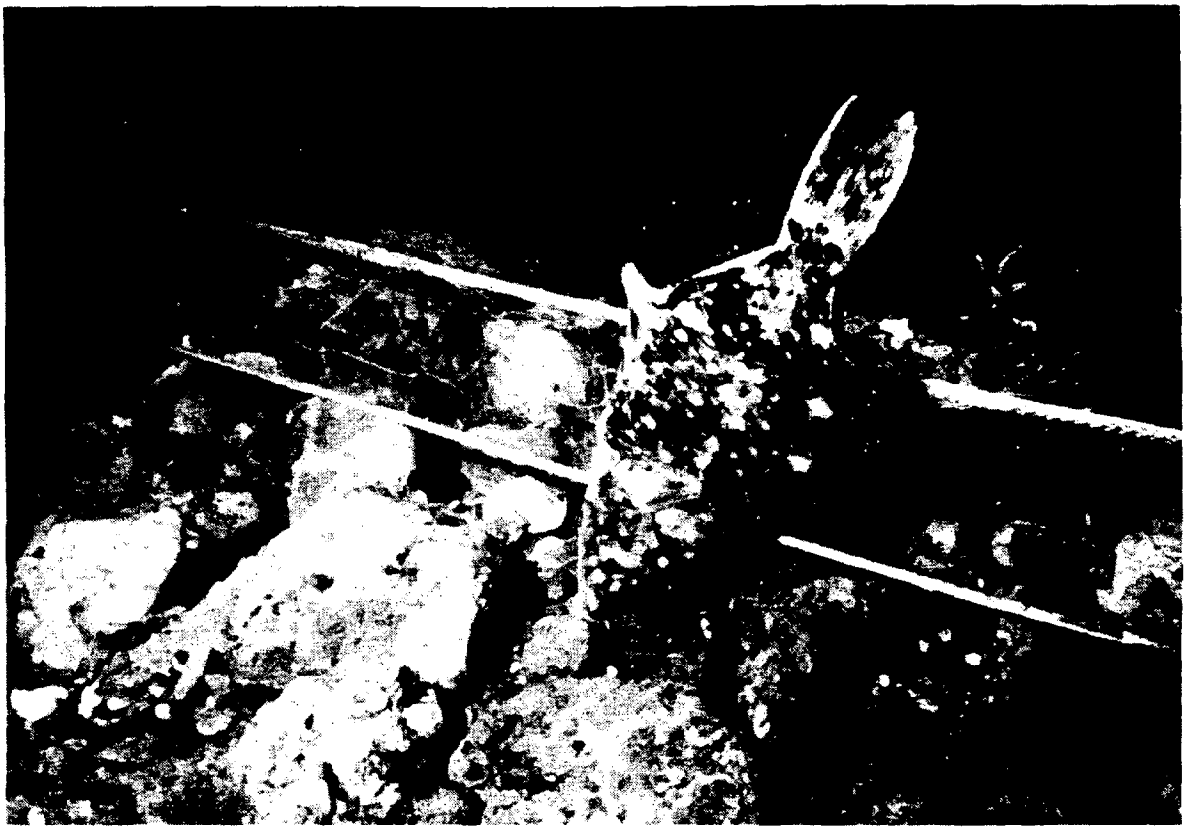
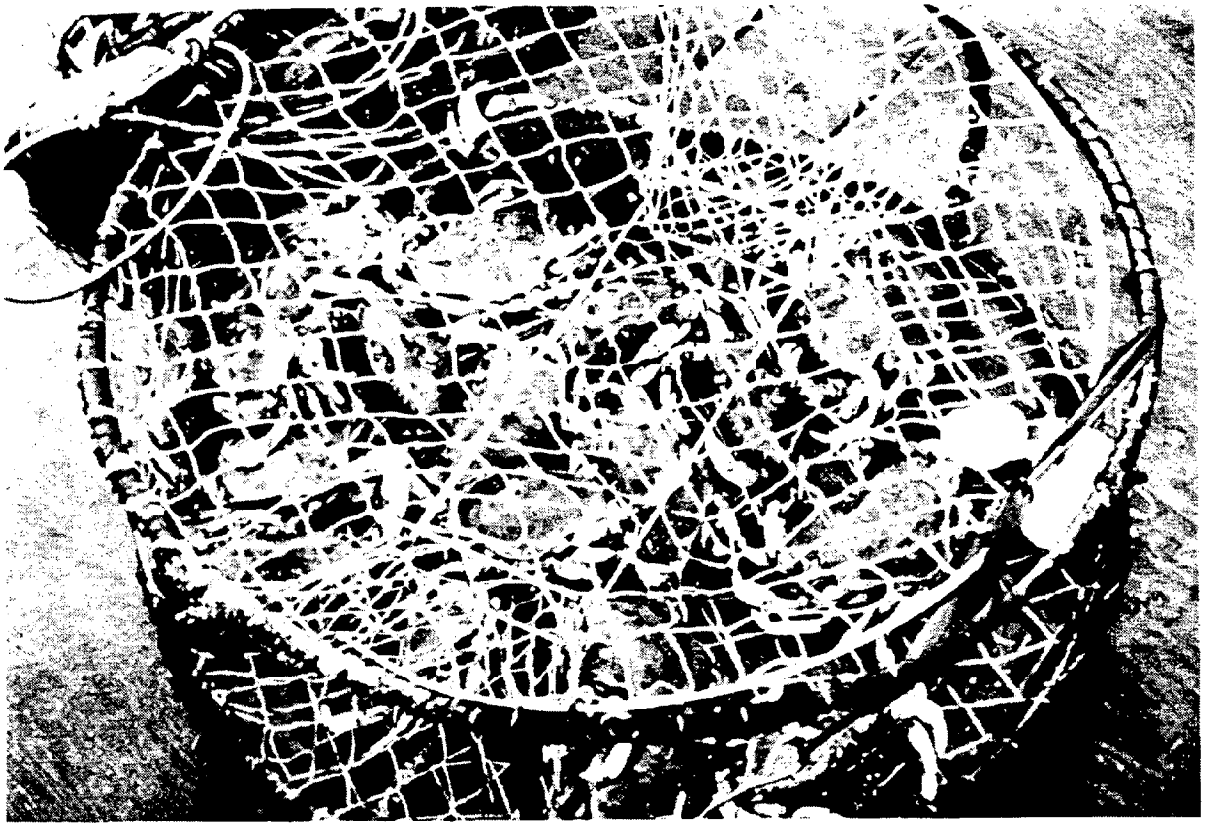


Figure 8. Derelict Dungeness crab trap found with crabs as result of "ghost fishing." Photo: W.L. High



Although lost fishing nets and traps present the greatest problem to fish and crabs, other plastic items also cause entanglement. Monofilament fishing line, six-pack rings and other items entangle both fish and crabs. (One of the more unusual items reported in literature is of a salmon which became in plastic strap used to bind spinach (Anonymous 1981). It is assumed that fish become entangled in these items while looking for food.

Land Mammals

Although plastics at sea present problems for marine animals, debris accumulating on coastlines has entangled land mammals as well. For instance, foxes and rabbits have been observed entangled in nets and other plastic items (Fowler and Merrell 1986, Fowler pers. comm.). A reindeer was also found with its antlers entangled in a 30 kg Japanese fishing net on Atka Island, Alaska (Beach et al 1976).

Ingestion of Plastic Debris by Wildlife

Along with the increasing reports of plastic debris in the marine environment appears to be an increase in the documentation of plastic ingestion by marine animals. Certain animals may ingest plastics nonselectively while feeding on other organisms in the water column. Factors such as winds and currents that tend to concentrate planktonic food items also concentrate debris. On the other hand, floating items may actually resemble authentic food items. For seabirds, small plastic pellets and fragments may resemble planktonic organisms, fish eggs, or even the eyes of squid or fish (Day et al 1985). The fact that sea turtles may mistake plastic bags and sheets for jellyfish has now become a widely recognized problem (Balazs 1985). Plastic items covered with encrusting organisms such as algae and bryozoans may actually "smell" or "taste" like authentic food items. In addition, it has been suggested that hungry animals are less likely to discriminate among authentic food items and debris.

The effects of debris ingestion are not as well understood. The fact that plastic has not been found in the intestinal tracts or feces of birds suggests that it may be indigestible by these animals. Large quantities of ingested plastics may cause intestinal blockage (Balazs 1985). Ingestion of plastics may also create a false feeling of satiation (Day et al 1985, Balazs 1985) or may reduce absorption of nutrients thus robbing an animal of needed nutrition. Suffocation, ulceration and intestinal injury could result from the presence of jagged edges on plastics or the grinding of these items against intestinal walls.

Long-term effects may result in physical deterioration due to malnutrition, decreased reproductive performance, and the inability to maintain energy requirements (Day et al 1985). Buoyancy caused by plastics in sea turtles could also inhibit diving activities needed for pursuit of prey and escape from predators. It has also been proposed that the absorption of toxic plasticizers (PCBs) may result from plastic ingestion, although this is still not well understood. The following sections provide a brief overview of those animals known to ingest plastics and the items involved.

Marine Mammals

Very little documentation exists in literature on the ingestion of plastic debris by marine mammals. One incident of a Minke whale reportedly feeding on plastic and other garbage discarded by a commericial fishing vessel was reported by Wallace (1985). Wehle and Coleman (1983) also listed the pygmy sperm whale, rough toothed dolphin, and Cuvier's beaked dolphin to have ingested debris. Records kept by the Smithsonian Institution listed nine species of cetaceans known to have ingested plastic debris, primarily plastic bags and sheeting (Table 7). An additional case involving a sperm whale that had stranded at Florence, Oregon was reported by Mate (1985) to contain approximately 1 liter of tightly packed trawl net in its stomach. Because most of information was obtained from dead animals that had stranded, the actual cause of death is speculative. However, a captive dolphin in Hawaii (species unknown) was reported to have died as a result of ingesting a piece of membrane plastic (Uyehara pers. comm.). In Texas, the stranded pygmy sperm whale which was taken into captivity died, apparently from ingestion of paper and plastic bags (Jones et al 1986).

Reports of pinnipeds ingesting plastic debris are rare in literature. Mate (1985) reported that a northern elephant seal and a Stellar sea lion had died from choking on styrofoam cups.

Sea Turtles

While the ingestion of plastic bags and sheeting by sea turtles has become highly popularized and is attributed to deliberate consumption by these animals who mistake these items for jellyfish, sea turtles consume a wide variety of debris (Figure 9). In a comprehensive review of this subject, Balazs (1985) reported five species of sea turtles known to ingest plastic: green, loggerhead, leatherback, hawksbill, Kemp's ridley. For all of these species, with the exception of the leatherback, reports of immature turtles that had ingested debris were more frequent than reports of adults. However, immature leatherbacks are rarely seen. While plastic bags and sheets were the most common item ingested (32% of 79 cases), tar balls (20.8%), and plastic particles (18.9%) were also common. Specific reports of sea turtles ingesting plastic debris in the United States included green turtles found in Hawaii, Florida and Texas; loggerheads in Georgia, Florida, Texas, and Virgina; Hawksbills in Florida and Hawaii and; leatherbacks in New York, New Jersey, Massachusetts, Virgina, Florida and Texas. In one case on Long Island, New York, a researcher reported that 11 of 15 dead leatherback turtles that washed ashore during a two week period had plastic bags blocking their stomach openings. Ten of the turtles had ingested four 8-quart sized bags, while one had eaten 15 bags (Anonymous, 1981a). Another leatherback found in New York had ingested 150 feet of 40-pound test monofilament fishing line.

There has been growing concern over the mysterious "lost year" period for juvenile sea turtles when they are rarely seen by researchers. Recent findings indicate that these small turtles may concentrate to feed in the open ocean at areas of convergence and upon sargassum mats (Carr pers. comm.) However, the downwelling in these areas not only concentrates food for these turtles, but also plastic debris.

Table 7. Records of cetaceans with plastic bags in stomach.

Records from National Museum of Natural History

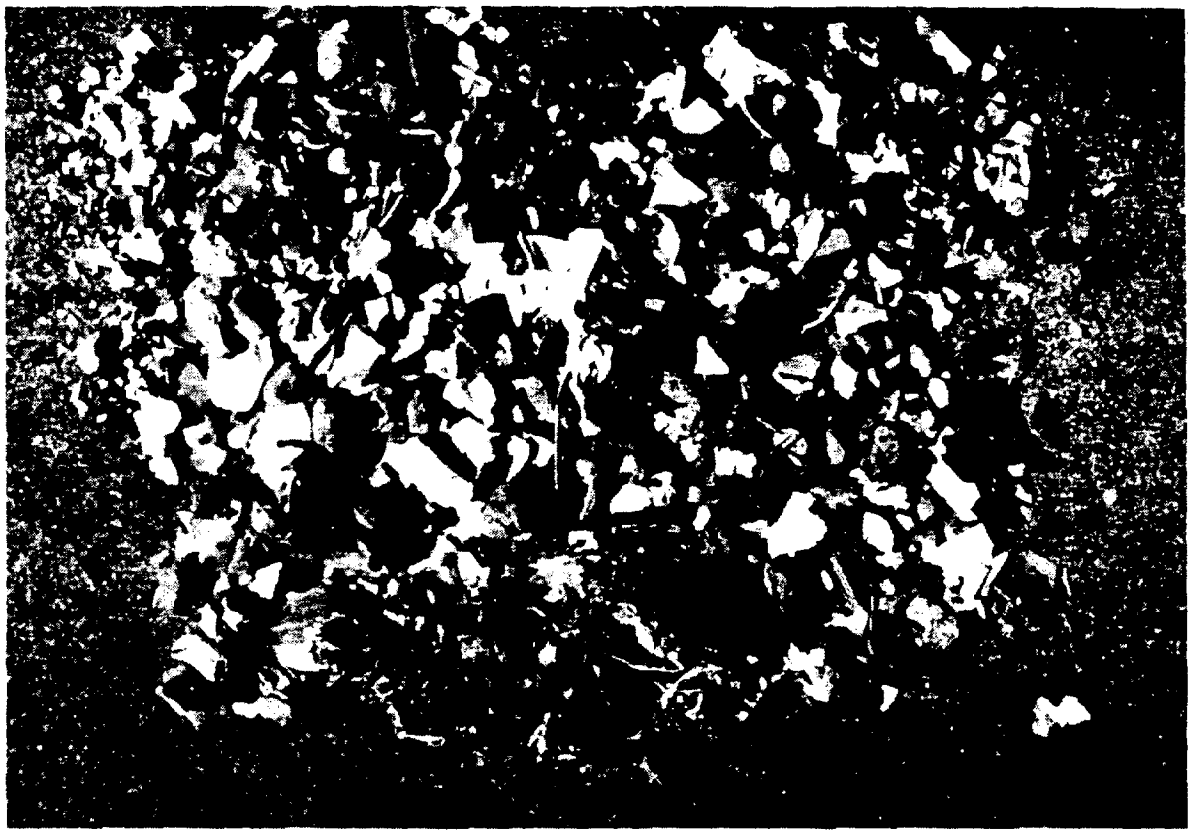
Species	Date	Sex	Length	Locality
Gervais beaked whale	12/18/83	F	371 cm	Cape May, NJ
Striped dolphin	3/22/83	M	220 cm	Cape Point, NC
Cuvier's beaked whale	1/?/81	F	580 cm	Assawoman, VA
Dwarf sperm whale	12/4/74	F	170 cm	Corolla, NC

Records from other organizations

Dall's porpoise	7/2/73	M	222 cm	Santa Monica, CA
Grampus dolphin	5/6/82	M	230 cm	Martha's Vineyard, MA
Pygmy sperm whale	1/1/84	M	182 cm	Galveston, TX
Pygmy sperm whale	5/17/85	M	320 cm	Brevard Co., FL
Sperm whale	7/1/85	?	510 cm	Seaside, NJ
Minke whale	8/7/85	M	370 cm	Acoaxet, MA

Source: 1986 Smithsonian Institution Museum of Natural History. Division of Marine Mammals. Computer printout. Retrieved Feb. 11, 1986. Washington, DC: Matt Hare pers. comm..

Figure 9. Plastic debris ingested by a sea turtle. Photo: G. Balazs



Birds

The ingestion of plastic debris by seabirds has received a great deal of attention in recent years. In a comprehensive review of this subject Day et al (1985) reported that 50 species of marine birds worldwide are known to ingest plastic debris. The tendency to ingest plastic debris appears to be closely related to feeding habits. Diving birds had the highest incidence of plastic ingestion. Plunging birds who sight prey below the water surface, and birds who feed by taking food dropped by others, had low incidences. Species feeding primarily on crustaceans or squid had the highest frequency of plastic ingestion whereas fish eaters were comparatively lower. Most birds also exhibit selective preferences for certain types of plastic in accordance with their color, shape or size. For example, the parakeet auklet, which feeds primarily on planktonic crustaceans, is found to ingest large amounts of light brown plastic particles that were classified as being "regular" in shape, primarily cylindrical, spherical, box- or pill-shaped. Most seabirds studied in Alaska appear to ingest light-colored plastics such as white, yellow, tan and brown. Only 7% of the birds ingested black-gray, dark blue, dark green or red-pink plastics. The most common plastic materials ingested are raw polyethylene pellets followed by plastic polyethylene fragments. Foamed polystyrene spherules are ingested less frequently.

Nearly all plastic particles ingested by seabirds float at the water's surface (Day et al 1985). Ingested plastic pellets and other debris can fill a birds stomach causing false feelings of statiation therefore leading ot malnutrition or internal injury that may lead to death (Figure 10). Seabirds that forage near areas of extensive plastic production or manufacture were reported to have higher incidences and amounts of plastic as compared to the same species located in areas away from plastic industries. Some species also feed plastic debris to their young (Fry 1986). Of 50 Laysan albatross chicks examined on Midway and Oahu Island, Hawaii, 90% (45) contained plastic. The weight of plastic ingested varied from 1.0 - 175.0 grams, with a mean of 43.5 grams per chick.

Fish

Ingestion of plastic by fish has primarily been recorded anecdotally in literature. One study in southern New England found eight out of 14 species examined contained white, opaque polystyrene pellets measuring 0.1 - 2.0 mm in diameter (Carpenter et al 1972). Bottom fish such as winter flounder and perch had the greatest concentrations of ingested pellets. Pellet ingestion was suggested to perhaps cause intestinal blockage for smaller fish. Similar observations of plastic pellet ingestion by flounder were noted in the Severn Estuary, England (Kartar et al 1973; 1976). The number of pellets in the intestines of junevile flounder (2 - 5 cm.) was as high as 30 spherules per fish.

Impacts on Ecosystems

While plastic debris has been shown to affect individual species, very little information is available on the broader impacts on marine populations, communities or ecosystems. To date, extensive research has only been carried out on northern fur seal populations. But among those species

Figure 10. Raw plastic pellets in stomach of seabird. Photo: R. Day

that appear to have the greatest degree of interaction with marine plastic debris, many are endangered or threatened species: Hawaiian monk seal, brown pelican, Kemp's ridley, hawksbill, leatherback, green and olive ridley sea turtles. The effects of plastic debris on these threatened and endangered species therefore should be closely monitored.

The possibility of bioaccumulation via food chains has also raised concerns. Although Day et al (1985) indicated that secondary ingestion of plastic by birds through plastic-contaminated fish was low, cases of secondary, or perhaps tertiary ingestion have been documented, including: bald eagles preying on parakeet auklets in Alaska (Day et al 1985), Antartic skuas preying on broad-billed prions in the South Atlantic (Bourne and Imber 1982), and short-eared owls in the Galapagos Islands preying on blue-footed boobies, which in turn had ingested fish containing plastic pellets (Anonymous 1981b). Others have noted encrusting diatoms, hydroids and bacteria on small plastic pellets at sea and have suggested that these organisms could absorb PCBs from seawater and pass these concentrated sources of PCBs along to organisms that ingest pellets (Carpenter et al 1972, Colton et al 1974)(Figure 11).

