

NOAA Technical Memorandum NMFS

DECEMBER 1990



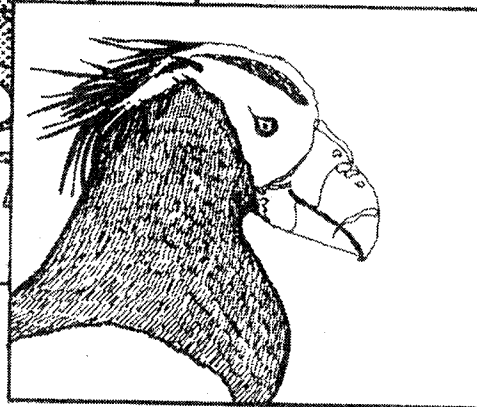
PROCEEDINGS OF THE SECOND INTERNATIONAL
CONFERENCE ON MARINE DEBRIS

APRIL 1989, HONOLULU, HAWAII

VOLUME I



Richard S. Stomura
Mary Jane Goffey
(Editors)



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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center
University of Hawaii Sea Grant College Program

NOAA Technical Memorandum NMFS

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NOAA Technical Memorandum NMFS

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DECEMBER 1990

**PROCEEDINGS OF THE SECOND INTERNATIONAL
CONFERENCE ON MARINE DEBRIS
2-7 APRIL 1989, HONOLULU, HAWAII**

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U.S. Fish and Wildlife Service
U.S. Marine Mammal Commission
U.S. Minerals Management Service
U.S. National Oceanic and Atmospheric Administration
U.S. Navy

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Finally, the editors owe the successful completion of these proceedings to two former employees of the Honolulu Laboratory, Ms. Louise Brewer and Ms. Elizabeth Young, who assumed the tremendous task of typing and checking the conference manuscripts.

