nologies for waste disposal. States and countries should work to develop alternative, cost-effective management strategies for garbage and trash.

- Governments must require that industries provide to consumers proper disposal information for their products. This would serve both to heighten the public's environmental awareness and to curtail improper disposal practices. Incentive programs designed for industry and the public should be implemented to encourage proper disposal of wastes.

- Although major efforts must be made by local, national, and international governmental organizations to alleviate the floatables problem, the majority of floatables present in coastal waters around the world are the result of careless and improper disposal habits of individuals, lots of them. Therefore, the most immediate, and ultimately most effective, method of curtailing the global floatable problem begins with public education in industrialized nations. Such educational efforts must be both formal (e.g. mandatory parts of school curricula and mandatory training courses within certain industries) and informal (e.g. television, radio, newspapers, and public awareness campaigns). Strong educational efforts must also be made in less developed countries. Many of these countries are becoming garbage dumps for other nations. Educational efforts in these countries should be directed toward government officials and business people in addition to the general public.

- The entire global society must be trained and retrained as to the proper way to dispose of their garbage and trash. People must be made aware that they are the ultimate source of most of the floatable debris present in the world's oceans and, therefore, that they hold the ultimate solution.

We all should be reminded of René Dubos' admonition: "Think globally, act locally."

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On The Significance of Floatable Wastes in the Marine Environment

Background

Floatable debris is made up of a variety of materials such as plastics, rubber, wood, paper, cardboard, line, cloth, tar balls, grease balls, garbage and medically-related wastes. These wastes have been sighted in every major body of water and stranded on coastlines of every continent. For a variety of reasons, floatable debris in the ocean has become recognized as a serious issue in recent years. Wash-ups of debris on beaches, particularly sewage-related debris, have caused major economic losses to recreation and tourism industries because of the aesthetically displeasing nature of the wastes and the public health fears that they engender. These wash-ups often lead the public to question the safety of the water adjacent to the affected beach as well as the seafood caught in those waters. There is also concern that marine animals may become entangled in floating debris or, mistake it for food and ingest it, causing internal damage or even starvation because of blockage.

While all floatable materials can cause environmental problems and economic repercussions, plastics are particularly troublesome because of their persistence. Compared to most other components of the floatable waste stream, plastics are extremely long-lived. As a result, they comprise a large and enduring component of marine floatable wastes. Plastics are extremely versatile and are increasingly used by society because they are strong, light-weight, resistant to chemical breakdown, and relatively inexpensive to manufacture. Unfortunately, the very characteristics that make plastics appealing ultimately make them a nearly permanent part of the marine environment once they enter it. It is not clear how long plastics persist in the ocean, but it is generally presumed that they remain intact for many years.

Although very few studies have been undertaken to assess the actual rates of degradation of plastics in the marine realm, it has been found that, in general, plastic and rubber materials degrade more slowly in a marine environment than in a terrestrial one. Several theories have been advanced to explain the differences in these degradation rates, including considerations of varying heat retention by these substances in the two environments and the role which encrusting marine organisms may play in limiting the surface area of the debris available to exposure to sunlight.

As both the global population and the use of plastics increase, so does the production of garbage and trash on land. A 1987 study by the Worldwatch Institute concluded that the solid waste stream in the United States increased substantially between 1960 and 1980 and predicted a continued increase to the year 2000.[1] This same study also concluded that the percentage of plastics in the nation's municipal solid waste stream had more than doubled between 1970 and 1980 and predicted that it would triple (relative to 1970) by the year 2000.

Of the plastics within the municipal solid waste stream, 30% were used as packaging material, indicating a growing use of these materials for this purpose.

Sources of Floatable Debris

Floatable debris is generated both at sea and on land from three sources: the disposal of garbage and trash, disposal of sewage and wastewater, and accidental spillage and loss. In all three cases, plastics comprise a significant fraction of the total debris and the most persistent component.

Garbage and trash handling and disposal by merchant ships at sea comprise a large source of marine floatable debris. Much of the non-fishing debris from vessels is cargo-associated items such as containers, strapping, sheeting, packing strands and plastic pellets. Debris from crew members usually originates from the domestic waste stream of the people on board and includes: food items, plastic eating utensils, six-pack rings, and disposable cigarette lighters. The most inexpensive and common way to dispose of these items is to throw them overboard. Although disposal of most organic wastes by this method does not pose a significant threat to the marine environment, disposal of inorganic wastes in this manner may produce serious problems.