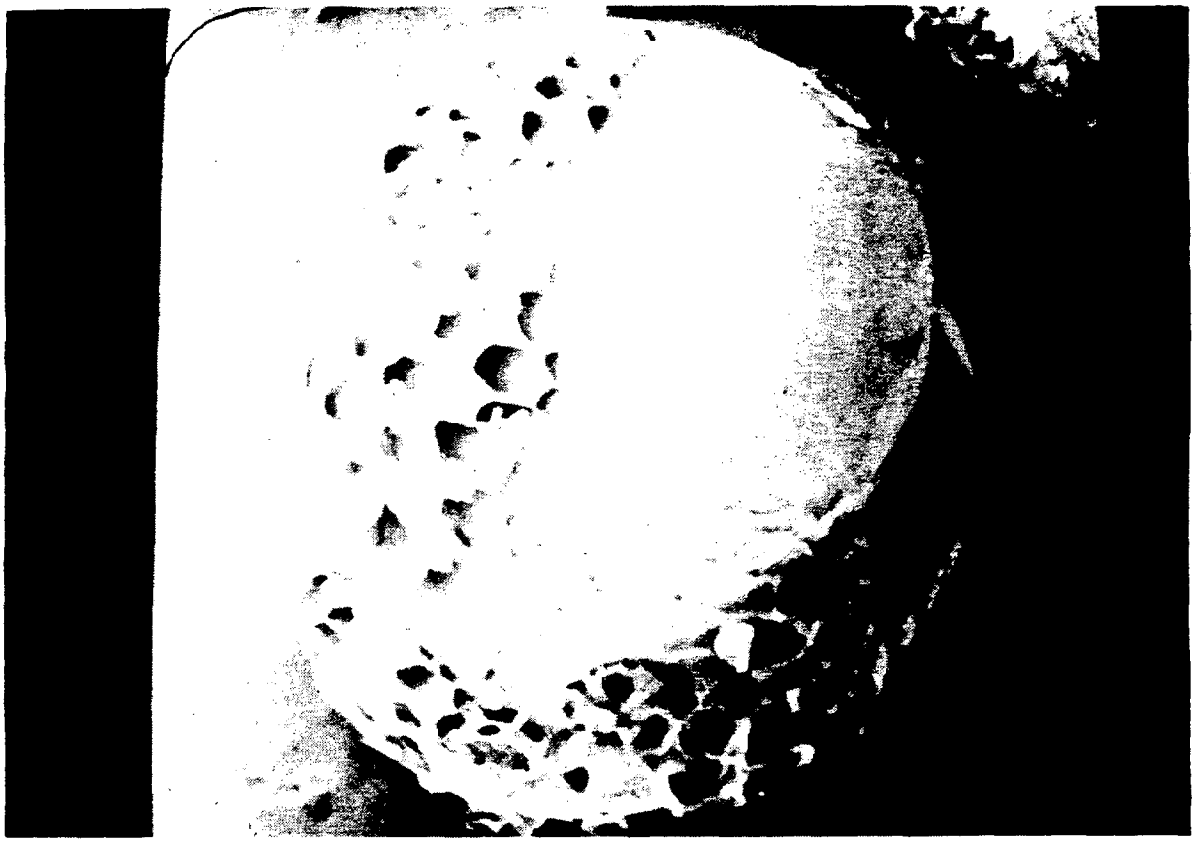
Some encrusting species have taken advantage of plastic debris. In Southern latitudes the increasing amounts of plastic debris, which is colonized by certain epipelagic organisms, may be offsetting the decrease of natural debris items such as logs, coconuts and sea beans due to deforestation and development of coastal areas. One species of bryozoan, Elletra tenilla, which had been relatively rare on the Atlantic coast of Florida, is now the most abundant bryozoan (Winston 1982). The recent success of this organism has been attributed to the presence of large quantities of drift plastic in the area, in combination with its ability to utilize this substratum in the absence of competition or predation. Refloatation experiments performed by Winston showed that all plastic debris with encrusting organisms floated at or just below the water surface. Many of the debris items, especially large fishing buoys, observed on the surface of the Pacific were also heavily encrusted with organisms (Dahlberg and Day 1985).

Other ecological impacts of plastic debris could be caused by lost fishing gear and other items which are snagged or lost on the ocean bottom and may damage coral reefs or other habitats as they are swept by currents and dragged across the bottom.

Value of Lost or Discarded Fishing Gear

Probably one of the most expensive but least known economic impacts is the loss of synthetic fishing gear sustained by commercial fishermen. Under the "Fishermen's Vessel and Gear Damage Compensation Fund," which compensates fishermen for damages from foreign fishing operations, fishermen received approximately 1.7 million dollars for cases filed between January 1983 and February 1986 (Table 1). However, fishermen do not usually receive full compensation for their estimated losses (Ford pers. comm.). Moreover, since domestic fishermen are not required to report fishing gear losses there is no way to determine how much gear was lost in the FCZ by fishermen who have not filed for compensation, or for fishermen who suffered gear losses in state territorial waters which are not covered by this fund. Nor is there a way to estimate the costs

Figure 11. Photomicrograph showing plastic pellet with encrusting organism. Photo: M. Gregory



associated with gear mending to replace sections of lost or discarded nets or other gear.

In areas of intense gear conflicts, recreational fishermen have reported substantial losses of fishing gear attributed to fouling of hooks and lines on commercial gill nets. In New England, this situation has become of particular concern for party boat operators who claim that it is becoming increasingly difficult to find places to fish without becoming entangled in gill nets. According to the Interstate Party Boat Association in New England, approximately $50,000 worth of hooks, synthetic lines and lures, and $1 million in operating expenses are lost every year in dealing with monofilament gill nets in the Gulf of Maine (Hill pers. comm.)

Impacts on Fishery Resources

The economic impact of lost fishing gear on fishery stocks could be the most severe cost attributed to marine debris. However, very few quantitative data are available on this problem (Carr et al 1985). Gillnets have been reported to continue fishing for years after they have been lost (Carr et al 1985, High 1985). These nets are also indiscriminate in species they catch. Consequently, a lost gill net may continue to catch target fish species in addition to lobsters, crabs or other economically important species.

In 1978, the economic impact of lost lobster traps in New England was assessed. According to Smolowitz (1978b) approximately 1.5 million pounds of lobsters valued at approximately 248 million dollars (1976 average price 1.66 per pound) are lost each year. Since then, the number of traps used in this fishery has increased from approximately 2.2 to 2.5 million traps while loss rates remain at 20 to 30 percent per year (Smolowitz pers. comm.). The cumulative effect of these lost traps in combination with the trend toward using plastic-coated wire or plastic traps in the shore fishery presents considerable problems for this resource.

In realizing the potential consequences of this situation, the state of Maine recently implemented regulations requiring that a biodegradable vent be placed in all traps to minimize the impact of ghost fishing. While Maine's inshore lobster fishery is the most significant area of lobster production in the U.S. (New England Fishery Management Council 1983) other areas do not as yet require biodegradable vents.

Damage to Vessels

Plastic debris has also been reported to interfere with vessel operations. The most common instances involve plastic items that foul propellors and clog cooling water intake systems which may lead to engine failure. In Alaska, vessel props have been reported to become fouled in lost gill nets (Anonymous 1983). In New England waters, garbage bags are considered to be the leading external cause for engine damage of commercial and recreational vessels (Gibson pers. comm.) In the Gulf of Mexico, several incidents have occurred in which large plastic sheeting used by merchant ships has wrapped up in the propellors of recreational vessels and in one case a disabled vessel near a jetty barely escaped a tragedy (Graham pers. comm.).

Although the disablement of vessels by plastic debris appears to be a problem, there is no source of information to determine the frequency of this occurrence. According to the Safety Evaluation Branch of the U.S. Coast Guard, over 10,000 vessel accidents have been reported in the past two and a half years, ten percent of which were caused by debris and only two or three individual cases involved fouling in plastic (Petton pers. comm.). However, according to another division of the Coast Guard that deals with accident review, vessel disablement caused by plastic debris is not specifically coded for in data analyses and therefore there is no way to determine the frequency of this occurrence (Gray pers. comm.). Therefore, either vessel disablement caused by plastic debris occurs infrequently, or with minimal damages, or is unreported. Persons who deal with propellor repairs and servicing were also contacted but no records were kept on such information.

The U.S. Navy also has its share of problems with plastic debris. Problems associated with plastics clogged in cooling intake systems for large naval vessels occur during exercises when a ship is not traveling at a brisk pace (Koss pers. comm.). Smaller vessels also tear up nets and get lines around propellors. Much of the information on the frequency of these occurrences, however, is either classified or not typically documented, but it is said to happen quite often.

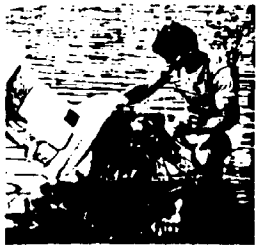
The fact that some boating supply companies have built devices on propellors to combat this problem, however, may give some indication that the problem is not merely a random occurrence (Figure 12).

Costs to Coastal Communities

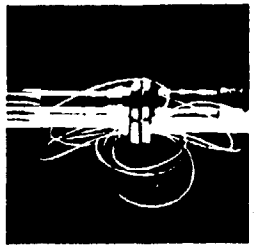
The aesthetic quality of an area as perceived by society is extremely important in determining its value. One's perception of pollution, however, is often measured more by what is visible on a beach as opposed to actual pollution indicators measured in a laboratory. Consequently, beaches that are maintained on a regular basis by clean-up crews have been reported to be more popular than those that are not, even if these areas are "polluted" in a technical sense (Squire 1982).

Therefore, many coastal municipalities carry out routine clean-ups of debris, while others employ enforcement officers to patrol and control litter deposited by beachgoers (Cahn 1984). But in certain areas the deposition of debris is beyond immediate surveillance, coming either from distant land-based or offshore sources. Padre Island National Seashore in Texas is a prime example of the costs incurred from debris deposited beyond the Seashore's jurisdiction. In 1985, 140 tons of debris was estimated to be along one 57 mile stretch of coastline in Texas (Amos 1985). Sampling studies showed that less than 10% of this litter is deposited by beach users (Lukens 1985). The other 90% comes from the Gulf of Mexico and consists primarily of plastic items associated with merchant shipping and oil industry activities, such as large pieces of plastic sheeting, computer 9-track write enable rings, seismic markers, drilling pipe thread protectors, hundreds of plastic milk jugs, jars and buckets and even hard hats (Lukens 1985, King 1985, Amos 1985). Presently the Park spends $10,000 per year on beach cleaning efforts, primarily concentrated on one half-mile of beach which is most visited by the public (King 1985).

Fouled Props Can Ruin Boating Fun.



Weeds like eel grass, Hydrilla, sawgrass, peppergrass and help are common problems.



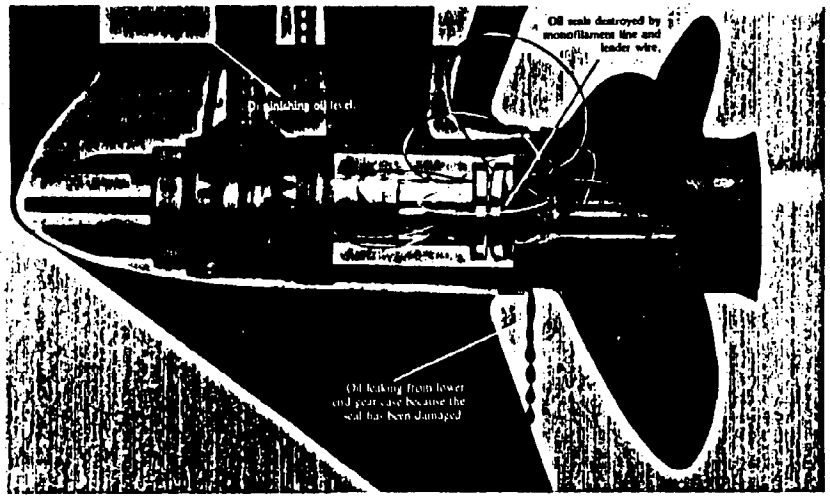
Monofilament line can wrap around the prop shaft, slicing through the oil seals.

Fishing lines and leader wire often foul up propellers.

The Problem

When engine problems develop, the first thing mechanics do is remove the prop and look for a wad of monofilament fishing line wrapped around the prop shaft. If any line is found, chances are good that it has sliced into the prop shaft seal and worn down the shaft, resulting in a loss of gear case oil.

Mechanics earn $30-$40 per hour to make routine repairs that can now be avoided. The cost for these lower end repairs and replacements can easily range from $1,000-$3,000. Saving time, however, can be just as important as saving money, especially in climates where summer is short and precious and in places where repair rooms are swamped with work.



Spurs Work. We Guarantee It! Period.

The Solution

Now Spurs proudly introduces its newest and most innovative product — a line, net and weed cutter for inboard/outboard and outboard engines.

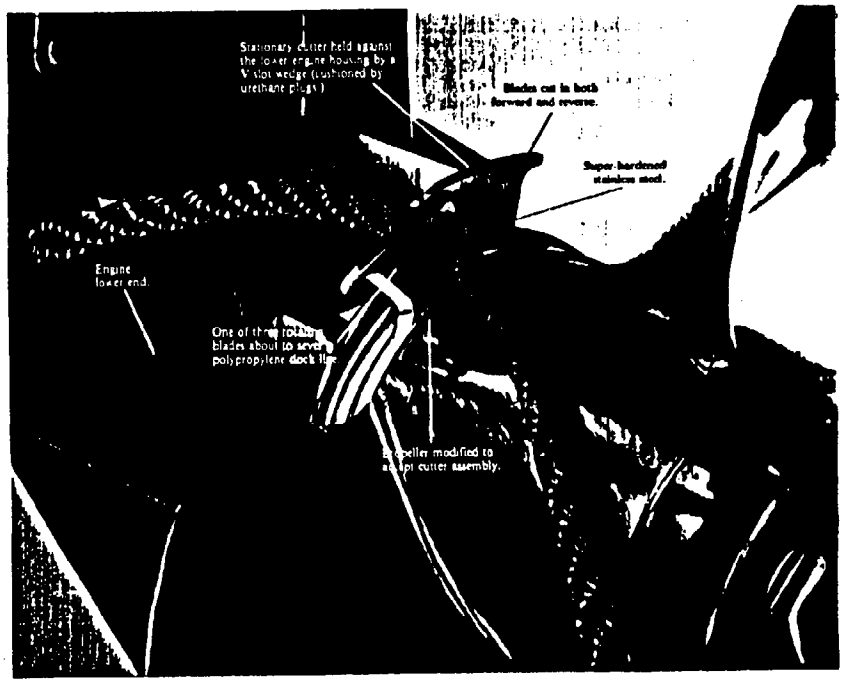
The cutter has three rotating blades and one stationary blade, which cut monofilament and dock lines, leader wires, weeds, etc., with each revolution of the prop shaft.

The cutter fits on any prop shaft, so now every boater can take advantage of this unique solution to an age-old problem.

The cutter and a propeller can be purchased as a matched set, or you can buy just the cutter, which adapts to any propeller with slight modifications, done at most prop shops or by a Spurs Marine manufacturer. (See back page to determine which cutter fits your engine.)

The super-hardened stainless steel blades, which never need resharpening, cut in both forward and reverse.

Will not hamper speed or engine efficiency.



END WEED ENTANGLEMENT FOREVER!

Figure 12. Device used on propellers to cut monofilament fishing line and other debris.

In 1978, the National Park Service purchased a mechanical beach cleaner for $18,000 but found this equipment to be inadequate on Padre Island because of the nature of the debris on the beach, especially synthetic rope and plastic sheeting along with glass, logs, and large oil drums, which caused equipment failure (Lukens 1985).

There is a growing concern that the visibility of Texas beach debris problems may have a severe impact on the tourist industry. Since the establishment of Padre Island National Seashore in 1962, 99% of the complaints received by staff members have been in regard to the beach litter problem and almost daily at least one visitor tells an employee that he will never return to Padre Island because of its "filthy beaches" (Lukens, 1985) (Figure 13).

The economic impact suffered by coastal businesses as a result of marine debris was clearly demonstrated by the "floatables episode" of June 1976, when unusual amounts of material washed up on beaches of Long Island, New York (Swanson et al 1978). Plastics were reported to far exceed all other materials in quantity and consisted mainly of tampon applicators (about one per 3 meters of beach), condoms, sanitary napkin liners, and disposable diapers. Other items included domestic waste such as plastic straws, pieces of styrofoam cups, plastic bottle caps, corks, plastic toys and plastic cigar and cigarette tips. Within a period of nine days after the first of this debris hit Long Island on June 14, all beaches were closed to swimming, waters were closed to shellfishing and the Governor of New York had declared most of Long Island as disaster areas. Later the President assigned the Job Corps to clean up Long Island's Southshore beaches under the supervison of the Coast Guard.

No one source could be blamed for this incident. Rather, a combination of factors including combined sewer outfalls, wastewater discharges, ocean dumping of sewage sludge, landfills, trash discarded by commercial and recreational vessels, oil spills, and pier fires along with unusually heavy rainfall and southerly to southwesterly winds caused the problem. Debris left by beach goers was minor compared to the amount that washed up from distant sources.

Water quality tests indicated that no immediate or long-term health hazard had been presented by this episode. In fact, coliform counts were well within state standards to allow swimming; the closings were precautionary measures. By July 1 all beaches had been cleaned and reopened. The total cost of cleanup operations was $100 thousand. The Long Island coastal recreational industry, however, suffered an even greater economic loss (Squire 1982). The pier fishing industry was reduced by 30%. Restaurants on the beaches lost 20% of their income. Bait and tackle shops reported as much as 30% less business. There was also a 30-50% reduction in beach attendance during and after the event because of a general opinion that the water was polluted. The total economic impact to business resulting from this incident was estimated at $30 million (Squire 1982). Unfortunately, some predict that similar episodes are likely to recur (Swanson et al 1978).

Figure 13. Aesthetic degradation caused by plastic debris at Padre Island National Seashore, Padre Island, Texas. Photo: Padre Island National Seashore.

Potential Threats to Human Safety

A final impact of plastic debris is the threat it may pose in certain situations to human safety in the marine environment. While the loss of fishing gear is often attributed to snagging on bottom structures such as reefs and wrecks these areas are also popular sites for scuba divers. Occasionally divers have become entangled in monofilament fishing line, but more frequently encounters involve gill nets (High 1985). Several near fatal incidents of divers entangled in gill nets have been reported. Even divers with special training and diving equipment modified for purposes of working near gill nets frequently become entangled. The disablement of vessels caused by plastic debris may also endanger human safety when power or steering control is lost Some have attributed fatalities at sea to vessel disablement during storms, particularly in the Bering Sea. As mentioned briefly above, disabled vessels near inshore structures such as jetties also face the risk of collision (Graham pers. comm). Research and military submarines have also had near fatal encounters with lost gill nets (Evans 1971).