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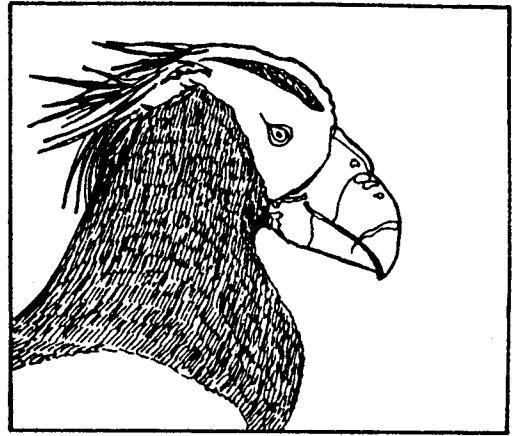
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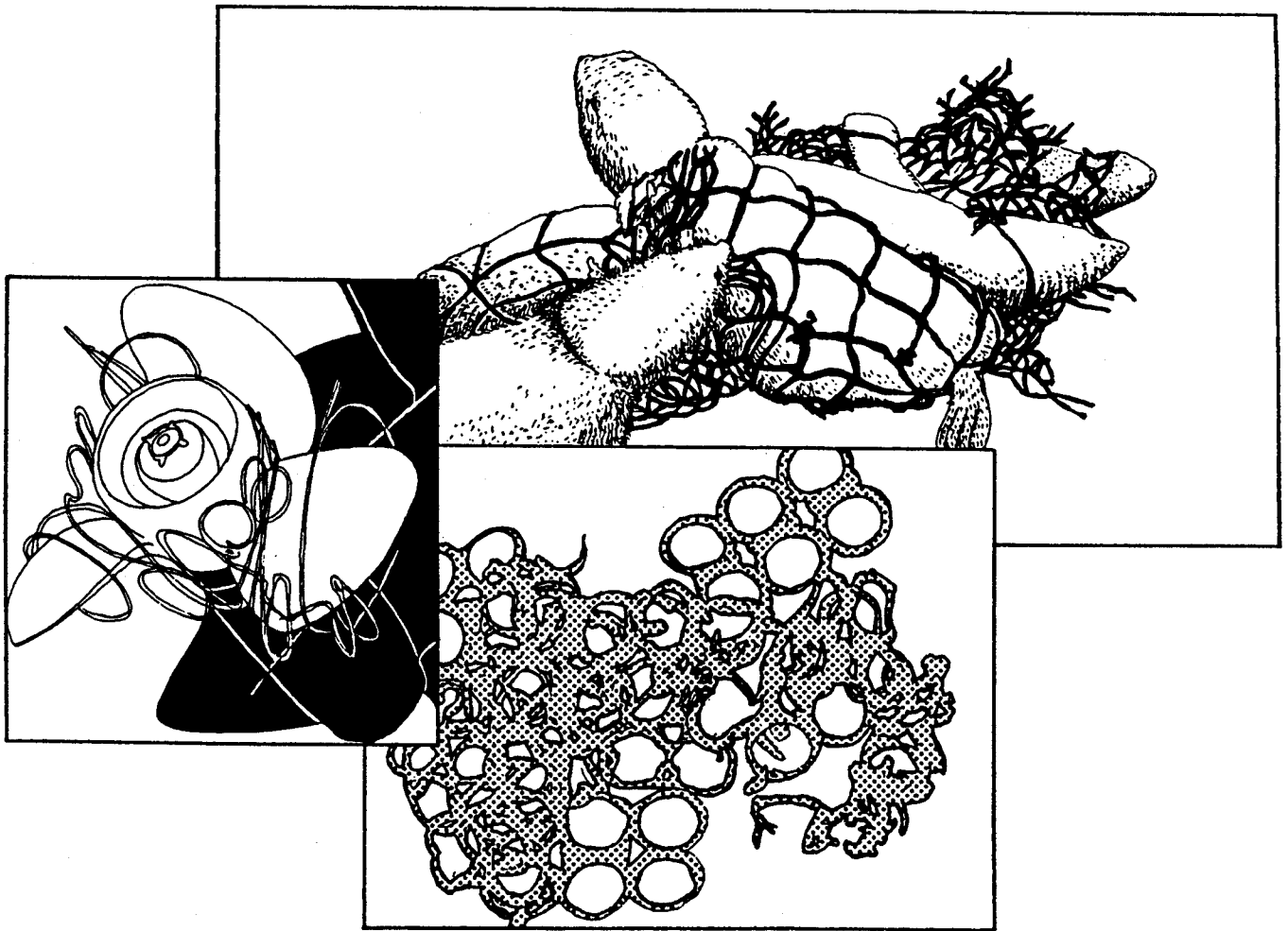
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EXECUTIVE SUMMARY



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I. INTRODUCTION

Until 10 or 15 years ago, the presence of debris in ocean and coastal areas was not recognized as a significant marine pollution issue. By the early 1980's, however, it became apparent that the amount of debris accumulating at sea and on beaches was increasing dramatically. There was also a corresponding increase in the incidence of marine species being adversely affected by ocean debris. These included marine mammals, seabirds and commercially valuable species of fish killed and injured in lost or discarded fishing gear and other debris, as well as beach-cast turtles with their digestive tracts blocked by plastic items. Clearly, marine debris was becoming a widespread marine pollution problem that could no longer be ignored.

In November 1984, the National Marine Fisheries Service, at the recommendation and with the assistance of the Marine Mammal Commission, convened a Workshop on the Fate and Impact of Marine Debris. The workshop was the first meeting ever undertaken to comprehensively assess information on the amounts, distribution, sources, effects, and management needs pertaining to problems of trash and other human-related debris lost or discarded into the ocean.

Participants in that conference concluded that many marine organisms throughout the world were being affected adversely by persistent debris and that there was an urgent need to: (1) educate vessel operators, fishermen and the public on the problem; (2) stop or reduce the deliberate disposal of persistent materials; and (3) obtain better quantitative data to assess the impact of marine debris on living organisms.

As a result of the workshop findings, a number of programs were undertaken in the United States and elsewhere to address the problem of marine debris. In view of the progress being made, in December 1986, the Marine Mammal Commission recommended to the National Marine Fisheries Service that it initiate planning for a second conference to review the marine debris issue. The Service agreed with this recommendation and, in fiscal year 1988, provided funds to begin planning and organizing a conference. In March 1988 the Marine Entanglement Research Program established a steering group to organize an international workshop. The Second International Conference on Marine Debris took place 2-7 April 1989 at the Ala Moana Americana Hotel in Honolulu, Hawaii.