Ship-generated wastewater (e.g. that produced during the hosing down

[1]Pollock, Cynthia. 1987. Mining Urban Wastes: The Potential for Recycling. Worldwatch Institute, Washington, D.C., 58 p.

of tanker holds) and bilge water may also be a source of floatables. The wastewater often contains oil, which upon losing its volatile fraction, leaves behind sticky tar-residues that float on the surface of marine waters as tar balls. Tar balls have been sighted in all the world's oceans, although they are most frequently seen in the shipping lanes of the sea and in the Mediterranean. Accidental cargo spills are another source of tar balls and plastic pellets in the marine environment.

Perhaps one of the largest maritime sources of floatable debris is the world's commercial fishing industry. The use of plastic materials in fishing operations throughout the world has proliferated; nearly all nets and lines are made of polyolefin and nylon rather than natural fibers. Accidental loss of entire nets or of pieces of them, as well as parts of plastic pots and traps during fishing operations, contribute significantly to the amount of plastic debris found in the marine environment.

Among the possible land-based sources of floatables, litter left on beaches and in streets of coastal cities may be the largest contributor of debris to the marine environment. Items discarded as litter include cups, cans, bottles, candy wrappers, plastic packaging materials, cigarette butts, paper, and both legal and illegal drug-related paraphernalia. Winds, waves and tides routinely transport beach litter into the ocean while heavy rains carry street litter into municipal sewers. Many older cities in the United States are served by combined sewer systems which handle both stormwater and sewage wastes. Following even a modest rainfall, the volume of water reaching wastewater treatment plants exceeds the volume of water that the plants can effectively treat. At these times, the excess water, and the street litter and the sewage wastes it contains, are released untreated directly into the coastal waters through combined sewer overflows (CSOs). In municipalities served only by storm sewers and not by CSOs, the street runoff routinely flows directly into coastal waters, without benefit of any screening. Because combined sewer systems also handle sewage wastes, any item which is disposed of via municipal sewage systems, in cities served by CSOs, has the potential to become part of the floatable sewage waste problem. Such items include prescription bottles, diabetic syringes, illegal drug-related paraphernalia, tampon applicators, condoms, and plastic sheeting from disposable diapers. Other floatable items associated with domestic use may enter the marine environment if disposed of improperly in rivers and estuaries, or through accidental spillage occurring at waste handling facilities along the coastline.

Industrial effluent from plastic manufacturing plants has been shown to be another significant contributor of plastics to the marine environment. Small plastic granules, called spherules or nibs, may enter marine waters from outfalls of manufacturing plants located along the coasts and rivers and from accidental spillage during cargo handling.

A large percentage (both by weight and by volume) of floatable debris comes from the deterioration of boats and piers. Wooden pilings and debris from derelict vessels often break loose and become floatables during and after severe storm events or harsh winters. An additional source of wood debris, primarily on the west coast of the United States, is the lumber industry. Cut timbers that escape during river transportation pose serious navigational hazards after entering the ocean.

Medical-type wastes (e.g. syringes, blood vials, needles, bandages and intravenous tubing) represent a very minor component of the floatable waste stream worldwide. Most medical-type wastes that have been reported probably were introduced to marine waters from malfunctioning sewage treatment plants, or from normal operations of storm sewers and combined sewer overflows.

Problems Related to Floatables

Problems associated with floatable wastes may be categorized into three general groups: those affecting marine and marine-related organisms, those affecting public health, and those affecting aesthetics. The most widely reported problems are related to the entanglement of marine organisms in nets, straps, and other debris. Many marine mammals, fish, and crustaceans become entangled in these items. Lost fishing nets may continue "ghost fishing" for long periods after their loss. These nets also pose a potential safety hazard to boaters as they may become wrapped around engine propellers, disabling vessels at sea.