PART IV
REGIONAL ANALYSIS OF PLASTIC DEBRIS

Much of the literature pertaining to the types, sources and problems associated with plastic debris in North America focuses on the North Pacific, where the National Marine Fisheries Service has directed its major Entanglement Program efforts. The subject of plastic debris has been documented to a much lesser degree for most other areas within the United States. In the Great Lakes region, this issue has received very little attention. Furthermore, individual perceptions of the magnitude of the problems caused by plastic debris is largely influenced by personal interests (Gerrodette 1985). A scientist or a conservationist may view plastic debris as a major cause of mortality for marine animals. A fisherman, however, may perceive plastics as a cause for economic loss while a recreational planner may perceive plastic debris to be a hinderance to beachgoers. Not all of these views are likely to be represented in the literature on this subject.

This section attempts to identify marine areas of the United States where plastic debris poses some type of problem and to identify unique situations which are not documented in literature. Included is information on the types and sources of this debris. States programs that are applicable to plastic debris are also identified. The information is grouped and presented according to geographic location as follows:

Northern New England (Maine, New Hampshire);
Massachusetts;
Southern New England (Rhode Island, Connecticut);
New York Bight (New York, New Jersey);
Chesapeake (Delaware, Maryland, Virginia);
South Atlantic (North Carolina, South Carolina, Georgia, East Florida);
Eastern Gulf of Mexico (West Florida, Alabama, Mississippi, Louisiana);
Texas;
Pacific West Coast (California, Oregon, Washington);
Alaska;
Hawaii;
Lake Ontario (New York);
Lake Erie (New York, Pennsylvania, Ohio);
Lake Michigan and Lake Huron (Michigan, Indiana, Illnois, Wisconsin);
Lake Superior (Minnesota, Wisconsin).

In addition, in 1985 several New England and west coast states recruited volunteers to conduct beach cleanups (Neilson 1986). The results of these activities are included where available to provide insight into the types of plastic debris found to be most prevalent in particular areas.

Northern New England

(Maine, New Hampshire)

During a beach cleanup that extended along 30 miles of Maine's coastline from Kennebunk to Eastport 363 volunteers collected 1,560 pounds of debris (approximately 52 pounds/mile). A special focus of the cleanup was on plastic items which constituted 32.8% of the total pieces of debris collected. This does not include fishing gear items which comprised 8.4 % of the total. The majority of the debris items were assumed to have come from within the Gulf of Maine as opposed to sources further offshore. Certain beaches appeared to be used as dumpsites for household wastes. Tampon applicators were particularly numerous in the southern part of the state.

Most debris items in Maine are apparently fishing gear associated with the lobster fishery such as netting from traps and bait bags, rope and buoys. There are also plastic salt bags (salt is used to preserve fish), motor oil containers, and numerous bleach and other types of bottles (Appollonio pers. comm., Shell pers. comm.). One source commented that plastic bottles of all types are used by lobster trap fishermen as buoys (Shell pers. comm.).

In New Hampshire fifteen volunteers collected 100 pounds of debris during a beach cleanup along four miles of coastline (25 pounds/mile). Debris items were not reported categorically, but included a substantial number of cut strapping bands in an area located near a major shipping port (Holzaetafel pers. comm.). Disposable diapers were also reported to be numerous and were thought to come from areas that did not have adequate sewage treatment facilities (Spurr pers. comm.).

In both Maine and New Hampshire the major problem caused by plastic debris is one of aesthetic degradation. However, one source commented that in Maine, fishing gear debris is not a major problem because it is often collected by tourists who would otherwise buy items such as lobster traps and buoys for souvenirs (Shell pers. comm.). The Maine Audubon Society (Johnson pers. comm.) had some knowledge of bird entanglements in plastic debris which mainly involve gulls entangled in monofilament line and Canada geese entangled in six-pack rings. Seals are also found at times entangled in netting. In New Hampshire, both birds and fish have been found on occasion entangled in plastic six-pack rings. No quantitative information was available on the frequency of animal entanglements.

Massachusetts

More than 500 volunteers participated in the state cleanup effort that extended over 30 miles of coastline in southern Massachusetts from Provincetown to Scituate and Swansea. Over 16,000 pieces of debris were collected with a total weight of 5000 pounds (approximately 167 pounds per mile). Some of the plastics collected on the beaches exposed to the ocean were noted to be directly related to fishing activities. Items included monofilament line, buoys, and parts of trawl gear. Other items on these beaches were plastic jugs and styrofoam. Plastic eating utensils and containers were found to be more common on beaches in the vicinity of

developments, picnic areas and marinas. The abundance of plastic bags, sheeting and, in particular, plastic tampon applicators was noted on at least 95% of all areas.

In view of the results of the beach cleanup and personal communications, the most prevalent items of debris in this state appear to be plastic bags, containers, six-pack rings and plastic tampon applicators. Although the sources of bags, containers and rings can be either land or ocean-based, plastic tampon applicators have been reported to come from combined sewers. According to the Environmental Protection Agency's Regional Office in Boston (Newman pers. comm.), the presence of large numbers of tampon applicators on beaches has stirred numerous complaints from state residents. The source of these items has been directly tied to the combined sewers located within Boston Harbor which occasionally overflow into the harbor during times of heavy rainfall. According to Keough (1980) 1/8 inch of rainfall on Boston's 29,440 acres will become 100 million gallons of waste water. This volume of water is directed toward sewage treatment plants which are unable to treat both this runoff and the city's sewage, and therefore open their gates and discharge into the Boston Harbor. Once these items enter the harbor they are transported to the mouth and taken in a southern direction by longshore currents travelling parallel to the coast.

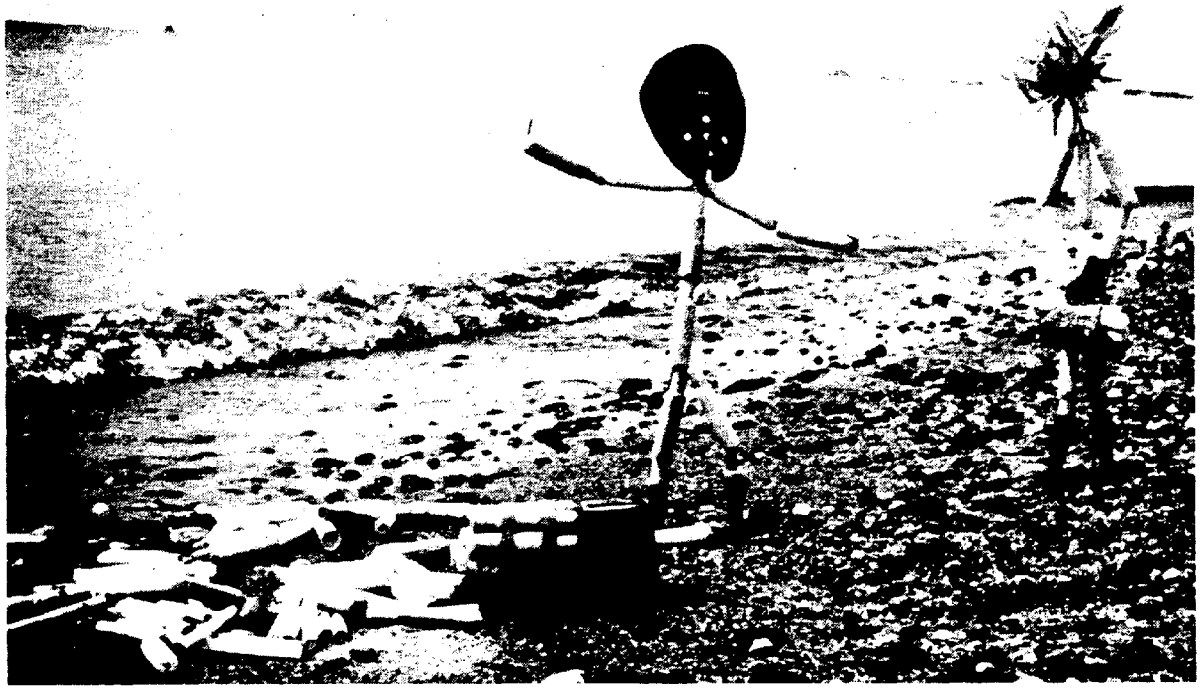
The situation of plastic tampon applicators on Cape Cod and surrounding beaches has caused much consternation for local residents. Residents complain that hundreds of applicators routinely wash up on town beaches (Critchley pers. comm.). Even a sense of humor has developed over the problem with local residents now referring to the applicators as "beach whistles", and a local artist, Jay Critchley, has formed an organization called TACKI (for Tampon Applicators Creative Klubs International). Sculptures created from plastic tampon applicators collected on beaches (Figure 14) have been used to draw attention to the increasing plastic debris problem in the area.

Recently a legislative bill has been filed that would ban the sale and distribution of plastic tampon applicators in Massachusetts. Introduced by Massachusetts Representative Howard Cahoon and Senator Paul Doane, the bill states that whoever sells or distributes disposable tampon applicators composed of plastic or other non-biodegradable material shall be punished by fines of $1,000 up to $5,000 for each offense.

Manufacturers of these items are not blaming consumers for disposing of the applicators improperly, but rather the inadequate Boston sewer systems. However, a spokesman for the Metropolitan District Commission stated that it would be impractical to install small enough screens on discharge pipes in attempts to correct this problem (Sleeper 1984). The latest public hearing on this issue was held on March 18, 1986 but no decision has been made on the bill.

Aside from the aesthetic problem described above, entanglement of wildlife in monofilament fishing line and plastic six-pack rings are common problems at Parker River National Wildlife Refuge in northern Massachusetts (Fillio pers. comm.), and in Cape Cod (Clarke pers. comm.). In addition to these problems, there was also an incident at Cape Cod

Figure 14. Sculpture made of plastic tampon applicators to draw attention to the problem of plastic debris in Massachusetts. Photo: J. Critchley



National Seashore in which a seal washed ashore entangled in a plastic net and subsequently died due to the stress of the entanglement (Olsen pers. comm.).

Southern New England

(Rhode Island, Connecticut)

In Rhode Island, 287 volunteers filled 350 large garbage bags of debris, weighing an estimated 5,400 pounds, which was picked up over 48 miles of coastline (113 pounds per mile). Although debris items were not quantified, monofilament line, lobster trap buoys, rope, disposable diapers and tampon applicators were noted to be prevalent. There was a question as to the source of tampon applicators and whether they could be generated by disposal systems in recreational boats.

Besides the beach cleanup, the issue of plastic debris in Rhode Island has received minimal attention. Several agencies contacted stated that they had very little knowledge concerning this issue. According to the Department of Environmental Management (Bell pers. comm.) the most prevalent types of debris in marine areas are six-pack rings, bags and fragments of styrofoam that are showing up in water sampling procedures. The only problem appears to be one of aesthetics.

Rhode Island has a program that encompasses all types of litter and recyclable items known as the Rhode Island's Ocean State Cleanup and Recycling Program (OSCAR). Although OSCAR does not presently address plastics or marine pollution specifically, plastics recycling will be a study topic in 1986.

OSCAR is under the jurisdiction of Rhode Island's Department of Environmental Management, Office of Environmental Coordination under the direction of Victor Bell. OSCAR resulted from the Litter Control and Recycling Act of July 1, 1984, with a sunset date of June 30, 1990. The budget derives from a tax on all carbonated beverages at the wholesale level at the rate of five cents per case. The tax makes approximately $850,000 available each year for this program and funds are divided equally between litter control and recycling projects. Examples of program components include education projects and litter cleanups.

In Connecticut, a beach cleanup covering 5 miles of coastline was conducted by 15 participants who collected an estimated 300 pounds of debris (60 pounds per mile). The majority of the debris consisited of styrofoam food containers, plastic straws, pieces of rope, and household items. No quantitative information was available on this debris.

The Connecticut Department of Environmental Protection is currently working on an EPA multi-agency effort to assess conditions in Long Island Sound (Stacey pers. comm.) but the issue of nonbiodegradable plastics has not been identified as a priority. The Marine Fisheries Office (Blake pers. comm.) reports that entanglement of marine species in lost fishing gear or other debris does not seem to be a major problem. However, there is a "slight" problem with ospreys that use monofilament fishing line as nest material. Reportedly, there could be at least one mortality each year

of young ospreys due to entanglement in monofilament before leaving the nest. The problem of lost lobster pots was considered as a possible future subject of study given the increase in gear and especially plastic-coated wire pots in Long Island Sound.

New York Bight

(New York, New Jersey)

The New York Department of Environmental Conservation has not carried out any studies which have been directed specifically toward plastic debris on Long Island (Weber pers. comm.). Reportedly there have been noticeable quantities of plastic debris at coastal beaches on the south shore of Long Island. For many areas the most prevalent types of plastics are six-pack rings, bags, and styrofoam cups. In East Hampton, large concentrations of debris items collect in harbor areas (Penny pers. comm.). While fishing gear debris is uncommon in this area, recreational and commercial vessels are thought to be the major sources of domestic type debris. Further west, on Fire Island National Seashore, considerable problems with plastic debris occur periodically due to wind direction and storms (Northrope pers. comm.). Plastic one-liter beverage bottles have been found on the bay side in increasing numbers even though they are marked for deposit. Further towards New York City at Gateway National Recreation Area in Brooklyn, tampon applicators and automotive product containers are most prevalent in addition to the items listed above (McIntosh pers. comm.).

The major problem associated with plastic debris in New York is the aesthetic degradation of marine areas. However, entanglement of gulls and turtles in six-pack rings and monofilament fishing line is also reported. In East Hampton, at least five incidents per year occur of sea turtles stranding due to ingestion of plastic bags (Penny pers. comm.). Ospreys also use monofilament as nesting materials in eastern Long Island. One source provided documentation of over 20 birds, primarily ducks and Canada geese, which had become entangled in six-pack rings and monofilament fishing line in recent years. (Zarudsky pers. comm.).

In New Jersey, the State Department of Environmental Protection has received incidental reports of gulls and wading birds entangled in monofilament fishing line and scuba divers have reported the presence of ghost gill nets off the coast on submerged wrecks (Freeman pers. comm.). Others noted that domestic wastes, such as plastic containers, six-pack rings, and tampon applicators are most prevalent (Caldwell pers. comm., Garabedian pers. comm.). The only type of fishing gear in any abundance appears to be monofilament fishing line.

Three primary sources suspected of generating most of the plastic debris along New Jersey's coastline are raw sewage discharges from treatment plants, sewage sludge dumping, and a major landfill located on Staten Island, New York (Tiedmann pers. comm.). Some of the plastic tampon applicators that are found on beaches are suspected to originate from the 12-mile sewage sludge dump site in the New York Bight. Presently, nine municipalities use this site. However, a recent EPA action has designated that all sewage sludge disposal will be conducted at a 106 mile site by 1988. It has also been alleged, but never proven, that sludge

barges may dump on their way out to designated sites, termed "short dumps" (Tiedemann pers. comm.). This practice, although it is illegal by EPA standards, saves both time and fuel by dumping on the way out and therefore lightening the load.

A larger portion of the tampon applicators is suspected to be coming from raw sewage discharges in the area (Tiedemann pers. comm.). The problem with the sewage treatment plants in this area is that many are technically secondary treatment plants, but some are actually less than this and are more like primary. Recently, the New Jersey Assembly Environmental Quality Committee gave initial approval of a bill similar to the one introduced in Massachusetts to ban the sale and distribution of plastic tampon applicators in the state. International Playtex Inc. lobbied against the bill and paid for female college students and doctors to testify against the bill (Benner 1986).

A large volume of the domestic wastes in this area is coming from the Fresh Kills landfill on Staten Island. Both escapement of debris from barges going to the landfill, and escapement of garbage directly from the landfill are causes for this debris. Reportedly, there are actually plumes of this debris following the coastline and emptying out onto Sandy Hook, New Jersey, and farther down the coast (Tiedemann pers. comm.). Sandy Hook, however, seems to get the brunt of most of this debris. Employees here can pick up all the debris on the beach in the morning and find that the beach is just as littered later in the afternoon. After a major storm the extent of debris escaping from the landfill can extend as far down as Ocean County. However, recent legal action has resulted in a judicial mandate for the discontinuation of this landfill (McHugh pers. comm.). Raw plastic pellets have also been observed on beaches at times but the source of the pellets is unknown (Zipf pers. comm.).

Major problems associated with plastic debris in New Jersey are the general aesthetic degradation of coastal areas but entanglement of wildlife, primarily birds, also occurs involving monofilament fishing line and six-pack rings. Incidents involving deer lodging their feet in plastic gallon containers was also reported (Treen pers. comm.). Fishermen in the area also claim that the dumping sites in the Bight are adversely affecting their ability to fish (Tiedemann pers. comm.).

Although there have been certain actions taken recently to minimize the problems associated with sewage sludge dumping and the Fresh Kill landfill, for purposes of this report the New York Bight area would be considered an area of particular concern.

Chesapeake

(Delaware, Maryland, Virginia)

Officials at National Wildlife Refuges in the states of Delaware and Maryland indicated that plastic debris causes problems in waterfront areas. The most prevalent plastic debris items in Delaware are domestic wastes, primarily six-pack rings and bottles or containers (Daly pers. comm.). Monofilament fishing line and some commercial fishing gear such as

trap buoys, net fragments and rope were also reported to be most prevalent in Maryland but were not as abundant as domestic types of wastes.

Wildlife refuges in Delaware and Maryland reported the entanglement of birds in six-pack rings and monofilament fishing line involving primarily snow geese and Canada geese (Daly pers. comm., Giese pers. comm.). At Blackwater National Wildlife Refuge in Cambridge, Maryland (Giese pers. comm.) ospreys have also been observed to use six-pack rings and monofilament line as nesting materials and there have been several incidents of young ospreys becoming entangled in these items. At Assateague Island National Seashore the most common problem relating to plastic debris involves fishing nets and snarls of monofilament line that often contain large numbers of marine animals including birds, fish and crabs (Rector pers. comm.). Plastic line also occasionally causes prop fouling for small boats in the area.

In Virginia, the State Public Beach Commission stated that plastic debris accumulates on public beaches but that the beaches are cleaned regularly and therefore the debris only presents a temporary aesthetic problem (Hardaway pers. comm.). Other sources in Virginia, however, reported that plastic debris causes problems with aesthetics and some entanglement of wildlife. The Eastern Shore National Wildlife Refuge in Cape Charles (Stairs pers. comm.) noted that domestic wastes accumulate in areas such as boat landing ramps, whereas on beaches with little public access common items of debris include rope, nets, buoys, containers, bags or sheeting and monofilament fishing line. Chincoteague National Wildlife Refuge often finds lost drifting gill nets in the area (Holland pers. comm.).

At Back Bay National Wildlife Refuge in Virginia Beach, plastic debris consists primarily of plastic articles that are reportedly coming from naval ships in the area, including cleaning agent containers as well as domestic types of trash (Dewhurst pers. comm.). In addition, there were also several items of debris with foreign labels.

Responses from Virginia also reported the entanglement of birds in six-pack rings; one source estimated that eight gulls are found entangled every year (Dewhurst pers. comm.). In York County, where plastic containers such as milk jugs, soft drink and motor oil bottles are most prevalent, there is a problem with these items causing blockages of normal tidal flux and nutrient transfer in marshes and estuarine areas (Rindfleisch pers comm.). Consequently, the stagnation of water caused by these blockages creates prime conditions for the breeding of the salt marsh mosquito which has considerable impacts on the quality of local life.

South Atlantic States

(North Carolina, South Carolina, Georgia and East Florida)

Three items of plastic debris common in all states are plastic bags, containers, six-pack rings, and monofilament fishing line. Both whole styrofoam objects, such as buoys, and small pieces are also common. According to the North Carolina Department of Natural Resources and Community Development (Shaw pers. comm.) plastic jugs (for milk and bleach)

were prevalent in this state until a recent regulation was amended to prohibit their use as floating buoys for marking traps. Plastic tampon applicators wash up on the Outer Banks of North Carolina following strong northeastern storms but appear to have been in the water for long periods of time nd therefore an immediate source is not ssuspected (White pers. comm.). Estimates are 100 tampon applicators for every one aluminum can on the beach.