Objectives

The objectives of the conference, as defined by the steering group, were to:

- evaluate new information on the types, amounts, sources, fates, and distribution of marine debris in different ocean areas;

- evaluate what has been done in the North Pacific basin as a prototype for activities that might be usefully undertaken in other regions;
- identify and evaluate existing and potential methods for gathering data on and monitoring trends in the sources, types, fates, amounts and distribution of debris at sea and on beaches;
- identify and evaluate information on the nature and extent of marine debris-related impacts on species and populations of marine life, including seals, turtles, seabirds, crustaceans, and fish, in different ocean areas;
- identify and evaluate the impacts of marine debris on human health and the safety of ships at sea;
- identify and evaluate aesthetic and other impacts of marine debris on coastal environment;
- review and evaluate information on existing and potential technological and procedural ways to reduce or eliminate the problem of marine debris;
- assess the effectiveness and future role of programs to educate the public and promote awareness of the problem;
- evaluate international, intergovernmental, domestic, and informally constituted regional authorities that might be usefully drawn upon to strengthen cooperative efforts to address regional issue;
- describe programs necessary to assess the effectiveness of measures presently being taken to address various elements of the problem; and
- prepare a report summarizing the results of the conference and the steps that should be taken to address different aspects of the problem.

Workshop Organization

The conference opened Monday, 3 April, with a keynote address and a plenary session that set the stage for discussions during the remainder of the week. Overview papers presented during the plenary described the marine debris issue in six geographic areas: the North Pacific, the northwest Atlantic; the southwest Pacific; waters off southern Africa; the Antarctic; and the Caribbean. During the next 4 days, background and experience papers were presented on aspects of the marine debris problem. The subject areas of these technical sessions included: (1) amounts, types, distribution and sources of marine debris; (2) entanglement of marine life and ghost fishing; (3) ingestion by marine life; (4) economic impacts on

vessels and shorelines; (5) solutions through technology; (6) solutions through law and policy; and (7) solutions through education. In some cases, these technical sessions ran concurrently. Beginning on Wednesday, 5 April, participants separated into eight working groups to discuss the results of the technical sessions and formulate recommendations on needed actions. The subject matter of the working groups mirrored those of the technical sessions except that entanglement and ghost fishing split into two working groups. At a final plenary session on Friday, 7 April, working group chairmen summarized the results of these deliberations for workshop participants as a whole. A conference summary was presented at the closing luncheon.

Sponsors and Participants

Sponsors of the workshop included: Canada Department of Fisheries and Oceans; Council for Solid Waste Solutions; Intergovernmental Oceanographic Commission (UNESCO); National Coastal Resources Research and Development Institute (U.S.A.); Pacific Rim Fishing Industries; Sea Grant Colleges--University of Hawaii; State University of New York at Stony Brook, Marine Sciences Research Center's Waste Management Institute; University of Hawaii, School of Ocean and Earth Science and Technology; U.S. Environmental Protection Agency; U.S. Fish and Wildlife Service; U.S. Marine Mammal Commission; U.S. Minerals Management Service; U.S. National Oceanic and Atmospheric Administration; and the U.S. Navy.

As at the 1984 conference, participants included representatives from these groups along with scientists from various disciplines, administration and management personnel from Federal and State offices, and representatives of the fishing industry, the academic community, conservation groups, and other public and private interests. Although participants were primarily from the United States, representatives from the Republic of Korea, Japan, New Zealand, Canada, Israel, The Netherlands, South Africa, and the United Kingdom were also present. This level of participation is indicative of the high degree of international interest in the problems of marine debris.