Ingestion of plastic debris has been implicated in deaths of several species of seabirds, sea turtles, and marine mammals. Many of these animals have been found to have plastic bags, nylon ropes, metal bottle caps, and plastic sheeting within their gastrointestinal tracts. An autopsy performed on a rare beaked whale which washed ashore in New York during the summer of 1989 revealed plastic bags in the whale's stomach. Although the plastic bags were not the direct cause of death, they are believed to have contributed to the whale's weakened condition making it more susceptible to the infection which caused its death.

It has been demonstrated that the threat posed by marine floatable debris to human health is minimal. Routine contact with floatable debris has not been shown to cause any ill-health effects in humans. Moreover, there is no known mechanism whereby diseases or contaminants, including the AIDS virus, can be transferred from floatable debris to fish, shellfish, or humans. Public safety hazard from floatable debris is possible from cuts or puncture wounds arising from the handling of sharp objects. Timbers washing ashore may also injure swimmers.

Although it is apparent that the human health risks due to floatable debris are minimal, the perceived threats are large and most people are repelled by the aesthetic degradation associated with floatables. No one enjoys swimming in waters littered with obnoxious floatables. Assurances that the waters are safe cannot overcome a person's revulsion at the sight of large amounts of debris and garbage floating in the water, nor can they assuage their fears regarding the presence of invisible pollutants. Severe adverse economic consequences often occur when large amounts of floatable debris wash up in regions which generate a significant portion of their income from commercial, recreational, and tourist industries connected with the coastal environment. The aesthetic problem posed by floatable wastes affects all three of these industries.

Conclusions and Recommendations

The issue of floatable wastes in the global marine environment is a multi-faceted one. The fact that many species of marine organisms are adversely affected by the presence of floatable debris is enough to warrant addressing the issue. The aesthetic problems and their economic impacts add to the urgency with which remediation of the floatable problem must be undertaken.

Currently, the most comprehensive international effort to deal with floatables is the International Convention for the Prevention of Pollution from Ships (MARPOL), which seeks to control the amount of pollution generated by normal ship operations. Annex V of MARPOL specifically prohibits ocean disposal of garbage and plastics from boats and ships. The Marine Plastic Pollution Research and Control Act of 1987, the U.S. law which implements Annex V of MARPOL, applies to all merchant vessels, recreational boaters, and offshore platforms, and further requires that ports, marinas, and terminals, provide trash reception facilities for incoming vessels. Further actions designed to alleviate the problem must be practical and workable. They must be designed not only to tackle the problems produced by the presence of floatable wastes, but to control, and eventually eliminate, the sources of the debris themselves.

- Better quantitative information is needed on the global floatables problem to define more accurately the nature and extent of the problem. The international laws and conventions already in existence regarding the proper use of the sea, while important for setting uniform standards and practices, are almost uniformly unenforceable within the existing framework of implementation. A more cooperative and concerted international enforcement effort is required if we are to expect any benefits of these agreements.

- All levels of government within each maritime country should review all means available to reduce the amount of floatable debris entering the ocean. Efforts to control floatable wastes need to be designed for implementation at the local level, however, since the sources and types of floatables differ from place to place. Although such multi-level government cooperation is difficult to achieve, it is necessary if the many sources of floatable wastes are to be controlled.

- Although some laws to reduce plastics have been enacted, most of these are aimed at changing how people use products rather than changing the products themselves. Industries throughout the world should be encouraged to work with scientists to develop alternatives to plastics. These alternatives must be non-toxic, as well as truly biodegradable. When appropriate, objects currently made of plastic should be replaced by objects made of natural materials. That is not to say, however, that we should abandon initiatives to reduce the waste stream, such as source reduction and recycling.

- Recycling of some plastics should be considered as an alternative to reducing the waste stream. However, plastic items that cannot be recycled and that are likely to get into marine systems, such as disposable diaper liners and tampon applicators, are candidates for application of degradable plastic technology. All these efforts are necessary components of a comprehensive waste management strategy for the entire world.

- One of the main problems encountered in managing the garbage and trash in today's world is the lack of markets for recyclable goods. To make recycling an integral part of society, many of the industrialized nations of the world must develop cost-effective uses for recyclable goods. Only then will recycling efforts contribute significantly to the decline of garbage and trash in these countries.

- Encouragement must also be given to correcting the leaks present within existing waste handling systems, such as CSOs, as well as to the development of alternative tech-