Specific problems caused by these items in North Carolina include aesthethic degradation and the entanglement of ducks, geese and pelicans in plastic six-pack rings and monofilament fishing line. Mackay Island National Wildlife Refuge in North Carolina (O'Neill pers. comm.) also finds ospreys using monofilament for nesting material, as well as racoons entangled in six-pack rings. After Hurricane Gloria in 1986 the beaches and near-shore areas of the Outer Banks of North Carolina were reportedly littered with plastic bags (White pers. comm.). At the same time a large number of dead loggerhead sea turtles also washed ashore and were suspected to have died from ingestion of plastic.

Sources identified an informal program in North Carolina that addresses entanglement problems in fishing areas. Fisheries regulations (3B.0503 and 3B.0504) prohibit leaving devices unattended in coastal fishing waters for periods longer than twelve consecutive months. Also, eel, crab, fish and shrimp pots must be taken out of the water from January 24 to February 4 each year to eliminate ghost pots. The cleanup efforts associated with these regulations are incidental to routine operations of patrol boats. The responsible agency is the Department of Natural Resources and Community Development, Division of Marine Resources. The contact for the project is Mike Street in Marine Fisheries, Morehead City.

In South Carolina, at least 3 to 5 lost gill nets are found in the Georgetown area every year with entangled fish and birds (Allen pers. comm.). Cape Romain National Wildlife Refuge has also documented that monofilament gill nets cause mortalities of loons and, on several occasions, boat damage.

Savannah Coastal Refuges in Georgia report that most of the plastic litter items on the beaches, such as jugs, monofilament line, and motor oil containers, are coming from shrimp boats off the coast and pose primarily a problem of aesthetics (Singleton pers. comm.).

In Florida, Hobe Sound National Wildlife Refuge (Marcus pers. comm.) and Cape Canaveral National Seashore (Graham pers. comm.) most of the plastic debris comes from recreational boats. Merritt Island National Wildlife Refuge reported the entanglement of manatees in rope and buoys from crab traps and monofilament fishing line (Whitmore pers. comm.). There was also a report of a manatee that ingested a piece of rope.

Eastern Gulf of Mexico

(West Florida, Alabama, Mississippi, Louisiana)

From Everglades National Park to Gulf Islands National Seashore in Florida the major types of plastic debris are domestic wastes such as bags and containers, and fishing gear such as styrofoam floats, rope from traps, nets, and monofilament fishing line. The most frequent problems caused by this debris is the entanglement of pelicans and wading birds in monofilament fishing line and the ingestion of plastic bags by sea turtles (Hatcher pers. comm., Larkin pers. comm.). In Everglades National Park, there are few places where monofilament fishing line is not present (Dawson pers. comm.). Pieces of plastic sheeting used to cover agricultural fields also wash into the park from surrounding areas during storms. Chassahowitzka National Wildlife Refuge reported the entanglement of a manatee in a plastic rope (Hartis pers. comm.). Gulf Islands National Seashore finds plastic sheeting from the oil industry washing up on beaches (Thackery pers. comm.). They also reported the ingestion of raw plastic pellets by birds. In Sanibel, Florida, even alligators become entangled in monofilament fishing line (LeBuff pers. comm.).

Alabama and Mississippi state government agencies had very little information on the issue of plastic debris. Other contacts in these states indicated that some fishing gear and domestic wastes were present but that these caused no major problems (Carroll pers. comm., Thomas pers. comm.).

A cleanup by 100 volunteers conducted on Grande Isle, Louisiana resulted in the collection of 500 garbage bags along 7.3 miles. The amount of styrofoam and plastic were noted to be significant. The Louisiana Department of Culture, Recreation and Tourism stated that 75 percent of all plastic debris in the area of Baton Rouge consisted of six-pack rings (Beckman pers. comm.). Aesthetic degradation, and entanglement of birds in six-pack rings and monofilament fishing line has been observed but not quantified (Clark pers. comm.). Sources in Louisiana also noted that a large portion of the plastic debris, including domestic wastes and fishing gear, come from offshore commercial fishing, merchant shipping, and petroleum industry activities (Brown pers. comm., Edmonson pers. comm.).

Texas

There is a major problem with plastic debris in Texas. Domestic items such as garbage bags and six-pack rings, and in the northern portion of the state, fishing gear including nets, rope and monofilament fishing line are prevalent (Bisbee pers. comm.). Plastic items lost or discarded by the oil and merchant shipping industries, however, are the dominant types of debris in other areas, primarily in South Texas.

Documentation provided by Padre Island National Seashore stated that 90% of the debris on Padre Island comes from the Gulf (Lukens 1985). In 1985, sampling surveys indicated that 140 tons of debris were present on 57 miles of Padre Island (Amos 1985). Approximately 800,000 one-gallon milk jugs wash ashore each year (Lukens 1985). The most prevalent types of plastic debris in order of abundance are: large pieces of plastic sheeting,

computer write enable rings, seismic marker buoys, drilling pipe thread protectors, and diesel oil and air filters (King 1985). Milk jugs, 55 gallon plastic barrels, 5-gallon grease, pickle, fruit and assorted vegetable containers, were among the most prevalent plastic items at Aransas National Wildlife Refuge (Johnson pers. comm.). Some reported entanglements of birds in monofilament fishing line and six-pack rings. Laguna Atascosa National Wildlife Refuge reported incidents of ingestion by birds of small plastic bottles (Labuda pers. comm.). However, the major problem appears to be one of severe degradation of aesthetic quality of the Texas coastline.

In 1985, a status report entitled "Litter on Texas Coastal Beaches" concluded that littering is a coastwide and year-round problem and the Gulf of Mexico is the major source of litter found on Texas beaches (Texas Coastal and Marine Council 1985). While all local governments are having problems with beach litter, the worst situations occur in coastal areas beyond county, town and village jurisdiction, namely Padre Island National Seashore. This area receives the greatest portion of debris generated in the Gulf because currents move both surface and subsurface debris towards Padre Island with a convergence of north and south longshore currents in the area of Big Shell Beach (King 1985). These currents sweep the entire eastern portion of the Gulf of Mexico and converge on this ten mile area of Padre Island. The rate of deposition in this area is approximately 7 pounds per day. Material entering the Gulf at coastal areas along Mexico, Texas and Louisiana may also be transported to the convergence on Padre Island at speeds of up to one mile per hour (Lukens 1986).

The convergence zone shifts slightly north and south seasonally. A researcher at Texas A & M University is studying this complex current system by using plastic debris as current indicators (Amos pers. comm.). Currents coming from the south bring, among other things, green plastic bottles of "Clarosil", a popular brand of bleach in Mexico. Currents coming from the north in late spring and fall bring plastic containers bearing the brand names of supermarkets in Louisiana, Mississippi and Alabama. By studying what types of debris wash up at particular times, it is hoped that a greater understanding of this current system can be achieved. Two peak offshore trash periods are during late spring and fall. Prevailing inshore winds also bring debris to the beaches.

The tourist and recreational industry in Texas not only fears the immediate effects of beach debris, but also the negative viewpoint of tourists that may persist even if the problem is solved. This industry is the second largest in the state ranked behind the oil and gas industry (Ditton 1985). In 1984, $13 billion was spent on tourism in Texas, over one-third of which (4.5 billion) goes to coastal counties. Approximately one third of the jobs and payrolls of the state's tourist industry are also located on the coast. In 1984, twelve coastal political jurisdictions received $391,568 in state funding for beach cleaning procedures. Matching funds on a 50/50 basis were obtained by local jurisdictions from hotel/motel occupancy tax monies and other revenues. Padre Island National Seashore, however, does not qualify for state funding and if problems here are not remedied, dropping visitation rates may affect the local tourist industry.

Texas Department of Parks and Wildlife (Boat Ramp Section) administers a program to maintain beaches authorized under the Natural Resources Code and Senate Bill 16, passed in 1969. The program covers Gulf Coast beaches only, and does not include any beaches in bay areas. The project aims to keep these important tourist areas free from litter, for both aesthetic and safety reasons. The cities and counties participating in the program determine their own cleanup schedules and methods. Costs are shared with the Department of Parks and Wildlife, which currently contributes $300,000 annually to the effort with biennial appropriations.

There is also concern that the debris problem in Texas may have serious affects on the state's fishing industry, although the Texas Shrimp Association (Rayburn pers. comm.) and PISCES (Professionals in Sea Concerned with Enterprises) (Steed pers. comm.) reported only minor problems with plastic debris. However, the accumulation of this debris may eventually interfere with fishing operations in the Gulf. The Gulf shrimp fishery is the most valuable fishery in this area with average annual landings of 200 million pounds worth $300 million (U.S. Department of Interior 1985).

Pacific Coast

(California, Oregon, Washington)

The 1500-1600 volunteers who participated in California's beach cleanup collected 89 tons of debris in three hours over 300 miles of coastline (593 pounds per mile). Estimates of specific types of plastic debris collected included: 5 tons of styrofoam including food containers, cups, packaging materials and ice coolers, and 3 tons of assorted plastics including 4,500 six-pack holders, 600 assorted types of containers, 930 pieces of monofilament fishing line and 200 pieces of nets and strapping. Picnic debris and fishing gear were noted to be most prevalent. Cleanups in the San Diego area noted that some trash appeared to come from Mexico. At Point Reyes National Seashore 450 pounds of debris consisting of monofilament fishing line, six-pack rings, containers, styrofoam and other non-plastics were collected on 3.4 miles of beach.

State agencies contacted in California reported that they had no information on the issue of plastic debris. Three county governments, however, responded with information. In San Diego the most common forms of plastic debris are bottles, bags and styrofoam cups, tampon applicators and disposable diapers (Melbourne pers comm). San Diego County reported having previous problems with passage of neutral bouyancy particles through wastewater treatment plants, but the use of fine screening or filtering devices has eliminated the discharge of plastics. Considerable quantities of sewage and stormwater borne plastics, however, come from the Tijuana area of Mexico where sewage is not treated.

Santa Barbara County reported that six-pack rings, cups, styrofoam pieces and monofilament fishing line are most prevalent (McCurdy pers. comm.). The source of this debris is considered to be mostly beach goers and problems are mainly aesthetics.

Mendocino County reported that there was only one specific problem with plastic debris, which occurred in the late 1970's and resulted from a

plastic tarp that had been placed over an agricultural area for fumagation but was not removed (Bengston pers,. comm.). During a period of high water and flooding from the Russian River the tarp was washed into the river and shredded into the tops of the trees along several miles of Highway 101 in Mendocino and Sonoma Counties. This resulted in the severe degradation of aesthetics for those travelling the highway years after the water receded. To avoid this problem in the future, permits for restricted pesticides issued by the County of Mendocino Department of Agriculture have implemented conditions requiring cleanup procedures of plastic tarps. However, these conditions are only applicable to permits for restricted materials and cannot be enforced for pesticides that do not require permits, or for activities that do not involve pesticides.

Los Angeles County beaches are maintained through arrangements with private industries. Coppertone provides trash barrels for the beach in return for using the barrels as advertising space. Sea and Ski gives prizes to volunteers participating in beach cleanups and the 7-Up company hires youths at minimum wages to clean the beaches (Cahn 1984).

In Oregon, the beach cleanup conducted in 1985 was probably the most well-organized, since the methodology had been well established from a previous cleanup conducted in 1984 (Neilson pers. comm.). In 1985, 2300 volunteers collected 2800 20-gallon garbage bags of debris weighing 25.5 tons. Eighty-five percent of all debris, consisting of 31,541 pieces, was categorized and tabulated. Plastic items included 3,634 pieces of rope, 2,019 strapping bands, 1,096 six-pack rings, 924 pieces of recreational fishing gear, 564 pieces of gill net, and 1,403 pieces of trawl net. In addition, 18,656 pieces of styrofoam were collected. Most of the styrofoam had come from broken floatation blocks rather than domestic wastes. Plastic bags used for frozen bait were found to be abundant near the mouth of the Columbia River on the north coast and in an area adjacent to Coos Bay on the south central coast. Forty-three percent of all debris collected was estimated to come from beach uses while 42 percent drifted in from the ocean.

A short-term project that is plastics-specific is being conducted in Oregon. Oregon's Bottle Bill requires plastic six-pack rings to be degradable within 120 days of disposal. At present, the Liquor Commission, in conjunction with the Attorney General's office, is testing the plastic rings for compliance with the Bottle Bill requirements. The project began in August 1985, and is budgeted through existing funds. The contact for the project is Darleyne Myer at the Liquor Commission.

Due to the difficult terrain in Washington, a beach cleanup was conducted with the use of hundreds of four wheel drive vehicles (in addition to two helicopters) and collected over 3,640 bags of debris. Although the debris was not reported categorically, one prominent finding, especially on the southern beaches, was an abundance of plastic bags used for frozen bait.

The Washington State Parks and Recreation Commission (Heiser pers. comm.) provided a detailed list of the prevalent types of plastic debris found at 102 developed parks in the state, many of which are located on Puget Sound, the Straits of Juan de Fuca and the Pacific Ocean. These items include domestic wastes such as plastic bags, sheets, bottles and

containers and disposable diapers. Fishing gear items included monofilament fishing line and tackle, buoys, ropes and nets. Styrofoam and plastic foam chunks from domestic wastes and docks were also reported. Large pieces of plastic sheeting and plastic barrels are also common and appear to be coming from offshore merchant shipping or pertroleum operations. Clallam County noted these items to be prevalent also, in addition to plastic six-pack rings (Stulquist pers. comm.).

Among the problems associated with plastic debris, the State Parks and Recreation Commission noted entanglements of waterfowl, mostly in six-pack rings, danger to bathers caused by broken rigid plastic pieces, and entanglement of scuba divers in monofilament line. The Commission has also received many reports from the public on incidents involving plastic bait bags and other types of bags clogging boat water intakes and causing overheating and vessel damage. In addition they noted the danger to firefighters when dealing with dune fires that emit toxic fumes especially if fishing nets or other plastic debris catch fire. They also reported on the aesthetic problem caused by plastic debris, especially in areas where driving on the beach is permitted and where commercial debris washes ashore.

Alaska

State Departments in Alaska indicated that they did not have direct involvement in studies concerning plastic debris. Many referred to the results of studies conducted on Amchitka Island (Merrell 1982, 1984, 1985) and the serious problems facing the northern fur seal in the Pribilof Islands (Fowler 1982, 1985, Fowler et al 1985, Fowler and Merrell 1986) which have been included in previous sections of this report. Others indicated that due to the volume of vessel traffic in Alaska there is a tremendous amount of debris. Charter fishing boats, commercial fishing boats, private recreational vessels, large passenger cruise ships, barges and cargo ships, some of which are foreign, all use the waters off the coast.

Kenai Fjords National Park, with approximately 600 miles of shoreline, and Kodiak National Wildlife Refuge, with approximately 800 miles of shoreline, are both situated in an area of major shipping activity. The most prevalent types of debris in this area include domestic wastes, commerical fishing gear, and merchant shipping wastes (Kaye pers. comm., Vivion pers. comm.). The most common items include plastic garbage bags, plastic sheeting, net fragments, various types of buoys and plastic containers. A good portion of the debris in these areas is from foreign vessels.

Problems associated with this debris include wildlife entanglement, particularly of sea lions, sea otters and seals in nets, and vessel disablement caused by monofilament line fouling propellors and plastic bags clogging cooling water intake systems. Although the aesthetic problem caused by plastic debris was recognized, one source commented that "it is hard to walk on Kodiak Island without seeing some type of debris but that debris in Alaska is a way of life" (Vivion pers. comm.).

Hawaii

Over 650 volunteers picked up over 8 tons of debris during two beach cleanups. Overall results were not available, but in Mauii 6,585 pounds of debris was collected including 412 plastic strapping bands, 655 pieces of commercial gill net, 150 pieces of styrofoam and 1,101 six-pack holders. Seventy-five percent of the debris in Mauii was assumed to have been generated from beach use.

An official with the Office of Environmental Quality Control (Uyehara pers. comm.) referred to general problems caused by marine debris including entanglement, aesthetic degradation and vessel fouling. A particular situation for Hananma Bay in Oahu was noted where scuba divers and snorklers bring food for fish and leave plastic bags behind.

Lake Ontario

(New York)

The eastern end of Lake Ontario receives much floatable debris from the rest of the lake (Mead pers. comm.). Plastic items, especially polyethylene seem to be quite prevalent at times on the eastern Ontario beach areas. Plastic tampon applicators are especially prevalent, about one every few feet. Monofilament fishing line was said to be an aesthetic problem at times in the Black River below Dexter. Several Canada geese in this area of Lake Ontario have become entangled in six-pack rings and monofilament fishing line.

After contacting two county and three state park officials, five waterfront towns, two marinas and six sewage treatment plants in Niagra County (at the opposite end of Lake Ontario), an official with the Niagra County Environmental Management Council (Walder pers. comm.) reported that from 45 to 80 percent of all debris collected in this area is plastic. This includes large plastic bags filled with garbage or leaves, tampon applicators, six-pack rings, cups, bottles, disposable diapers and monofilament fishing line. The sewage treatment plants in the area have problems with plastic tampon applicators and disposable diapers since they sometimes float below the surface thereby escaping the skimming process. During high flow periods they are bypassed into Lake Ontario.

The specific problems caused by plastic debris are entanglement of birds in six-pack rings, vessel disablement caused by monofilament fishing line and the attraction of rats to the debris.

Lake Erie

(New York, Pennsylvania, Ohio)

The Pennsylvania Fish Commission (Kenyon pers. comm.) indicated that monofilament fishing line, six-pack rings and styrofoam are the most prevalent types of debris on Lake Erie. Also mentioned were monofilament and multifilament gill nets and plastic shotgun shells. Problems such as vessel disablement caused by monofilament fishing line, and the entanglement of waterfowl in monofilament and six-pack rings were said to occur, but very infrequently. Aesthetic degradation is the primary problem especially at Presque Island State Park where styrofoam left by visitors is becoming an increasing nuisance (Giza pers. comm.).

According to the Ohio Division of Watercraft, Office of Litter Prevention and Recycling (Hawse pers. comm.) the majority of plastic debris found on the Ohio border of Lake Erie consists of domestic wastes and monofilament fishing line. The most prevalent items are styrofoam articles. Rubber tires are also numerous, because they are often disposed of in the Lake, rather than paying a fee of $5 per tire at local dumps. Problems include the aesthetic degradation of lakefront areas, entanglement of wildlife in six-pack rings, and vessel disablement which occurs frequently due to fouling in monofilament fishing line.

The Department of Natural Resources, Division of Waterways, administers a litter education and cleanup program to maintain lakefront areas and adjoining waterways which is sponsored under the Ohio Litter Control and Recycling Act (Hawse, Director, pers. comm). The program's funds come from a $72,000 grant from Ohio's office of Litter Prevention and Recycling. Under the program, the state is divided into seven district offices that set up the litter program.

Education efforts are aimed at informing boaters and members of sporting groups about water pollution problems. Schools have also been included in education sessions. River and stream cleanup projects are also organized by the district offices and are conducted by volunteers in environmental groups and other interested individuals.