II. SUMMARY OF OVERVIEW SESSION (chaired by Brian Boyle)

Several papers were presented addressing the marine debris situation in various parts of the world. Activities were reported under way to reduce the impact of marine debris on North Pacific seabirds and marine mammals. Effects of these actions are as yet unknown. Impacts of marine debris in the northwest Atlantic were also discussed, and it was concluded that aesthetic degradation of beaches and the cost of cleaning beaches appear to be the most serious effects of marine debris in the study area. Threat to marine life appears to be limited to sea turtles. Addressing accumulation, distribution, and environmental effects of plastic pollution in the southwest Pacific, it was noted that plastic debris of all kinds and in all sizes is widespread in this region, including shores of isolated and unpopulated islands. Ingestion of plastics has been recorded for at least 7 species of mammals, 26 seabird species, and 2 marine turtles species in

the waters off southern Africa and the adjacent Southern Ocean. In addition, 5 marine mammal species and 13 seabird species have been found entangled in plastic debris. Steps are being taken by the Commission for the Conservation of Antarctic Marine Living Resources to monitor marine debris in the Antarctic. Assessment of petroleum hydrocarbons in the marine environment of the Caribbean was also discussed.

III. SUMMARY OF TECHNICAL SESSIONS

Session I: Amounts, Types, Distribution, and Sources of Marine Debris (chaired by Murray Gregory and Satsuki Matsumura)

Debris is found in all oceans in all parts of the world. Regional evaluations of the amounts, types, distributions, and sources of persistent debris are required to develop efficient strategies for its control. Such evaluations are also critical to the discovery of current and potential problems caused by marine debris. This session included 22 papers, including several on concentrations of marine debris in the North Pacific/Bering Sea areas and others addressing the debris problems in the Gulf of Maine, New York Bight, the Outer Banks of North Carolina, a Texas barrier island, the east Mediterranean, the Israeli coast, and elsewhere. Papers also discussed the National Marine Debris Data Base and suggested guidelines for the design of beach debris surveys.

Session II: Entanglement of Marine Life (chaired by Charles Fowler)

The destruction of marine organisms through encounters with synthetic debris has been widely reported, and entanglement is the most common mechanism for this destruction. While the consequences of entanglement are obvious for individual animals, the implications for the status of the populations involved have been difficult to ascertain. Sixteen papers were presented on these topics, including ten on the northern fur seal and one each on Hawaiian monk seal, pinnipeds in the Southern California Bight, and marine mammals and sea turtles in the New York Bight. Presentations also addressed ghost fishing and the preliminary results of a study on the impact of the changing shape of derelict driftnets.

Session III: Ingestion by Marine Life (chaired by Peter Lutz)

Ingestion of plastic bags, synthetic rope, plastic pellets, and other marine debris has been reported as the cause of death of individual sea turtles, seabirds, marine mammals, and fish. The extent to which such incidents occur is uncertain, and thus it is also uncertain whether such occurrences have negative impact on population levels. This session included 15 papers presenting the latest scientific findings on research on debris ingestion. Six papers addressed incidence and effects of ingestion by seabirds, four focused on ingestion of plastics by sea turtles, and others addressed ingestion by fishes and marine mammals.

**Session IV: Economic Impacts on Vessels and Shorelines
(chaired by John Sutinen)**

Netting, rope and sheeting discarded at sea can disable vessels, thus threatening human safety on the open water. Floating debris has a negative aesthetic impact on beaches and inshore waters and can pose a human health hazard. Coastal communities that depend on tourism can incur significant costs as a result of decreased tourist traffic and cleanup costs. An economic perspective on the problem of persistent marine debris addressed problems in enforcing regulations to prevent marine debris. A research agenda was proposed. One report described how the Japanese commercial fishing fleet suffered damages as a result of marine debris. Other papers addressed recent incidents of medical wastes washing up on U.S. Atlantic beaches and the New York State Marine Debris Program.

Session V: Solutions Through Technology (chaired by Bruce Perlson)

A vast range of useful applications of new and modified technology is available for reducing the marine debris problem. Areas ripe for advancement include: simplification of shipboard waste handling, control of land-based sources, port waste handling systems, plastics and other recycling systems, waste heat recovery; fishing gear loss and recovery, and controlled-lifetime plastics. There is apparently a changing attitude in the packaging industry toward the development of biodegradable plastics. A paper described results of studies of the weathering behavior of five types of plastic materials commonly found as marine debris, and another reported on a recently initiated project to encourage recycling of marine plastic debris. Other papers in this session addressed control and disposal of wastes aboard ships and the port's role in reducing marine debris by providing refuse reception facilities.

Session VI: Solutions Through Law and Policy (chaired by Timothy Keeney)

Solutions to the marine debris problem involve many disciplines, industries, institutions, and agencies of government. This session focused on models of public process that have dealt with fractionated leadership and authority structures in solving the marine debris and similar multidimensional problems. The U.S. Environmental Protection Agency's Interim National Coastal and Marine Policy, which is aimed at controlling medical wastes and other marine refuse, was described. Another paper discussed international and regional regulations to prevent and control pollution by ships and noted, for example, that a recent survey of the German Bight estimated that 95% of the 8.5 million pieces of debris dumped annually, come from ships. Five papers addressed aspects of MARPOL Annex V and its potential for reducing marine pollution, and the Marine Plastic Debris Action Plan adopted in the State of Washington was described.

Session VII: Solutions Through Education (chaired by Bernard Griswold)

Because a great deal of the persistent debris reaching the ocean is the result of actions by individuals, public education on impacts of debris and disposal alternatives is seen as an important factor in solving the

problem. Papers in this session represented a wide range of educational programs and materials in place throughout the world, and one discussed how the plastics industry has responded to the problem of marine pollution, specifically to the presence of resin pellets in the marine environment. Efforts being carried out by The Tidy Britain Group to control marine litter were documented. Other authors discussed marine education and cleanup programs being implemented by the shipping industry, the U.S. Navy, various states and localities, and Japan. The final paper pointed out the need to consider and understand public attitudes and perceptions when designing an education program.

IV. SUMMARY OF WORKING GROUP MEETINGS

Working Group 1: Methods to Assess the Amounts and Types of Marine Debris (chaired by Christine Ribic)

The working group reviewed various methods currently being used to survey debris at sea, on beaches, on the sea floor, and emanating from land. Participants agreed that certain areas should be selected for concentrated study: on an international level, MARPOL special areas were suggested as appropriate; on national or regional levels, areas should be chosen to meet local areas of interest or management.

The group proposed methodologies to be used to determine amounts of debris. For nearshore, open ocean and sea bottom areas, platforms of opportunity, or dedicated surveys are appropriate. Beach surveys could be done using either designed programs or volunteer programs.

To improve accuracy and usefulness of strip transect surveys used to assess floating debris, the group recommended: using two or three observers instead of a single observer; calibration runs to estimate strip width; and experiments to investigate color and size biases. The working group further recommended that, when accurate distance measurements can be made, line transect methodology should be used. It also noted the possibility of using low-flying aircraft to survey nearshore areas.

As regards the magnitude of bottom debris, the group identified fishermen as a potential source of baseline information. It recommended that a survey form be developed to collect information from fishermen on debris tangled in their nets. One suggestion was made to classify all debris in one of four size categories ranging from "mega" (>2-3 dm) to "micro" (powdered or unseen in general).

The working group attempted to list certain debris types for purposes of recordkeeping, such as: nets (by type); other fishing gear; strapping bands (open/closed) (cut/not cut); granulated plastic (recycled plastic); particulate plastic; fragmented plastic; plastic bags; plastic containers (country of origin, age); Styrofoam; medical wastes; rope; entanglement remains (e.g., bones). The group recommended that other lists be reviewed to develop a common list that can be tailored to individual areas.

The working group agreed that the technique currently appropriate for assessment studies on a large scale was the beach survey. On a limited scale, dedicated surveys using visual observations and neuston tows in the nearshore areas (e.g., bays, harbors) or limited ocean areas (e.g., off-shore dumping areas) could also be used for assessment. Techniques using aircraft are experimental and could probably be used for baseline studies. Bottom debris studies are currently in the baseline category. Development of techniques to study bottom debris is needed.

Most members of the working group agreed that a procedures manual should be compiled for use as a starting point for people interested in initiating marine debris studies.