Lake Michigan and Lake Huron

(Michigan, Indiana, Illinois, Wisconsin)

The state of Michigan borders three of the Great Lakes and state authorities in Michigan addressed the issue of plastic debris statewide. Lake Superior will be discussed in a separate section. The types of plastic debris that are most prevalent along lakefront areas of Michigan are domestic wastes such as plastic containers and bottles, bags and sheeting, six-pack rings and styrofoam (Gahsman pers. comm., Wright pers. comm.). Fishing gear, namely monofilament fishing line and gill nets was also reported. There is a concern that lost gill nets may continue to catch fish in the Great Lakes, and researchers at Michigan State University are exploring ways to study the effects of this on fishery resources (Groll pers. comm.). Although Michigan law banned the use of gill nets some years ago, other jurisdictions bordering the Great Lakes have not. Another

problem is the entanglement of waterfowl and fish in monofilament fishing line and six-pack rings. State biologists have estimated that one in every 100 waterfowl observed are entangled in monofilament fishing line (Martin pers. comm.). It was also reported that mortality of diving ducks and loons may be caused by entanglement in plastic debris used for nest materials. A documented case of fish entanglement in Lake Michigan involved a steelhead salmon tightly encircled by a plastic ring (Richey 1986). Vessel disablement caused by monofilament line, and recreational fishermen snagging hooks on plastic debris were also cited as problems.

Sleeping Bear Dunes National Lakeshore on Lake Michigan, noted the accumulation of large amounts of plastic debris, much of which consists of plastic containers for detergent or motor oil (Abbett pers. comm.). The major problem is the aesthetic degradation of the area.

Indiana Department of Natural Resources (Simpson pers. comm.) reported that there are few problems associated with plastic debris. Indiana Dunes National Lakeshore, which extends along a major portion of the Indiana border on Lake Michigan, reported that they were unable to provide any information on the specific types of plastics that were routinely removed from beach areas, but that they too are unaware of any major problems associated with plastic debris (Alexander pers. comm.).

Illinois also indicated that there are no specific problems with plastic debris that would restrict recreational use or present a hazard to the public or wildlife (Moylan pers. comm., Dinning pers. comm.). The Chicago Metropolitian Sanitary District indicated that there are more severe environmental problems in the area than accumulation of plastic (Gosden pers. comm.). However, beaches are routinely maintained and therefore plastic and other types of debris do not accumulate.

The Wisconsin Department of Natural Resources (Baker pers. comm.) reported that on the western shore of Lake Michigan domestic wastes, particularly bags and six-pack holders, and monofilament fishing line were most prevalent on waterfront areas. Entanglement of birds and animals in fishing line were said to occur but were not quantified. In Marinette County, Wisconsin domestic wastes such as trash bags, containers and six-pack rings are most prevalent in the area, but these items are more of an aesthetic problem inland as compared to waterfront areas on Green Bay (Crowley pers. comm.).

For lakefront areas in Huron-Manister National Forests on Lake Huron, monofilament fishing line, plastic fishing tackle packaging are most prevalent (Mann pers. comm.). Styrofoam coolers are also prevalent in some of the major canoeing streams. Problems caused by this debris are primarily the degradation of aesthetics. Entanglement of waterfowl in monofilament fishing line and the potential hazard of this line to divers were also reported.

Hiawatha National Forest, which borders both Lakes Michigan and Superior, also reported that monofilament fishing line and plastic six-pack rings are the most prevalent types of debris in the area but there are no particular problems associated with this debris (Awkmann pers comm.).

Lake Superior
(Wisconsin, Minnesota)

At Apostle Island National Lakeshore in Bayfield, Wisconsin domestic wastes and a variety of fishing gear are the most common types of plastic debris (Miller pers. comm.). The problems caused by this debris are aesthetic degradation, entanglement of wildlife in six-pack rings and lost nets, and vessel failure caused by plastic bags and net fragments getting entangled in propellors.

In Minnesota, the Department of Natural Resources commented on a "very obvious litter problem" in the lakefront areas (Shannon pers. comm.). Here, plastic debris is the most prevalent type of litter, second to beverage cans. Although, specific types of plastic debris were not reported by this source, Superior National Forest (Beal pers. comm.) commented on the abundance of particular items, namely garbage bags, styrofoam insulation chunks and disposable diapers. It was suggested that vessel traffic is the primary source of the garbage bags.

Problems associated with plastic debris reported by all observers are aesthetic degradation, the entanglement of wildlife (primarily ducks and loons) in six-pack rings and monofilament fishing line, and the nuisance to fishermen of having bags entangled on fishing hooks and lines. In the vicinity of Superior, Wisconsin, there is also a problem with erosion of debris into Lake Superior from a discontinued landfill (Beal pers. comm.).

PART V

LEGAL AUTHORITIES PERTAINING TO DISPOSAL OF PLASTICS IN THE MARINE ENVIRONMENT

Introduction

The following analysis examines international, federal, and state authorities relevant to the disposal of plastics in the marine environment, focusing on the particular issues of entanglement of marine species in discarded plastic materials or ingestion by marine biota of plastic debris. The broader issue of solid waste disposal as it relates to any and all plastic litter that ultimately finds ins way in to the ocean is not examined in detail at the state level, although relevant authorites are noted. With regard to international agreements, the analysis presents detail on several agreements, but where groups of agreements are patterned after each other (for example, the United Nations Regional Seas Program), one model is examined in detail, and similar models are noted.

For purposes of the analysis, each authority is examined as follows: its purpose; its authority, including responsible party/agency, provisions, and jusrisdiction; its application to entanglement, included express provisions, construction and interpretation by the courts, and possible new interpretations; its relationship to other laws; and its limitations, including further issues for review.

Abbreviations and citations used are according to A Uniform System of Citation, Thirteenth Edition, published by the Harvard Law Review Association. For unabbreviated titles, see the list of references. Relevant portions of all laws cited are included in Appendix 3. Where the complete text of a law or treaty was extremely long, and where provisions were not applicable to the instant discussion, only those portions discussed are reproduced in the Appendix.

Because much of the following analysis hinges on definition and interpretation of words and phrases, terms that are used repeatedly are defined separately, rather than each time they occur in the discussion. Unless otherwise noted, the following terms used in this analysis have the meanings set out below.

Vessel: waterborne craft of any type whatsoever, including air cushioned craft and floating craft, whether self-propelled or not; but not artificial islands.

Garbage: solid waste including, but not limited to, waste by-products of food handling; household waste such as paper, cans, bottles; and any other discarded, used materials normally attendant to domestic activity.

U.S. Territorial sea: the belt of the seas measured from the line of ordinary low water along that portion of the coast which is in direct contact with the open sea and the line marking the seaward limit of inland waters, and extending seaward a distance of three miles.

Contiguous zone: the belt of the seas measured from the limit of the territorial sea and extending seaward a distance of 12 miles.

Navigable waters: waters of the U.S. including the territorial sea.

Ocean: any portion of the high seas beyond the contiguous zone.

Exclusive Economic Zone: zone contiguous to the territorial sea, and extending to a distance 200 nautical miles from the baseline from which the breadth of the territorial sea is measured.

International Authorities

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)

Purpose

Promote the "effective control of all sources of pollution of the marine environment...by dumping of waste and other matter that is liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea."

Authority

- Individual contracting parties responsible for passing applicable statutes; treaty not self-implementing.

- Individual nations responsible for promulgating regulations, issuing permits, enforcing provisions.

- Provisions:

  (1) Prohibits deliberate disposal at sea of materials listed in Annex I.

  (2) Annex II lists materials that may be dumped under special permit.

  (3) Annex III lists factors to be considered before issuing general permit for dumping of materials not listed in Annex I or II.

- Prohibited materials listed in Annex I include "...persistent plastics and other persistent synthetic materials, for example, netting and ropes, which may float or remain in suspension in the sea in such a manner as to interfere materially with fishing, navigation or other legitimate uses of the sea." Annex I, 4.

- Each nation's jurisdiction extends to vessels and aircraft:

  (1) registered in territory or flying flag;

(2) loading in territory or territorial seas matter which is to be dumped;

(3) under its jurisdiction believed to be engaged in dumping. Article VII, 1.

Application to Entanglement

The dumping of persistent plastics such as netting is expressly prohibited under Annex I. Dumping is defined in Article III 1(a) as "any deliberate disposal at sea...." Therefore, a deliberate discard of fishing nets seems to be prohibited, for example, throwing damaged nets overboard, or purposefully cutting nets loose in an effort to avoid detection for fishing violations, or purposefully cutting nets loose to release illegally entangled marine mammals. However, the convention excludes "disposal at sea of wastes or other matter incidental to, or derived from the normal operations of vessels...." Therefore, the accidental loss of a net in the course of fishing operations probably would not be covered by the Convention.

Relationship to Other Laws

- The treaty is implemented in the U.S. by 33 U.S.C. 1401 et seq., Marine Protection, Resources, and Sanctuaries Act. See below.

- The Convention does not preclude the parties from prohibiting materials in addition to those listed in Annex I, nor from adopting other measures to prevent dumping at sea. Article VII.

Limitations/Further Considerations

There has been some criticism of the Convention because it addresses a narrow scope of ocean dumping, rather than all sources of debris that pollute the seas. (6 Law and Pol in Int Bus 575 at 578-579(1974)). At the time negotiations were taking place, however, it was the U.S. position that the introductiion of issues such as river and land-based sources of ocean debris would have posed too many obstacles to the ratification of the convention. (Ibid., 579). The Convention has also been criticized because of each nation's discretion in enforcement, (Ibid., 583-585), and it is not known how each party has implemented the Convention through its own domestic law. (Gosliner, 1984). Even if each party implemented the Convention through domestic enabling legislation, however, enforcement still would be difficult because the discard of netting and other debris takes place at sea where there is little chance of observation by the contracting nation's enforcement agencies. (Ibid.)

Yet another problem with the Convention stems from possible varying interpretation of the key phrases "derived from the normal of operations of vessels...and their equipment,..." and "legitimate uses of the sea." Neither phrase is defined in the Convention. One analyst contends that accidental loss of debris, such as a broken net, is not governed by the Convention. "Net discards which are generated in the course of fishing operations may be considered to fit [the] exception" excluding disposal derived from normal operations. (Ibid., 6).

On the other hand, there is some history of implementing legislation to indicate that "normal operations" meant the discharge of bilge water or water flushed as part of the propellant system of a vessel that might include some oil or wastewater, with the intent that such discharges not come under the prohibitions of the Convention. This is clearly the intent under the U.S. law that implements the London Dumping Convention. See 33 U.S.C. 1402(f) for definition of dumping and exclusions. Yet another interpretation is that the London Dumping Convention would apply to disposal of nets only if they were put aboard a vessel for the express purpose of dumping them. (Bean, at 33(1984)).

Once the determination were made as to whether a discarded net was deliberately dumped, it would still remain to be determined that such dumping interfered with "legitimate uses of the sea," a phrase which is not defined in the Convention.

It can be argued that "ghost fishing" by discarded nets (continued capture of both target and non-target species) affects not only the health and maintenance of those species and the other marine organisms that use them for food, but also affects the legitimate economic use of fisheries resources by humans. Another argument made is that "the utilization of the oceans to ensure healthy populations of marine mammals and other marine fauna is a legitimate use of the sea which is materially interfered with by casting off netting and other debris...."(Gosliner, p. 7).

Therefore, if discard of nets met the first test of the Convention definition of "dumping" as a deliberate disposal, it can be argued that the second test, interference with a legitimate use of the sea, is also met when a discarded net captures fish and entangles marine mammals and birds.

Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships, 1973, with annexes and protocols, 1978, entered into force 1983.(MARPOL Protocol).

Purpose

To prevent and control pollution generated by ships by amending the 1973 Convention.

Authority

- Annexes contain regulations for enforcement and administration of pollution prevention.
- Individual contracting parties pass implementing domestic legislation to enforce.
- Annexes III, IV, and V are optional.
- Provisions:
  (1) Annex III regulates disposal of hazardous packaged substances.

  (2) Annex IV regulates disposal of sewage.

(3) Annex V regulates disposal of garbage, prohibiting, inter alia, disposal of "all plastics, including but not limited to synthetic ropes, synthetic fishing nets and plastic garbage bags...."

- Optional Annexes do not enter into force until after adoption by at least 15 nations whose fleets jointly constitute 50 per cent of the gross tonnage of the world's merchant shipping fleet. (15 of MARPOL 73/78).

- Jurisdiction treated below in discussion of U.S. implementing legislation.

Application to Entanglement

Barring the limitations to the MARPOL Protocol set out below, it has been argued that its provisions apply to disposal of fishing gear that causes entanglements. First, it covers accidental disposal, unlike the London Dumping Convention. Secondly, it expressly denotes synthetic fishing nets among prohibited disposals in optional Annex V. Thirdly, since only one or the other convention may apply, because discharges as defined in MARPOL exclude acts defined as "dumping" under the London Dumping Convention, it is more likely that MARPOL addresses nets because of the problems outlined above in covering nets under the London Dumping Convention. One analyst describes the relationship between the two conventions as a distinction between waste carried to sea for the purpose of dumping, and waste discarded in the normal course of operation. The analysis is illustrated with the following example: "...if a fisherman damages his gear at sea and discards it there, his action is contrary to the MARPOL Convention; if, however, he returns to port and gives it to a junk dealer who then hauls it to sea and dumps it overboard, the junk dealer's action is contrary to the London Dumping Convention." (Bean, 33).

Relationship to Other Laws

- Implemented in U.S. by 33 U.S.C. 1901.

- Definition of "discharges" prohibited by MARPOL Convention specifically excludes acts which constitute "dumping" under the London Dumping Convention.

- Amends provisions of the International Convention for the Prevention of Pollution from Ships, 1973.

- To be read and interpreted as one single instrument with above.

Limitations/Further Considerations

Annex V may have applicability to the entanglement issue, however, it is not yet in force. To date, 26 nations have ratified the Annex, but their combined tonnage, which currently stands at 44.53%, falls short of the requirement in Article 5. The U.S. has not ratified any of the optional annexes, because at the time the Protocol was submitted, "the Coast Guard, which was the key decision-making agency..., was so keenly

interested in getting the Convention's oil pollution provisions in place that it did not want to jeopardize that goal by asking the Senate to consider extraneous matters like those addressed in the optional annexes." (Bean, 34).

The Coast Guard is considering ratification and implementation of Annex V at this time, but officials state that such a move is about two years away. Recent support for U.S. ratification of Annex V has been expressed by the Coast Guard and the U.S. Delegation to the IMO Maritime Safety Committee and Maritime Environment Protection Committee. A recommendation that the U.S. support ratification was made to the Secretary of State, who is expected to forward that position to the President. (Testimony, RADM J. William Kime, Chier Office of Marine Safety, Security and Environmental Ptotection, U.S.C.G., before Committee on Merchant Marine and Fisheries, Subcommittee on Coast Guard and Navigation, U.S. House of Representatives, 12 August, 1986.)

If the United States were to ratify the optional annexes, including Annex V which addesses plastics and netting, there would still be three hurdles to clear before MARPOL could be applied to the entanglement problem: 1) passage of implementing legislation, 2) determination that the loss of a net was not accidental in the course of repair, and 3) that reasonable precautions to prevent the loss were not taken. The enforcement problems in proving that the latter two exemptions did not apply would be significant. (Gosliner, 8-9, see also, Bean, 32-34).

Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, 1983. (Caribbean Convention)

Purpose

To provide a cooperative mechanism on a regional basis for coastal states in the region to reduce and control pollution in the Convention area. Article 4, 1.

Authority

- Contracting parties to "endeavor to conclude bilateral or multilateral agreements,...for the protection of the marine environment." Article 3, 1.

- Provisions:

  Parties shall take "all appropriate measures" to:

  (1) Prevent, reduce and control pollution from ships.

  (2) Prevent, reduce and control pollution caused by dumping.

  (3) Prevent, reduce and control pollution caused by coastal disposal or by discharges emanating from internal waters.

- Jurisdiction extends to 200 miles in Convention area, which includes the Gulf of Mexico, the Caribbean Sea and the areas of the Atlantic Ocean adjacent thereto, south of 30 north latitude.

Application to Entanglement

The provisions of this Convention are very broad and general, and nowhere in the Convention is the phrase "all appropriate measures" defined. However, Article 3, 2, states that the provisions "shall be construed in accordance with international law relating to their subject matter," and Articles 5 and 6 each state that appropriate measures shall be taken "to ensure the effective implementation of the applicable international rules and standards...." Since these two Articles seem to be patterned after the London Dumping Convention, it could be argued that the London Dumping Convention is the "applicable international rule." If that is the case, the same considerations and limitations in applying those provisions to entanglement would apply to the Caribbean Convention.

Relationship to Other Laws

- The Caribbean is one of 10 regional seas areas delineated under the United Nations Regional Seas Program.

- The Regional Seas Program provides a mechanism for regions to identify issues and draw up an action plan designed to address marine pollution in their respective areas.

- The Caribbean Convention is typical of the Conventions that result from the regional action plans.

- Five other regions have negotiated Conventions, noted below, Section G. Four regions which are still in the planning state are East Africa, East Asia, Southwest Pacific, Southwest Atlantic.

Limitations/Further Considerations

The Caribbean region is the only region in the Regional Seas Program which encompasses waters of the U.S. teritorial sea and contiguous zone. The U.S. has signed and ratified the Convention, and is providing advisors on a consultative basis to the United Nations Environment Program in the area. Other nations which have signed, but not ratified, the Convention are: Barbados, Colombia, France, Grenada, Guatemala, Honduras, Jamaica, Mexico, Netherlands, Nicaragua, Panama, Saint Lucia, United Kingdom, Venezuela, and the European Economic Community. The Convention does not enter into force until 30 days after the ninth state ratifies.

Programs

The United States participates in the Regional Seas Program through the Wider Caribbean regional group. Although there are no specific projects being carried out by the United States, advisors have been sent to consult on the Caribbean Action Plan. The Coast Guard provided an oil spill consultant to the Plan, and the Army Corps of Engineers also has

assigned a consultant to the Plan. Most of the projects being conducted under the program concern oil spill contingency plans for the region. The liaison for the Regional Seas Program in the United States is located in the Bureau of Oceans and International Environmental And Scientific Affairs, Department of State.

United Nations Convention on the Law of the Sea, 1982.

Purpose

The codification of existing maritime law, with a goal, among others, to protect and preserve the marine environment.

Authority

- The Convention binds those nations that are party to it.
- Defines territorial seas and exclusive economic zones.
- Individual states to pass laws, prescribe permitting procedures relating to pollution.
- Individual states to promulgate conservation measures regarding fish and marine wildlife.
- Individual states to enforce laws and regulations adopted.
- Creates methods for arbitration and adjudication of disputes.
- Provisions relevant to plastics dumping/entanglement:

  (1) In its exclusive economic zone, each state has the right to protect and preserve the marine environment. Article 56, 1(b))iii).

  (2) Each state shall determine allowable catch of marine resources, and shall take conservation measures designed to maintain maximum sustainable yield. Article 61.

  (3) Coastal states shall promote optimum utilization of resources, including other states' access to surplus of allowable catch. Article 62,2.

  (4) Nationals of other states fishing in coastal state's exclusive economic zone shall comply with regulations, including those applying to vessels and equipment. Article 62, 3(a).

  (5) States shall adopt laws to indemnify owners for loss of nets or other fishing gear. Article 115.

  (6) States have a duty to take measures to conserve living resources. Article 117.

  (7) States shall adopt laws and regulations to prevent, reduce and control pollution by dumping. Article 210.

(8) States shall establish international rules and standards to prevent, reduce and control pollution from vessels. Article 211.

(9) States shall enforce their laws and adopt laws to prevent, reduce and control pollution from land-based sources. Article 213.