Working Group 2: Entanglement of Marine Life (chaired by W. R. P. Bourne)

The working group found that there is accumulating anecdotal evidence that virtually all marine animals are occasionally entangled in debris, but that quantitative data are available for only a few species. Care is needed in the interpretation of available information because it is difficult to distinguish between the effects of marine debris and other factors such as oceanic fluctuations, disturbance of animals while breeding, the impact of fishing on both animals and their food supply, disease, and other forms of pollution.

The group found that entanglement of cetaceans appears to be infrequent, but even small numbers may represent a serious impact on the reduced population of North Atlantic right whales. Phocid seals are occasionally entangled in netting but the incidence is not high. One phocid seal for which the entanglement problem appears to be most significant is the endangered Hawaiian monk seal. Otariid seals appear to be among the marine species most prone to entanglement, young animals being particularly vulnerable. As regards marine turtles and seabirds, the group concluded that entanglement does occur but that there is little if any evidence of any impact on numbers when compared to other factors such as loss of habitat or incidental take in certain fisheries.

The working group concluded that, in view of the number of problems that require investigation and the wide area to be covered, there is need to establish an international organization to coordinate and standardize systematic collection and dissemination of information about the occurrence and impact of marine debris and possible conservation measures to mitigate its impact.

The group further recommended, among other things, that efforts be continued to monitor, remove, and destroy lost or discarded nets and other debris presenting a hazard to monk seals, marine turtles, and other wildlife in the Northwestern Hawaiian Islands; and that monitoring be continued on the numbers, survival, breeding success, and incidence of entanglement of northern fur seals. It also recommended the investigation of the impact of entanglement and other possible hazards on right whales in the northwest Atlantic and Kemp's ridley turtles in the Caribbean, and a review of the long-term evidence for the incidence of entanglement provided

by bird-banding and beach surveys. Continued analysis of population level effects of entanglement through simulation modeling are to be encouraged.

Working Group 3: Ghost Fishing (chaired by Paul Breen)

The group concluded that ghost fishing is a potentially serious problem because of the very large volume of fishing gear now in use and the increasing use of nondegradable materials such as plastic, vinyl-coated wire, and fiberglass. Traps and gillnets were seen as the primary cause of ghost fishing problems, with trawl and longline gear types presenting a lesser problem. The group concluded that mitigation of ghost fishing by traps is technologically simple, but that ghost fishing by nets may be more difficult to solve. It recommended that both time-failure devices and degradable meshes be developed and tested.

The group agreed upon a series of recommendations classified by priority. High priority was placed on the following four proposals:

1. Fishery agencies responsible for trap and tanglenet fisheries should conduct lost gear simulations to determine whether ghost fishing occurs and, if so, the rate at which target and nontarget species are killed. If ghost fishing is found to be a problem, the rates of gear loss should be estimated through logbook programs or questionnaires. Useful information might be obtained from surveys of manufacturers.
2. Where ghost fishing has been demonstrated or is suspected in a trap fishery, the fishery agency should decide what timed-failure mechanisms would be most appropriate to reduce the lifespan of traps and how soon timed failure should occur. Research under actual fishing conditions should then be conducted to determine the most appropriate regulation for timed failure.
3. Further studies with simulated lost pelagic gillnets should be conducted using nets larger than those studied to date and approximating commercial nets. These studies should examine whether ghost fishing takes place; if so, at what rate; and the rate at which the nets form a mass or otherwise cease to fish.
4. Direct observations should be made of lost pelagic gillnets to determine their shape and to determine the apparent rates at which ghost fishing for fish, birds, sea turtles, and marine mammals is taking place.

Working Group 4: Debris Ingestion by Marine Life (chaired by Louis Sileo)

The working group noted that studies to determine the prevalence of ingested plastics require monitoring. It recommended that future studies have statistically adequate sampling schemes designed to test hypotheses

that the prevalence is increasing or decreasing in given areas, taxa, etc. The group found that, regardless of the species, the same three general pathophysiological effects were proposed: (1) mechanical blockages; (2) pseudosatiety or other impairment of a chick's ability to accept a full meal; and (3) absorption of toxins from the plastic.

The working group placed priority on research on turtles, i.e., experimental feeding studies to determine how to interpret the lethality or other significance of ingested plastic and the range of pathophysiology in ingested plastic in turtles, along with continued monitoring of the prevalence of ingested plastic and its association with lesions. The group also recommended controlled experiments be carried out on birds to (1) determine if pseudosatiety does occur; (2) elucidate the duration of retention and erosion rates of ingested plastics; and (3) determine the toxicity of ingested plastics. The results of such studies will determine the need for long-term population studies.

**Working Group 5: Economic Impacts of Marine Debris
(chaired by Kenneth McConnell)**

The working group viewed the marine debris problem as an example of a situation where markets have failed to allocate resources efficiently, leading to the creation of nonmarket, or external, costs. The presence of an external cost indicates a problem that requires some form of public policy to solve. However, policies to reduce marine debris require people to change their behavior. Incentive schemes may be especially cost-effective in controlling debris when education and moral suasion fail. The working group proposed a list of projects to investigate the use of fees and incentives as part of the solution. These include: deposits on the return of nondegradable products, fees on the use of nondegradable materials, and incentives at the production level.

As regards compliance, the working group proposed investigating alternatives to the traditional approach of seeking compliance through persuasion. Policies combining punishment and reward and which partly subsidize the adoption of techniques are used elsewhere. For example, sewage treatment has been enhanced by Federal subsidies to construct waste treatment plants linked with the requirement that all households hook up. Methods of linking compliance to rules and regulations for handling marine debris can be linked to access to other beneficial programs.

Public campaigns to reduce pollution by moral suasion have been attempted for other forms of pollution. A study of such prior public campaigns would help understand their failures, which have been many, and their successes, which have been few.

As regards on-shore disposal, the working group proposed an investigation of the economic gains that can accrue to a particular region as a consequence of consolidating waste handling facilities.

On the matter of aesthetics, the working group noted that debris makes beaches less attractive and traps fish and wildlife. Each of these entails

an aesthetic loss to some individuals. Currently, little or nothing is known about the economic cost of either. The working group recommended two types of studies to help understand the magnitude of the economic costs of marine debris. These are a study of the economic costs of debris on a specific set of beaches and a study of the economic costs incurred when some individuals of a noncommercial species (e.g., birds, mammals) are entangled in marine debris.

When vessels and their gear are impaired by contact with marine debris, there are two kinds of costs: the cost to repair or replace damaged gear and the opportunity cost of the vessel and gear when it is not in service. The working group suggested research to investigate the incidence of impairment and the magnitude of costs for one of the following industry groups: commercial fishing, shipping, or recreational boating.

The biggest impact of marine debris on fish stocks is the ghost fishing phenomenon, but there is also the possibility that consumers' perception of contamination of fish stocks by marine debris can influence the demand and price of selected fish products. Ghost fishing has an economic cost in terms of the lost resource. The working group suggested a joint project involving economists and biologists to study the impact of perceived contamination on the price of and demand for fish.

Working Group 6: Technological Solutions (chaired by William Gordon)

The working group recognized that further work is required to quantify the types and volumes of ship-generated debris, but felt strongly that technology/methodology currently exists to address management of the majority of the wastes generated at sea. Because a large measure of the ship-generated debris ultimately will be transported ashore, satisfactory resolution of much of the marine debris issue will require rational resolution to many of the terrestrial waste management issues and problems.

The group concluded that more information should be obtained about types, quantities, and distribution of the plastic materials that will be brought ashore under MARPOL regulations for disposal ashore. Such information should be disseminated throughout the plastics industry to encourage reuse of such material.

The working group recommended that development of new technologies be encouraged. For example, in the area of low technology burning, research is needed on the environmental impacts of air emissions, development of guidelines concerning materials separation and operations, and environmental implications of ash and methods of its disposal. Regarding incineration, research is needed on environmental impacts of air emissions and the environmental implications of ash and methods of disposal.

In the area of ship design, new designs should accommodate waste management strategies and new construction should include facilities and space accommodations for waste management.

Regarding policy, no single methodology or technology will ensure compliance with waste management regulations. The working group felt that, accordingly, no policy should be established which will prohibit technologies which have potential.