Application to Entanglement

Like the London Dumping Convention, the Convention on the Law of the Sea defines dumping as a deliberate disposal, Article 1.1(5)(a), and excludes disposal incidental to normal operations of vessels, 1.1(5)(b)(i). Therefore, the same interpretation problems as exist with the London Dumping Convention would apply to the Law of the Sea. On the other hand, the Law of the Sea directs contracting parties to prevent or control "pollution of the marine environment," which is defined as "the introduction by man, directly or indirectly, of substances...into the marine environment..., which results or is likely to result in such deleteriorus effects as harm to living resources and marine life...." Article 1.1(4). Therefore, even if discard of nets were not covered as "dumping," it could be argued that it is covered within the meaning of "pollution" as defined, since entanglement is a "harm" to marine fauna.

The provisions noted above that may be relevant to entanglement include several possibilities for interpretation. For example, the provisions directing states to conserve their living ocean resources for maximum sustainable use could be applied to encourage regulatory schemes that prohibit fishing in areas where entanglement of marine birds and mammals is a significant threat. Further, such fisheries regulations might prescribe types of gear and netting that minimize entanglement. In establishing rules and standards for preventing pollution, pursuant to Articles 211 and 213, coastal states could become signatory to and enforce the London Dumping Convention, by strengthening provisions relating to entanglement and disposal of plastic debris.

Since the Law of the Sea is not in force, the preceding discussion is theoretical only, in terms of how its provisions might be used to address the entanglement problem. One commentator has noted, however, that the provisions of the Law of the Sea enjoy wide support as customary practices even though not ratified, and "while not offering any new basis for resolution of the entanglement problem, may be useful by giving added force and legitimacy" to other efforts. (Bean, 39).

Relationship to Other Laws

- Codification of existing maritime law.
- Encourages contracting parties to enter into local and regional agreements.
- Does not prevent parties from negotiating agreements with stricter applications to pollution prevention measures.

Limitations/Further Considerations

The Convention on the Law of the Sea was opened for signature on December 10, 1982, and will enter in force 12 months after 60 of the signatory states have ratified. To date 26 of the 159 signatory nations have ratified. The U.S. is not signatory.

Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft, Oslo, 1972. (Oslo Convention)

Purpose

Prevent the pollution of the sea by substances that are liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea. Article I.

Authority

- Individual contracting parties responsible for passing applicable measures; treaty not self-actuating.
- Individual nations responsible for promulgating regulations, issuing permits, enforcing provisions.
- Provisions:

  (1) Prohibits disposal at sea of materials listed in Annex I (Article 5).

  (2) No wastes listed in Annex I shall be dumped without a permit (Article 6).

  (3) Annex III provides criteria for determining whether and where a permit shall be issued.
- Prohibited materials listed in Annex I include "persistent plastics and other persistent materials which may float or remain in suspension in the sea, and which may seriously interfere with fishing or navigation, reduce amenities, or interfere with other legitimate uses of the sea." (Annex I, 6).
- Each nation's jurisdiction extends to:

  (1) ships and aircraft registered in its territory;

  (2) ships and aircraft loading in its territory the materials to be dumped;

  (3) ships and aircraft believed to be engaged in dumping within its territorial sea (Article 15).

- The area governed by the convention is the North Atlantic, specifically:

  (1) high seas and territorial seas situated within those parts of the Atlantic and Artic Oceans north of 36 north latitude, and between 42 west longitude and 51 east longitude,

  (2) but excluding the Baltic and Mediterranean Seas (Article 2(a)).

- Contracting parties are Belgium, Denmark, Finland, France, Federal Republic of Germany, Iceland, Ireland, Netherlands, Norway, Portugal, Spain, Sweden, and the United Kingdom.

Application to Entanglement *

Relationship to Other Laws *

Limitations/Further Considerations *

Convention on the Conservation of Antarctic Marine Living Resources, Canberra, 1980. (Antarctic Convention)

Purpose

General conservation and protection of the marine environment and resources of the Antarctic, through scientific and technical cooperations.

Authority

- Creates a Commission made up of members from each of the contracting parties.

- Commission shall (inter alia):

  (1) encourage research,

  (2) compile data,

  (3) publish information,

  (4) identify conservation needs and measures to address them,

  (5) formulate, adopt and revise conservation measures, including measures regulating harvest of Antarctic species.

- Contracting parties bound by Commission conservation measures.

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* NOTE: The Oslo Convention is a regional agreement similar to the London Dumping Convention, and the same applications and limitations apply. Other regional agreements which follow pattern are noted below, Section G.

- Jurisdiction: The area south of 60 Deg. South latitude to the Antarctic Convergence (a line joining the ollowing latitude/ longitude points: 50 Deg. S, 0 Deg.; 50 Deg. S, 30 Deg. E; 45 Deg. S, 30 Deg. E; 45 Deg. S, 80 Deg. E; 55 Deg. S, 80 Deg. E; 55 Deg. S, 50 Deg. E; 60 Deg. S, 150 Deg. E; 60 Deg. S, 50 Deg. W; 50 Deg. S, 50 Deg. W; 50 Deg. S, 0 Deg.).

Application to Entanglement

The issue of pollution or dumping is not addressed per se in the Convention, even though the agreement is aimed at general conservation and protection of the Antarctic marine environment. However, since the Convention addresses harvest of marine species in the Antarctic, some of the conservation measures described in the provisions could apply. For example, among these provisions is one for regulation of the types of fishing gear not likely to entangle, or, conversely, prohibit types of gear which are known to cause entanglements. The Commission also is authorized to take "...such other conservation measures as...necessary..., including measures concerning the effects of harvesting and asscoiated activities on components of the marine ecosystem other than the harvested populations" (Article IX 2 (i). Under this language it is possible that the Commission could prohibit dumping or take other measures if it were found that harvesting activity in the area generated enough discarded gear or garbage to entangle or affect non-target species.

Relationship to Other Laws

- Relates to Antarctic Treaty with regard to territorial claims.
- Does not derogate from rights and obligations or parties under other agreements affecting the Antarctic.

Limitations/Further Considerations

The Convention does not address the issue of pollution directly, so it could be argued that its application to control of marine debris is limited. However, its main goal is the conservation of the living marine resources of the area, so to the extent that any of those species are endangered by entanglement, or to the extent that the health of the ecosystem is threatened by pollution, marine debris might be an issue to which the Commission could address itself. In transmitting the Convention to the President with recommendations for ratification, the U.S State Department pointed out that the intent of the parties was to give the Commission broad discretion in taking conservation measures. "The listing makes clear that the Commission may draw on the full range of such measures in pursuing the objective of the Convention." (Letter of Submittal, October 29, 1980.

Other International Agreements Noted, but not Examined

U.N. Regional Seas Program (See Caribbean Convention, above, as model)

- Convention for the Protection of the Mediterranean Sea against Pollution, Barcelona, 1976.

- Protocol for the Prevention of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft, Barcelona, 1976.

- Protocol for the Protection of the Mediterranean Sea Against Pollution from Land-based Sources, Athens, 1980.

- Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution, Kuwait, 1978.

- Convention for Cooperation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region, Abidjan, 1981.

- Protocol for the Protection of the Southeast Pacific Against Pollution from Land-based Sources, Quito, 1983.

- Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment, Jiddah, 1982.

- Protocol Concerning Regional Cooperation in Combating Pollution by Oil and Other Harmful Substances in Cases of Emergency, Jiddah, 1982.

Other Regional Agreements (See Oslo Convention, above, as model)

- Convention on the Protection of the Marine Environment of the Baltic Sea Area, Helsinki, 1974.

- Agreement for Cooperation in Dealing with Pollution of the North Sea by Oil and Other Harmful Substances, Bonn, 1983.

Foreign Domestic Legislation

- An Italian law prohibiting the use of non-biodegradable plastic grocery bags was passed recently. However, its major thrust was to block competition by plastic bags over paper packaging and paper bag manufacturers were the major sponsors and advocates for the legislation. While the law will have an inadvertant benefit in addressing marine pollution, the environment was not its primary purpose.

- Discussions with experts in the course of research indicate there may be Korean legislation providing a bounty for return of discarded fishing nets. However, no authority was found.

- Discussions in the course of research indicated there is Japanese domestic legislation relating to discard of nets. Attempts to secure copies of this legislation have been successful.

U.S. Federal Authorities

Rivers and Harbors Act of 1899, 33 U.S.C. 407 (The Refuse Act).

Purpose

To keep navigable waters free of obstructions.

Authority

- Coast Guard and Department of Justice administer.
- U.S. Army Corps of Engineers has permitting authority.
- Any federal agency may bring action for violation.
- Citizens may not bring action against federal officials to enforce.
- Provisions

  (1) Prohibits discharge into navigable waters or their tributaries "any refuse matter of any kind or description whatever other than that flowing from streets and sewers and passing therefrom in a liquid state."

  (2) Prohibits deposits of "material of any kind" anywhere it is likely to be washed into navigable waters. This would include active or abandoned dump sites on land.
- Phrase "navigable waters" has been construed broadly. (61A AmJur 2d 726, Sec. 215).
- Jurisdiction includes all internal navigable waters and extends to three miles.

Application to Entanglement

The Refuse Act contains no provisions specific to marine entanglement or disposal of plastics. However, its general provisions have been construed very broadly by the courts. The term "refuse" has been held to include oil, gasoline, industrial wastes and solids, animal waste, brush, timber pilings, logs, and earth removed in strip mining. (Ibid.) In fact, the only exemption to the kinds of "material" or "refuse" is the specific exception to matter "flowing from streets and sewers." Under these interpretations, it is likely that plastic debris would be covered. Further, the courts have held that the act is a criminal, strict liability statute, and as such requires no intent for a violation. (Ibid.). Therefore, it could be argued that disposal of plastic debris such as beverage container connectors (six-pack rings), plastic pellets, buoys, and other types of debris set out above would be prohibited by the Refuse Act, even if such disposal were not deliberate. The only exclusion would be if such debris were carried into waters from a sewer.

Relationship to Other Laws

The Refuse Act was used in the 1970's against violaters who could not be reached by the Federal Water Pollution Control Act (FWPCA) before its amendments in the late 1970's. The permit program that had existed under the Act was subsumed under the FWPCA permit program after the 1972 Amendments. However, two federal district court cases have held that the Act is not superseded by FWPCA, and the U.S. Supreme Court has held that the absence of a permit system under the Refuse Act did not bar prosecution of a company for a violation. ("The Refuse Act of 1899," Environmental Reporter, Vol. 5, No. 20, Sept. 13, 1974).

Limitations/Further Considerations

The principal limitation to applying the Refuse Act to disposal of plastics that lead to entanglement is that its jurisdiction extends only to the three-mile limit. Therefore, it would have applicability to marine disposals within the three-mile limit, or to a land-based source of debris. A further consideration is in the likelihood and effectiveness of enforcement. It is conceivable that the Act could be used against, for example, an industrial source of large quantities of plastic pellets or a landfill operated in such a way that refuse could be washed into rivers. It is inconceivable, however, that the Coast Guard, or any other federal agency, would be willing or able to invoke the Act against individual litterers who toss six-pack rings onto river banks where they ultimately are washed into navigable waters.

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

Purpose

In addition to its main purpose of regulating the siting and construction of ports, protection of the coastal and marine environment in the course of such construction is a stated purpose of the Act. (33 U.S.C. 1501).

Authority

- Department of Transportation administers.
- Governors of coastal states approve licenses.
- Provisions:

  (1) Secretary shall determine, in issuing licences, that deepwater ports will be constructed and operated to minimize adverse impacts on the marine environment (33 U.S.C. 1503 (b) (5)).

  (2) Secretary shall prescribe by regulation and enforce procedures including but not limited to rulse "...(A) to prevent pollution of the marine environment, (B) to clean up any pollutants which may be discharged, and (C) to otherwise prevent or minimize any adverse impact from the construction and operation of such port." 33 U.S.C. 1509 (a).

- Jurisdiction includes:

  (1) coastal environment;

  (2) marine environment.

Application to Entanglement

- Would apply if:

  (1) environmental criteria considered in licensing construction included threat to marine species;

  (2) in course of construction, associated debris led to entanglement problems.

Relationship to Other Laws

- For purposes of the FWPCA, a deepwater port is a "new source."

- Applicable principles of international law apply with regard to safety and environmental protection under the Act.

Limitations/Further Considerations

- Act limited only to activities surrounding the siting, construction, and operation of deepwater port facilities. Only one is in operation at present.

Outer Continental Shelf Act, 43 U.S.C. 1301 et seq.

The discharge and pollution prohibitions of the Act deal only with oil, and as such are not relevant to this discussion. Therefore, the Act is noted only, not examined.

Intervention on the High Seas Act, 33 U.S.C. 1471 et seq.

Purpose

Environmental protection in the event of an accident on the high seas through intervention to contain or remove pollutant.

Authority

- Secretary of Transportation authorized to act, authority delegated to Coast Guard.

- May take action to remove pollution, salvage vessel, and/or cargo, or, if necessary, destroy ship and/or cargo.

- Provisions:

  (1) Must be "...grave and imminent danger to the coastline or related interests of the U.S. from...pollution of the sea...by a substance other than conventional oil which may reasonably be expected to result in major harmful consequences." (16A Am Jur 2d 718, Section 209.)

  (2) In determining whether grave and imminent danger and major harmful consequences will result, Secretary shall consider human health; fish, shellfish, and other living marine resources; wildlife; coastal zone and estuarine activities; public and private shorelines and beaches.

- Jurisdiction: High seas.

Application to Entanglement

Even though this act applies to substances other than oil, it is not intended to deal with substances that are not hazardous, therefore plastic debris would not be covered. See discussion of Comprehensive Environmental Response and Liability Act (CERCLA) below for a discussion of "imminent danger."

Relationship to Other Laws

- CERCLA and FWPCA funds available to pay for clean-up.

- Implements International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution, and the 1973 Protocol Relating to Intervention on the High Seas in Cases of Marine Pollution by Substances other than Oil.

Limitations/Further Considerations

The scope of the Act is limited to response and clean-up of substances which, in the definition of hazardous set out in relevant regulations, would not include plastic debris.

Act to Prevent Pollution from Ships, 33 U.S.C. 1901 et seq

Purpose

To prohibit and prevent discharges of oil or other hazardous substances into the navigable waters of the U.S.; to implement the MARPOL Protocol.

Authority

- Coast Guard to enforce provisions.

- EPA to develop mechanisms and procedures to insure high standard of care in handling of hazardous substances in U.S. waters.

- Provisions:

  (1) Violation to dump in U.S. waters (33 U.S.C. 1902).

  (2) Violation for ship of U.S. registry or operated under authority of U.S. to dump anywhere (33 U.S.C. 1902(1)).

  (3) Optional Annexes of the MARPOL Protocol are not implemented. (33 U.S.C. 1909).

- Jurisdiction extends to any vessels operating in the navigable waters of the U.S., including the territorial seas, and to U.S. ships operating anywhere. Naval and warships are excluded. (33 U.S.C. 1902(b)).

Application to Entanglement

Since the U.S. has not ratified the optional Annex V of the MARPOL Protocol which specifically relates to plastics, the Act to Prevent Pollution from Ships is not applicable to entanglement. The definition of substances covered by the Act, as set out in regulation, does not include plastics. The courts have held that unless a substance is specifically included in the list, the provisions do not apply. U.S. v. Ohio Barge Lines, 410 F. Supp. 625, aff'd 531 F. 2d 574 (1975). Therefore, this Act is limited to enforcement against dumping of the named substances.

Ocean Pollution Planning Act, 33 U.S.C. 1701 *et seq*.

Purpose

Establish program to plan ocean pollution research and monitoring; coordinate and disseminate information on federal programs; develop an information base to support conservation and development of ocean resources (33 U.S.C. 1701(b)).

Authority

- Prepare 5-year plans to address ocean pollution issues, identify priorities, and recommend projects and programs.

- Establish an ocean pollution research and development and monitoring program.

- NOAA is lead agency.

- Provide grants and financial assistance to educational and reseach grantees and contractors.

- Plan may include policy recommendations that propose legislative changes, interagency cooperation, changes in funding of existing efforts at ocean pollution monitoring.

- Jurisdiction: The "marine environment" to be addressed in the plan is defined as the water, seabed and subsoil of the territorial sea, waters of the high seas, and sea bed, and subsoil of and beyond the outer continental shelf (33 U.S.C. 1702(4)).

Application to Entanglement

Since the Act authorizes only a planning and policy effort rather than regulatory measures, there are no provisions that would apply to prohibiting, preventing or mitigating entanglement as such. However, in developing its most recent 5-year plan, completed in September 1985, the National Marine Pollution Program Office included the issue of entanglement and the problem of ingestion of marine debris by ocean organisms. While these issues were raised, they did not receive very high ranking in the list of national problems and priorities. Entanglement was ranked as number 46 of 50 issues, and ingestion of marine debris as number 48 of 50. The two issues were included in the Plan's discussion of Marine Transportation as a source of ocean pollution, as one of five broad areas categorized as "Low Priority National Problems." In its recommendations for addressing the entanglement/ingestion problem, the Plan states that "[h]ighest priority in the program should be given to efforts for precisely estimating the magnitude of debris-related mortality on animal population levels, obtaining accurate estimates of the amounts and longevity of released materials in marine waters, and implementing actions to eliminate or reduce the introduction of marine debris into U.S. waters." (Federal Plan, NOAA, 1985, p.206). A specific recommendation in the plan identifies marine debris from vessels as an "emerging issue," and states that "NOAA, in cooperation with the Marine Mammal Commission, should conduct a research program to evaluate the potential threats to marine biota from release of net fragments and other types of marine debris..." (Ibid., p.315).

Relationship to Other Laws

The Ocean Pollution Planning Act is limited in its scope to planning, cooperation, coordination, and policy recommendations. However, as a reflection of national ocean pollution policy, it provides a vehicle for focusing research and monitoring resources on the entanglement problem. Although this focus has not emerged strongly in the most recent plan, the plan has recognized the issue as one of increasing concern. It remains to be seen how its recommendations for further research into the issue will be implemented.

Marine Protection, Research & Sanctuaries Act, 33 U.S.C. 1401 *et seq* (MPRSA, "Ocean Dumping Act")

Purpose

Regulate dumping of all types of materials and prevent or strictly limit ocean dumping of materials "...which adversely affect human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities." (33 U.S.C. 1401(b)).

Authority

- EPA has permitting and enforcement authority.

- Army Corps of Engineers also has permitting authority over dumping of dredged materials, but the Corps' role is not relevant to this discussion of plastics.

- Coast Guard has surveillance authority for compliance with regulations regarding transportation and marine safety and that dumping is done at the time and place specified in EPA permits.

- Provisions:

  (1) Prohibits dumping within territorial sea without a permit (33 U.S.C. 1411(b));

  (2) Prohibits all transportation of materials from U.S. for purpose of dumping, unless authorized by permit. (Ibid.)

  (3) In issuing permits, EPA to consider factors such as need for dumping, alternatives to ocean dumping, effects of dumping on human health and welfare and uses of the oceans, and effects of dumping on marine environment and ecosystems. (33 U.S.C. 1412(a)).

  (4) Regulations prohibit dumping of floatable materials in compliance with Annex I of the London Dumping Convention. (40 C.F.R. 227.5(d)).

  (5) Enforcement provisions include civil and criminal penalties as well as permit suspension or revocation.

  (6) Citizen suits may be brought (a) after 60-day notice to EPA of violation, (b) if federal officials have not begun civil, criminal or permit proceedings.

- Jurisdiction

  (1) For purposes of the Act, ocean waters are defined as waters of the open seas lying seaward of the baseline from which the territorial sea is measured (33 U.S.C. 1402(b)).

  (2) Includes territorial sea, contiguous zone, and oceans, as defined in CWA (see below for analysis of relationship of two laws.

  (3) Although at time of passage of the Act, the "contiguous zone" was 12 miles, after later passage of the 200-mile "exclusive economic zone," it seems consistent to extend the jurisdiction of this Act. Amendments to that effect were introduced in 1985 and 1986, but the Congress failed to act upon them. (See also, Bean, 32-35).

(4) Transportation used as basis of jurisdiction to avoid international conflicts, because the U.S. has the power to regulate transportation from and into its border, but not activity on the high seas, except activity by U.S. citizens. (5 Ecol LQ 753, at 761 (1976)).

Application to Entanglement

Before the passage of the Ocean Dumping Act, the U.S. had no effective means of regulating ocean dumping. "There were virtually no regulatory controls over the dumping of wastes beyond the three-mile territorial sea. Several federal agencies were empowered to regulate limited facts of dumping activities within the territorial sea, but no agency attempted comprehensive regulation." (Ibid., 758). In 1970, the Council on Environmental Quality (CEQ), in its Fourth Annual Report, pointed out that while ocean dumping was not a major contributor to marine pollution, the concentration of such dumping at coastal sites could lead to potential harm. Further, the report stated, increasing controls on land-based waste disposal could force more dumping into the oceans. (61A Am Jur 2d 744). In 1971, the U.S. was party to negotiations that led up to the London Dumping Convention; in 1973, the Ocean Dumping Act became effective, and in 1975, the Convention entered into force.

One problem with the Ocean Dumping Act is that it expressly regulates transportation for purposes of dumping, not simply dumping. This could make its application to a fishing boat which discards gear very difficult, since it "...fails to provide for instances where materials originally shipped for some other purpose subsequently may be dumped on the high seas." (5 Ecol LQ 761). However, one commentator suggests that the Act be interpreted to cover this omission, because the legislative history indicates Congress wanted to control all purposeful dumping, and regulation of transportation was the only means to get at the issue. (Ibid.) However, even if the Act were interpreted in light of this legislative history, the hurdle of "purposeful" dumping still would have to be cleared if the Act were to be applied to nets discarded in the course of fishing activity. Since the Act implements the London Dumping Convention, it could be argued, given the limitations of that Convention pointed out above, that the parallel prohibitions against purposeful dumping would limit its effectiveness against discarded nets. On the other hand, the Act broadly delegates the permitting function to EPA, and in promulgating regulations as to how permits will be granted, the agency has provided that it will never issue permits for dumping "...persistent inert synthetic or natural materials which may float or remain in suspension...." (40 C.F.R. 227.5(d)). It is therefore within the agency's discretion to consider fishing nets and other floating plastic debris as falling within the absolute prohibition of the Act and the regulations.

Relationship to Other Laws

- Implements London Dumping Convention

- Exceptions to dumping of any matter in any manner are limited to activities covered by other environmental statutes.

- Act is consistent with Clean Water Act, using same definitions and criteria for evaluating permit applications.

Limitations/Further Considerations

If the Act were unavailable to reach discarded fishing gear because of the "purposeful dumping" limitation, another possible consideration might be within the definition of "material," which the Act defines to include "wrecked or discarded equipment" as well as garbage and other material. If a discarded net were considered "wrecked equipment," it might fall within the prohibitions.

Another possible application would be to the industrial disposal of plastic pellets which find their way to the oceans and are ingested by marine biota. Again referring to the definitions in the Act, industrial waste includes "any solid, semi-solid, or liquid waste generated by a manufacturing or processing plant." Pellets discarded in such a manner could be covered if such disposal "may unreasonably degrade or endanger...the marine environment." The determination of "unreasonably degrade or endanger" is within the discretion of the Administrator of EPA.

One last consideration can be found under a provision in the Act enabling the EPA to limit dumping to designated sites, to designate the sites, and to "designate regions in which the disposal of certain materials will be prohibited in order to protect 'critical areas'." (33 U.S.C. 1412(c)). The term "critical areas" is not defined in the Act, and no such areas have been designated. However, areas where particularly sensitive populations of marine birds or mammals were subjected to threat of entanglement might be so designated.

Clean Water Act. 33 U.S.C. 1251, 1262, 1311 et seq. (CWA, also called Federal Water Pollution Control Act (FWPCA)

Purpose

Restoration and maintenance of the chemical, physical and biological integrity of the national waters (33 U.S.C. 1251(a)). The purpose of the Act has been interpreted by the courts to establish a means for EPA to develop and implement programs to control pollution (U.S. v. Holland 373 F. Supp. 665 (1974)), and also to enable the agency to create interrelated regulatory programs to preserve national water quality. (Sierra Club v. Lynn, 364 F. Supp. 834 (1973)).

Authority

- EPA is lead agency.
- States retain primary responsibility for implementation, but must use federal standards at minimum.
- Provisions:

  (1) Sets water quality standards.

  (2) Sets limitations on effluents from point sources.

(3) Regulates discharges from point sources through National Pollution Discharge Elimination System (NPDES) permit program.

(4) Any discharge of any pollutant by any person is prohibited unless the discharge is under a NPDES permit.

(5) Prohibits discharge of toxic substances in toxic amounts.

(6) Prohibits discharge of oil or hazardous substances in harmful amounts, except where permitted under MARPOL Protocol.

(7) EPA designates hazardous substances other than oil, which, when discharged, present an imminent and substantial danger to the public health or welfare, including, but not limited to, fish, shellfish, wildlife, shorelines, and beaches. (33 U.S.C. 1321(b)(2)(A); 40 C.F.R. 116).

(8) Sets up program to assist communities in financing construction of publicly owned waste treatment plants.

- Prohibitions have been construed by the courts in an enormous body of case law from many jurisdictions. While a detailed examination of this entire body of case law is not within the scope of this analysis, it can be said that the decisions have hinged on the particular state implementing legislation, and the particular language each state has used. Most of the case law has served to extend the scope of federal authority over waters inland, and to broaden the types of waters covered.

- For purposes of the instant discussion, the key issue is whether the substance (plastics) is among those prohibited. A sampling of cases on this issue is discussed in the section on Application to Entanglement, below.

Application to Entanglement

The principal application of the Clean Water Act to the issue of entanglement or ingestion of plastic debris would be to land-based sources of debris, since its jurisdiction extends to the territorial sea, but covers rivers, harbors, lakes, and adjacent wetlands. The Clean Water Act is not limited, like the Ocean Dumping Act, by the need for "purposeful" dumping. There are, however, three key questions which must be answered before the Act could be applied to the problem: Is plastic a "pollutant" under the Act? Is plastic a "toxic pollutant" under the Act? If plastic is neither, could it be designated by the Administrator as a covered substance?

The Act defines pollution as "man made or man-induced alteration of the chemical, physical, biological, and radiological integrity of water" (33 U.S.C. 1362(19)). "Pollutant" is defined as "dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive material, heat, wrecked

or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water." (33 U.S.C. 1362(6)). The Act defines "toxic pollutant" as "those pollutants or combination of pollutants, including disease-causing agents, which after discharge and upon exposure, ingestion, inhalation, or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will, on the basis of information available to the Administrator cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions...or physical deformations, in such organisms or their offspring." (33 U.S.C. 1362(13).

Under the definition of pollutant, plastic debris such as pellets, beverage container connectors, packaging materials and other such litter, could be interpreted to fall within the definition as a type of industrial waste, for the former, and as types of garbage or municipal waste, for the latter. As discussed above, the courts have taken many different routes to interpret statutory language of water pollution. However, even in those jurisdictions which have applied the maxim expression unias est exclusio alterius to exclude non-named substances from coverage in a list of named substances, plastic debris would certainly be construed to be part of a list that included "garbage." The next hurdle is to determine whether these substances are covered within the meaning of "discharge" as a prohibited action under the law.

The Clean Water Act defines "discharge of a pollutant" as (1) any addition of any pollutant to navigable waters from any point source, and (2) any addition of any pollutant to the waters of the contiguous zone or the ocean from any point source other than a vessel or other floating craft (33 U.S.C. 1362(12)). Discharges from point sources are allowed only under a NPDES permit, but those permits are used primarily to deal with effluents. Therefore, the only effective use of CWA in dealing with the problem of plastic debris might be as a tool against point source discharge of plastic pellets used in the manufacture of plastic items, and which are flushed into waterways as part of the industrial waste disposal process, or against those municipal waste treatment plants which fail to filter out plastic tampon applicators which eventually find their way into rivers and the ocean.

The next question is whether discarded plastic nets and debris could be covered as hazardous substances under Section 311 of the Act, or as toxic pollutants. A list of about 5 dozen toxic pollutants has been incorporated into regulation after a court decision ordered the EPA to designate such substances. Inert plastic is not one of the toxics. Nor is it included as one of 300 hazardous substances set out at 40 C.F.R. 116.4. However, the standard for determining toxicity might apply. Certainly entanglement causes "death, disease, behavioral abnormalities,...or physical deformations," part of the criteria set out in the Act. "While it is conceivable that a creative interpretation of the hazardous substances definition could be used to include netting and debris, the toxicity of the chemicals currently designated as being hazardous evidences a narrower interpretation of this phrase by the EPA." (Gosliner, p. 18). It is within the discretion of the Administrator to make a determination if he so chose.

Relationship to Other Laws

- Not to be construed as affecting or impairing any treaty, or limiting authority under any other laws consistent with its provisions.

- Provides basic definitions for all other water pollution statutes.

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

Purpose

Promote the protection of health and the environment by regulating the disposal of solid waste.

Authority

- EPA is lead agency.

- Management of solid waste is delegated to the states after EPA approval of plan.

- EPA promulgates regulations establishing criteria for solid waste management.

- EPA provides technical assistance to states.

- EPA regulates disposal of hazardous wastes.

- Provisions:

  (1) Solid waste is "any garbage, refuse...and other discarded material...resulting from industrial, commercial, mining, and agricultural operations, and from community activities...." (42 U.S.C. 6903).

  (2) Any solid waste management practice or disposal of solid waste or hazardous waste which constitutes open dumping of solid waste or hazardous waste is prohibited. (42 U.S.C. 6945(a)).

  (3) Materials covered in other pollution laws are excepted.

  (4) Criteria to determine whether a solid waste is hazardous are its toxicity, persistence, degradability in nature, potential for accumulation in tissues, flammability, corrosiveness, and other hazardous characteristics. (42 U.S.C. 6921(a), 40 C.F.R. 261.10, 261.11).

  (5) If a substance is determined hazardous, the Act provides a permit program for those who treat, transport, store, generate, or dispose hazardous wastes.

Application to Entanglement

Because netting is a solid waste generated in the course of commercial fishing activity, it probably is a waste covered by the Act. However, unless netting is considered "hazardous," the prohibitions of the Act would not apply. The standard for determining what constitutes hazardous waste set out at 42 U.S.C. 6903(5), is a waste which, "because of its quantity, concentration or physical, chemical, or infectious characteristics may cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness, or which may pose a substantial present or potential hazard to human health or the environment...." Under this standard, the Agency has designated a list of hazardous wastes appearing at 40 C.F.R. 261.30 et seq. Inert plastic is not among the listed items. Further, plastic netting exhibits none of the characteristics listed in the regulations for designating hazardous wastes. However, one analyst has suggested that netting might be designated as hazardous because of its persistence or slow rate of degradation. (Gosliner, p. 20). "Changes in the EPA regulations may be appropriate to accommodate the listing of net fragments and other synthetic materials....While no materials have been designated by EPA...based upon their persistence or slow rate of degradation, these are considerations expressly enumerated in the Act." (Ibid.)

Relationship to Other Laws

- Distinguish "hazardous waste" under RCRA from "hazardous material" regulated by the Department of Transportation.
- Distinguish "hazardous waste" under RCRA from "hazardous substance" regulated by CWA.

Limitations/Further Considerations

Even if discarded netting were designated as a hazardous waste under RCRA, the requirements of the Act upon those who handle such materials may be burdensome and inappropriate for the fishing industry because the standards for generators of hazardous waste (40 C.F.R. 262) are totally inapplicable in the context of the fishing industry. Further, enforcement would require the identification of the source of the material, and discards in the open ocean would be difficult to pinpoint.

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

Purpose

To regulate those chemical substances and mixtures "whose manufacture, processing, distribution in commerce, use, or disposal may present an unreasonable risk of injury to health or the environment." (15 U.S.C. 2601(a)(2)).

Authority

- EPA Administrator may make determination of potential harm of chemical, then require testing.

- If testing indicates a chemical poses an unreasonable risk, then Administrator may:
  (1) prohibit or limit manufacture, processing or distribution;

  (2) prohibit or limit amounts for particular use;

  (3) require warnings;

  (4) require records;

  (5) prohibit or regulate disposal;

  (6) prohibit or regulate commercial use;

  (7) require notice of risk;

  (8) require replacement or repurchase.

- Requires coordination with other federal agencies and within agency to use laws other than TSCA to prevent or reduce risk of injury.

- However, if the Administrator determines it is in the public interest to use TSCA rather than other laws, he may do so.

Application to Entanglement

In contrast to authorities examined above which regulate the disposal of debris, TSCA authorizes direct regulation of chemical substances. The Act enables the EPA to focus on the constituent substances which are used to manufacture the plastic items or articles which ultimately become marine debris. Authority under TSCA may be used to prohibit or limit the manufacture, processing or distribution in commerce of a substance for a particular use. TSCA also can be used to require labeling with instructions for use, and to regulate certain disposals. This authority could, for example, allow EPA to focus on the issue of biodegradability of plastics by examining and affecting the manufacturing processes that result in articles which ultimately are discarded in the oceans.

The operative standard for regulation under TSCA is "unreasonable risk." The Act does not define the term, but legislative history suggests that such a finding is a discretionary matter, involving balancing "the probability that harm will occur and the magnitude and severity of that harm against the effect of proposed regulation on the availability to society of the benefits of the substance, taking into account the availability of substitutes...and other adverse effecs which such proposed action will have on society." (House Report, TSCA, 94th Congress, 1976). Whether the discretion extends to a determination that an inert plastic compound, or some component of that compound, poses and unreasonable risk must be decided within the agency.

Once that determination were made, Section 6(c) of the Act then requires that EPA consider four factors before a rulemaking, and publish a statement as to its findings regarding: (1) the effects of the substance on human health; (2) its effects on the environment; (3) the benefits the

substance provides and the availability of substitutes; (4) the economic consequences of regulating the substance. (15 U.S.C. 2605(c)(1)).

In a memo exploring such a use of TSCA, the Regulatory Program Branch of the Agency points out the first criteria is not at issue, and the second is a matter for continued research "to ascertain the extent of the problem." (Cohen memorandum, 1985). The memo further points out that little is known regarding the advantages of nondegradable versus degradable plastic products, and that such an examination could be an area for the agency to focus its efforts. (Ibid.) The memo concludes that if Section 6(c) findings were made, a variety of options from prohibiting the manufacture of nondegradable plastics to labeling such products or regulating their disposal, could be available as regulatory measures. (Ibid. pp. 12-13).

Relationship to Other Laws

- Administrator may give other agencies with authority to act the opportunity to do so in order to avoid duplication of regulatory activity against a toxic substance.

- Compared with other pollution laws, TSCA has a "lenient standard of proof," which requires only a potential for harm, rather than a demonstrable showing of harm. (30 Vanderbilt L. Rev. 1149(1977) at 1186).

Limitations/Further Considerations

If the Agency decided that TSCA was applicable to the manufacture of plastics to require manufacturers to make biodegradable those items that ultimately become ocean debris, there are still some additional hurdles to be crossed. Because the unreasonable risk analysis requires consideration, among other things, of the costs of regulation and the availability of substitutes, the Administrator must consider whether the costs, for example, of prohibiting or limiting the manufacture of substances used in fishing nets which cause them to be non-biodegradable might outweigh the benefits of regulation. Also, if CWA, RCRA, or some other authority might be used to control the same risks, the Administrator would have to address, why, in the public interest, action should be taken under TSCA. Similarly, the Administrator must address whether the risks can be prevented or reduced to a sufficient extent by action taken under federal laws not administered by the EPA.

Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. 9601 et seq. (CERCLA, "Superfund")*

Purpose

To provide a mechanism to act in the face of substantial environmental damage, and to address the costs of environmental clean-up associated with such action.

Authority

- President has authority to act to clean up when a situation poses "imminent and substantial danger to public health or welfare."
- EPA generally lead agency in national response team.
- Federal action usually deferred if owner/operator of vessel or facility will clean up, although EPA may clean up regardless of owner's plans.
- Creates a fund from industry specific taxes, punitive damages collected, transfers from CWA fund, and appropriations.
- May impose liability on owners, operators, transporters, storage facilities.
- Hazardous substances which may be responded to include substances designated under:

  (1) CWA

  (2) TSCA

  (3) RCRA

  (4) Clean Air Act

  (5) Federal Insecticide, Fungicide and Rodenticide Act

  (6) Section 9602 of CERCLA, which authorizes the Administrator of EPA to promulgate and revise regulations to designate additional hazardous substances.
- Jurisdiction extends to navigable waters, territorial sea, contiguous zone, and ocean waters within the Exclusive Economic Zone.

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*Note: Superfund was amended in the closing days of the 99th Congress, October, 1986. This report does not analyze any changes the amendments have made to the Act, nor their effects on the instant discussion.

Application to Entanglement

Before CERCLA could be used to address the problem of entanglement in and ingestion of plastic debris, a two-pronged test would have to be met. First, the debris would have to be found hazardous under one of the statutes discussed above. Second, the existence of the debris in the marine environment would have to pose an imminent and substantial danger. The determination that plastics are hazardous cannot be found per se in any of the statutes discussed, however, as pointed out, this determination is within the discretion of the Administrator. Assuming, arguendo, that such a finding were made, could it also be determined that plastic debris poses an imminent and substantial danger? The Act uses the phrase "there may be an imminent and substantial endangerment." Guidelines issued by the Agency state that "evidence need not demonstrate that an imminent and substantial endangerment to public health or the environment definitely exists. Instead, an Order may be issued if there is sound reason to believe that such an endangerment may exist." (EPA Guidance Memorandum). Further, the Guidelines point out that while the risk of harm must be imminent before the Agency may act, the harm need not be. (Ibid.) The circumstances to be examined in determining whether the presence of a substance poses an imminent risk of harm include the nture and amount of the substance, the potential for exposure, and the known or suspected effect of the substance on the environment. (Ibid.) Under these criteria, it would seem difficult to extend the authority of CERCLA to the clean-up of net fragments or to other plastic debris, except under extraordinary circumstances. "Congress intended to give the federal government tools for prompt and effective response to problems of national magnitude resulting from hazardous waste disposal," according to the courts (U.S. v. Reilly Tar and Chemical Corp., 546 F. Supp. 1100 (1982)), and the entanglement issue has not yet been determined to be a problem of national magnitude, as evidenced by the most recent National Marine Pollution Plan discussed above. Therefore, it seems unlikely the Act would apply.

Relationship to Other Laws

- CERCLA applies to substances designated as hazardous by other federal laws, see above.

Limitations/Further Considerations

While CERCLA authority might be stretched to include clean-up of plastic ocean debris, the priorities of the Agency are focused on more pressing clean-up problems.

Marine Mammal Protection Act, 16 U.S.C. 1361 et seq. (MMPA).

Purpose

To ensure that species and population stocks of marine mammals do not diminish beyond the point where they cease to be a significant functioning element in the ecosystem of which they are a part. (16 U.S.C. 1361).

Authority

- Establishes a moratorium on taking of marine mammals.
- Take is defined as harass, hunt, capture or kill.
- Provides for permit programs for incidental take of non-depleted species.
- Secretary of Commerce and Secretary of Interior authorized to promulgate regulations and issue permits.
- Provides for both civil and criminal penalties for violations.
- Secretaries have enforcement authority.
- Jurisdiction extends to 200-mile Exclusive Economic Zone and to U.S. citizens anywhere.
- Creates the Marine Mammal Commission.

Application to Entanglement

Although the prohibition against taking any marine mammal has never been used to prosecute a person who discarded a net which later entangled and killed an animal, the Marine Mammal Commission has said that under certain circumstances, intentional or negligent discard of nets could constitute a "take." On the prevention side, the Act has been used to limit takings incidental to fishing activity. Regulations may restrict fishing techniques which cause undue fatalities, and permits are issued restricting incidental take. For example, the National Marine Fisheries Service (NMFS) requires that the tuna purse seine fleet use certain procedures as a condition of the incidental take permit issued to that industry. In most net fisheries, however, the Service has to work with state fisheries management entities to regulate fishing in such a way to reduce or eliminate the incidental taking. (Gordon, 1985).

Recent Congresional directives and appropriations created a program to address the entanglement issue through research and education, see below, and both NMFS and the Marine Mammal Commsision are conducting studies on ways to address the problem. See generally, Marine Mammal Commission Annual Reports; see also, testimony of David Laist before House Merchant Marine Committee, 1986.

Limitations/Further Considerations

The MMPA, like other wildlife conservation laws discussed below, addresses entanglement after the fact, that is, no violation occurs until an animal is actually taken. Therefore, application is limited from the perspective of preventing entanglements by reducing ocean debris. Since the disposal of gear does not violate these acts generally, and since many entanglements occur in lost gear, the enforcement of wildlife law is further limited. "Without some mechanism for identifying the owners of gear responsible for entanglement, enforcement of these provisions is virtually impossible." (Gosliner, p. 21)

Programs

The National Marine Fisheries Service Entanglement Research Program focuses on the the issue through more than a dozen education and data collection projects, including working with fishermen in the Pacific Northwest. Data collection projects focus on gathering information on fisheries management, species-specific entanglement problems, and methods of assessing marine debris. There are also efforts underway to address the plastics problem at its source by working with the plastics industry to develop degradable plastics and to find alternative disposal methods. A complete list of projects is attached at Appendix 1.

The Marine Mammal Commission also has centered much attention on the entanglement problem through sponsoring research, data collection, and informational workshops. A complete discussion of Commission activities can be found in its testimony before the House Merchant Marine Committee. (Laist, 1986).

Endangered Species Act, 16 U.S.C. 1531 et seq. (ESA)

Purpose

Provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species. (16 U.S.C. 1531).

Authority

- Prohibits taking of any endangered or threatened species by any person subject to U.S. jurisdiction.
- Term "take" includes kill, trap, harass, pursue, hunt, shoot, wound, capture or collect, or to attempt to engage in any such conduct. (16 U.S.C. 1532).
- "Harm" is broadly defined in regulaton to include significant habitat modification or degradation where it actually kills or injures by impairing (50 C.F.R. 17.3), and has been construed by the courts to include indirect and unintended harm. (Palila v. Hawaii Dept. of Land and Natural Resources, 471 F. Supp. 985 (1979), aff'd, 639 F. 2d 495(1981).
- Permits may be issued for indidental take in the course of otherwise lawful activity (16 U.S.C. 1539(a)(1)(B)), or for scientific research purposes (50 C.F.R. 17.22(b)(1)).
- Section 7 of the Act provides for consultation among federal agencies about to engage in actions that may affect endangered species.
- Section 10 sets out procedures for developing conservation plans with mitigating measures in the course of activity that may affect endangered species.

- Jurisdiction extends as far as the territorial sea, and to U.S. citizens anywhere.

Application to Entanglement

Of the animals subject to entanglement, those that are endangered are the Hawaiian monk seal, Guadalupe fur seal, some species of sea turtles, and most of the great whales. The prohibition against any taking would apply to taking of the listed species in lost or discarded fishing gear. Further, no permits could be issued for entanglements in discarded gear, because the permits apply only to takings incident to lawful activity. "If disposal of nets at sea is considered to be a violation of one or more of the aforementioned pollution control laws a permit could not be issued." (Gosliner, p. 25).

Another potentially relevant section of the ESA is section 10(a)(1)(B), which authorizes the issuance of an incidental take permit whan an applicant complies with certain requirements, including the filing of a conservation plan intended to benefit the impacted species. 16 U.S.C. 1539(a)(1)(B), (a)(2). It is, therefore, conceivable that a permit could be issued under the ESA that would allow for the taking of certain species incidental to a lawful activity, such as fishing, if an approved conservation plan is in place. For additional discussion of this authority, see, Bean, The Evolution of National Wildlife Law (1983).

Relationship to Other Laws

- If an endangered animal is a marine mammal, the more restrictive prohibitions of MMPA apply (16 U.S.C. 1543), because ESA requires that where another law is applicable, the more restrictive shall apply.

Limitations/Further Considerations

One analyst has suggested that the incidental take permit under ESA could provide an incentive to reduce entanglements, because it "legalizes what would otherwise be an illegal act punishable by substantial criminal and civil penalties." (Bean, 45). The argument points out that a permit with negotiated conditions, such as agreements not to discard gear, or to report sightings of lost gear, could be offered as an alternative to prosecution. (Ibid.) The problem, however, is that the threat of prosecution is flimsy, in that with ESA, as with any of the wildlife laws or ocean dumping laws, enforcement is virtually impossible without actual observation of a violation.

Migratory Bird Treaty Act, 16 U.S.C. 703 et seq. (MMPA)

Purpose

To protect migratory birds.

Authority

- Prohibits taking of migratory birds listed in treaties between United States and Great Britain, Mexico, Japan, and the Soviet Union.
- Department of Interior has authority to issue regulations, enforce provisions.
- Permits, through regulation, taking of migratory game birds, and taking for various scientific and collection purposes.
- Prohibition against taking has been construed by the courts to require no intent for a violation.
- Jurisdiction extends only to the territorial sea, but may apply to U.S. citizens on the high seas.

Application to Entanglement

Of the many species of seabirds susceptible to entanglement, most are included on the lists of protected migratory birds (50 C.F.R. 10.13). Eiders, scoters, mergansers, old squaws, harlequin ducks, all termed "sea ducks," are considered migratory "game" birds, so there is permitted taking pursuant to regulations governing hunting (50 C.F.R. Part 20). The remaining listed species are not considered "game" birds, so there can be no permitted taking pursuant to hunting regulations.

The courts have construed the Act to prohibit any taking, whether intentional or not. (U.S. v. Corbin Farm Services, Inc., 444 F. Supp. 510 (1978), aff'd 578 F. 2d 259). In interpreting the legislative history, the courts have said "...it was not the intention of Congress to require any guilty knowledge or intent to complete the offense of killing any migratory bird. (U.S. v. Schultze, 28 F. Supp. 234 (1939). Further, prosecution is justified under the MBTA where the person in danger of taking migratory birds is reasonably in a position to foresee the danger and prevent it. (Corbin, at 535). Since entanglement of marine birds in discarded gear is preventable, and since entanglements do kill listed species, entanglement deaths would be prohibited and prosecutable under the Act.

Relationship to Other Laws

- MBTA is enabling legislation to implement the treaties.

Limitations/Further Considerations

In addition to the enforcement problems of either tracing lost gear to a specific vessel or observing a vessel in the act of entangling sea birds there is little impetus to prosecute event those offenses which have been observed. While recognizing the Department of Interior's responsibility to enforce the Act, the U.S. Fish and Wildlife Service (FWS) has stated that it and the U.S. Attorney General's office are "reluctant to criminally prosecute such cases...and it may be worth mentioning that prosecutions have apparently had very limited success in other areas where incidental

take of seabirds has occurred...." (U.S. FWS, 1985).

Another limitation of the MBTA is its applicability beyond the three-mile limit, where significant entanglements take place. A 1980 opinion from the Department's Assistant Solicitor for Fish and Wildlife outlines a four part test that must be met before a U.S. law can be applied extra-territorially. Applying the language of the treaties and the Congressional intent behind the MBTA, the opinion concludes that the "primary function of the Act is to implement the treaties within the United States." (Solicitor Memorandum, 1980).

On the other hand, a subsequent opinion concludes that the Act does apply to foreign citizens while within U.S. territorial waters. (Solicitor memorandum, 1981). And one analyst has argued that the MBTA might be applicable to takings by U.S. citizens upon the high seas, because "[t]o limit the statute's applicability to U.S. teritory would leave open a large immunity for violations by U.S. citizens on the high seas." (Gosliner, 28).

Fishery Conservation and Management Act, 16 U.S.C. 1801 et seq. (FCMA)

Purpose

Conserve and manage the fishery resources found off the coasts of the United States and (inter alia) to promote sound conservation and management principles.

Authority

- National Marine Fisheries Service (NMFS) within the Department of Commerce is principal management agency.
- System of Regional Fisheries Management Councils promulgates fishery management plans, and states promulgate regulations consistent with those plans.
- Establishes a fishery conservation zone (FCZ) which extends from the baseline of the territorial sea seaward to 200 miles. (16 U.S.C. 1821).
- Foreign fishermen may fish within the FCZ only after issuance of a permit (16 U.S.C. 1821).
- Regulations promulgated pursuant to the above contain conditions and restrictions on fishing permits, inter alia, a prohibition against intentionally placing abandoned fishing gear in the FCZ which may "...(1) Interfere with fishing gear or vessels; or (2) Cause damage to any fishery resource or marine mammal." (50 C.F.R. 611.16).

Application to Entanglement

The plans promulgated by the Regional Councils are to include conservation and management measures which are appropriate to the fishery being regulated. "It is not clear whether conservation and management measures may be included in an FMP if their purpose is solely to provide protection to marine mammals or birds. However, entanglements of wildlife are only one aspect of the problem created by the disposal at sea of fishing gear. There is little doubt that the dumping of gear and debris may be regulated under the Magnuson Act if the prohibition is directed toward alleviating the problems of ghost fishing or vessel entanglement." (Ibid, p. 30).

State Legislation

Each of the states has enacted legislation on the state level to implement federal pollution control laws such as the Clean Water Act and the Resource Conservation and Recovery Act. The provisions of these laws are substantially the same as the federal law, though may be more restrictive. This analysis does not examine each of the 50 states' pollution control laws, however, a series of laws known as "bottle bills" is worth examining in the entanglement context. The Oregon bill, which was the first such legislation, is examined in detail, and other states with similar bills are noted, and the statutes are included in Appendix 4. Those states with exemplary programs, such as beach clean-up programs, are set out in detail. Although not within the scope of this analysis, it is worth noting that several coastal states have passed fisheries regulations or laws aimed at reducing entanglements in active fisheries, as opposed to entanglement in ocean debris.

An Act Relating to beverage containers; and providing penalties. Chapter 745, Laws 1971, State of Oregon

Purpose

To reduce litter by banning: the sale of non-returnable beverage containers; sale of beverage containers with detachable pull tabs; sale of beverage containers connected with non-biodegradable plastic rings.

Authority

- Oregon Liquor Control Commission certifies acceptable containers.
- Commission establishes redemption centers.
- Establishes misdemeanor penalties for violation.
- Commission or State Department of Agriculture may revoke or suspend license of any person who wilfully violates the Act.

Application to Entanglement

Although the primary purpose of the Oregon bill is to reduce litter, it is litter such as plastic ring connecters that eventually makes its way to the ocean as debris. Since there is evidence that both fish and birds have become entangled in plastic ring connectors, the mandate tht these connectors be bio-degradable within a certain time (120 days, in Oregon) would be effective in reducing entanglements. however, it is unknown whether the litter reduction effects of the Oregon bill also have reduced entanglements.

Other States with Plastic Ring Connector Bans

Alaska

Beginning Jan. 1, 1985, no sales of beverage containers that are held together by plastic rings unless degradable. AS 46.06.090(b).

California

Beginning July 1, 1981, no sale of beverages with plastic rings tht are not degradable. California Health and Safety Code 24384.5(a).

Connecticut

Holders used for beverage containers must be either photo, chemical, or bio-degradable within a reasonable period of time upon exposure to the elements. Effective Jan. 1, 1980.

Delaware

No beverage shall be sold or offered for sale in containers connected to each other with plastic rings or similar devices which are not classified as biodegradable or photo-degradable by the Department of Natural Resources and Environmental Control. Delaware Code, Chapter 60, Title 7, 6059(b).

Maine

No beverage container shall be sold with containers connected to each otyher by a separate holding device constructed of plastic rings or other device or material which cannot be broken down by bacteria into basic elements. MRSA 1868(2) (1978).

Massachusetts

No dealer shall sell containers connected to each other by a separate holding device constructed of plastic rings or any other device or material which cannot be broken down by bacteria and/or by light into constituent parts. Chapter 94, Mass. General laws, Section 323 (1983).

New York

No distributor or dealer shall sell beverage containers connected to each other by a separate holding device constructed of plastic which does not decompose by photodegradation or biodegradation. Environmental Conservation Law, Article 27, Litter and Solid Waste Control, Title 10, Section 27-1011(4) (1983).

Vermont

No beverage shall be sold in containers connected to each other with plastic rings or similar devices which are not classified as biodegradable by the Secretary of the Agency of Environmental Conservation. 10 V.S.A. 1525(2) (1975).

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Appendix 1. National Marine Fisheries Service
Entanglement Research Program FY86 and FY85

RECOMMENDATIONS SUMMARY FOR THE FISCAL 1986 NMFS ENTANGLEMENT/DEBRIS PROGRAM

NO.	TASK DESCRIPTION	FUNDING LEVEL
1.	Marine Debris Education (cont.) By contract	$120K
2.	Disposal Technology Development By contract	60K
3.	Degradable Materials Applications Solicit in-house/contract; travel less than $1K	not funded
4.	Benthic Debris Impacts Review By contract	20K
5.	Fur Seal Pup Entanglement (cont.) NWAFC, NMML; travel, $7.5K	35K
6.	Hawaiian Islands Entanglement Monitoring SWFC, Hawaii Lab; travel, $0.0	10K
7.	Gillnet Dynamics (cont.) SWFC, Hawaii Lab; travel, $0.0	10K
8.	Large Debris Impacts on Fur Seals, Pilot NWAFC, NMML; travel, $7.0K	35K
9.	Net Fouling and Sinking Rates Solicit in-house/contract; travel less than $1K	not funded
10.	Hawaiian Seabird Ingestion Studies U.S. Fish & Wildlife Service, Hawaii	20K
11.	Fur Seal Site Clean-Up NWAFC, NMML in cooperation with Japanese; travel $2.0K	5K
12.	Beach Debris Survey Methods (cont.) NWAFC, Auke Bay Lab.; travel $5.0K	25K
13.	Female Fur Seal Entanglement (cont.) NWAFC, NMML; travel $5.5K	25K

Appendix 1. (continued).

14. Spectrophotometrics of Debris NWAFC, Auke Bay Lab; travel $0.0	27K
15. Program Management NWAFC; travel $9.0K	78K
16. High Seas Squid Fisheries Investigation NWAFC, Auke Bay Lab; travel $9.0K	250K

Appendix 1. (continued).

NMFS MARINE ENTANGLEMENT RESEARCH PROGRAM, FY 85

Appropriation: $1,000,000 in FY 85 (ref. Senate Report 98-514, calendar no. 980, p. 18).

Related Legislation: (from Bean, 1984)

- National Ocean Pollution Planning Act
- Clean Water Act
- Endangered Species Act
- Marine Mammal Protection Act
- Marine Protection, Research, and Sanctuaries Act of 1972
- National Sea Grant Program Act
- Saltonstall-Kennedy Act
- Commercial Fisheries Research and Development Act
- Outer Continental Shelf Lands Act
- Fisherman's Protective Act
- American Fisheries Promotion Act
- Magnuson Fishery Conservation and Management Act
- MARPOL Convention, Annexes

Program Management:

James M. Coe, Program Manager Northwest and Alaska Fisheries Center 7600 Sand Point Way, NE BIN C15700 Seattle, WA 98115 Telephone: (206) 526-4009, FTS 392-4009	$56.6K

Research Tasks:

Education	
Marine Debris Education in the North Pacific (RFP)	$173.0K
Beach Clean-up Programs (RFP)	35.0K
Information Collection	
Workshop on Fate and Impact of Marine Debris (done)	$50.0K
Northern Fur Seal Entanglement (NMML)	45.0K
Northern Sea Lion Entanglement (NMML)	81.4K
Debris Identification & Reference Collection (RACE)	28.0K
Beach Accumulation & Loss Rate Estimation (ABL)	32.0K
Foreign Fishery Observer Data Summary (REFM)	23.0K
Squid Gillnet Fishery Observations (ABL)	95.0K
Analysis of Debris Threats to Monk Seals (SWFC)	13.0K
Dynamics of Derelict Gillnet (SWFC)	27.0K
Sea Turtle Debris Ingestion Impacts (SEC/RFP)	27.0K
At-Sea Debris Survey Methodology (RFP)	18.0K
Stranding Program Information Expansion (RFP)	9.0K
Mitigation	
Disposal Methods Development (RFP)	37.0K
Total	$750.0K

RFP: work to be contracted for. **NMML:** National Marine Mammal Laboratory
ABL: Auke Bay Laboratory, Northwest & Alaska Fisheries Center (NWAFC)
RACE: Resource Assessment & Conservation Engineering Division, (NWAFC)
REFM: Resource Ecology & Fisheries Management Division, (NWAFC)
SEC: Southeast Fisheries Center. **SWFC:** Southwest Fisheries Center

Appendix 2. **Programs Related to Entanglement**

The **Marine Mammal Commission** (MMC) has supported research into the marine debris problem for many years. They originally recommended and provided the seed money for the Hawaii Workshop on the Fate and Impact of Marine Debris; they supported a review of the problem in Australia and Asia, they convinced the State Department to focus on the issue, through the International Maritime Organization; and they have presented the issue to a number of other organizations, including the Intergovernmental Oceanic Commission, and the Commission on the Conservation of Antarctic Marine Living Resources. They recently subcontracted with the Center for Environmental Education to examine the marine debris problem in the North Atlantic and other areas outside the United States.

The **Center for Environmental Education** (CEE) in Washington, DC has a comprehensive program concerning the entanglement of marine animals in plastic debris and active fishing gear. CEE's activities include research on techniques for saving entangled animals, providing technical advice to federal and state agencies, and promoting beach cleanups by private citizens.

A number of Washington-based conservation organizations participate in the **Entanglement Network**, a cooperative effort to facilitate the exchange of information on the problem of marine debris entanglement and incidental take.

Conoco, Inc. is seeking to reduce the amount of marine pollution from oil and gas operations in the Gulf of Mexico. Conoco's Fisheries Advisory Subcommittee is supervising the production of a 12-minute film on beach litter aimed at educating rig workers about pollution problems and how to prevent them.

The **Society of the Plastics Industry** (SPI), a trade organization of more than 1800 members representing all segments of the plastics industry in the United States, has begun an educational campaign on the problems caused by the improper disposal of plastics in the marine environment. **Dow Chemical USA**, a member of SPI, has produced a 4-minute video on Dow's waste reduction program on dealing with lost plastic resin pellets during production and handling.

Center for Environmental Education
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