Working Group 7: Marine Debris Law and Policy
(chaired by David Cottingham)

The working group reviewed existing legal and institutional arrangements to curtail the disposal and loss of solid wastes into the marine environment. The group concluded that solutions to the problem of marine debris should be developed and implemented in concert with efforts to address broader solid waste management issues. The most pressing needs identified include: (1) expanding participation to relevant international agreements; (2) assuring that adequate port reception facilities are available at all ports and harbors to receive ship-generated garbage returned to shore; and (3) adopting national policies and programs, such as recycling and innovative packaging, to reduce quantities of generated solid waste.

The group identified two international agreements as being of greatest importance to the problem of marine debris: MARPOL Annex V and the London Dumping Convention (formally known as the International Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter). In addition, at least 10 regional conventions control various forms of pollution, including the disposal of plastics and other solid wastes into the marine environment. The working group concluded that these international conventions establish the prohibition of disposing of plastics and other solid materials into the sea as "customary international law."

The group recognized that control of land-based sources of marine debris is a difficult problem that must be addressed domestically by individual nations. For example, it recommended that governments encourage recycling programs to reduce the volume of material that becomes solid waste.

Regarding compliance and enforcement, the working group recommended that the International Maritime Organization and pertinent governments party to MARPOL Annex V develop incentives to encourage vessels owners and operators to comply with garbage disposal regulations, and that vessel owners and operators be encouraged to report ports and harbors that do not have required port reception facilities.

Working Group 8: Marine Debris Education (chaired by Kathy O'Hara)

Education has been identified as an important way to help reduce the marine debris problem and is particularly important because land-based sources of debris are primarily nonpoint. Ethics and behavior patterns of individuals both on land and at sea must be changed, and education is a known means for effecting such changes.

The working group was charged with assembling a comprehensive list of the types of educational materials currently in use. The group

identified more than 100 different types of educational materials, including 21 brochures, 19 reports, fact sheets and special documents, 11 posters, 10 videos, 9 curriculums and guides for educators, 6 newsletters, and more than 30 other types of educational materials.

Marine debris education encompasses two key elements: the implementation of educational programs and the development of educational materials. With regard to the former, the working group recommended that marine debris education should be incorporated into three primary types of programs: (1) formal education in a structured academic setting; (2) informal education outside a formal academic setting but within structured educational events such as adult education classes and organized youth groups; and (3) general public awareness. Among the groups identified as target audiences for marine debris education, the working group concluded that five major groups are priority audiences: (1) general public, (2) media, (3) teachers and educators, (4) school children, and (5) all marine user groups.

A public awareness campaign is of utmost importance at present. Specific elements that should be addressed in developing this campaign include an initial assessment of human behavior and public perception of the marine debris problem. The working group felt that a comprehensive strategy to effectively use the media to disseminate information was paramount to the success of this campaign.

After reviewing the list of marine debris educational materials, the working group concluded that there is a wealth of materials currently available but there is a need to facilitate the dissemination of these materials to appropriate groups. In 1988, the National Oceanic and Atmospheric Administration's Marine Entanglement Research Program established two Marine Debris Information Offices, which respond to requests for information on marine debris. The working group suggested that the dissemination of educational materials would be facilitated if these offices were given increased visibility as a resource center along with sufficient quantities of educational materials to meet the demand.

Existing government distribution mechanisms should also be used to increase dissemination of materials, such as licensing and registration procedures for fishing and boating, the working group concluded. The group recognized the difficulty of disseminating educational materials on an international level due to the diversity of cultures and languages. However, it was suggested that specific international agencies, such as the United Nations Environment Programme, the Food and Agriculture Organization, and the International Maritime Organization, should be encouraged to facilitate information exchange.

Efforts should be made to include the marine debris issue on the agendas of international conferences and meetings that address the issues of marine pollution and education.

Appropriate means for evaluating the success of educational programs were discussed. The working group concluded that evaluation techniques could be conducted through long-term citizen monitoring of beach debris and

monitoring the usage of shoreside refuse reception facilities. Formal surveys should be conducted, where possible, to assess changes in attitude and behavior.

It was agreed by all working group participants that the marine debris issue is part of the larger solid waste problem and therefore we should incorporate lessons learned from dealing with solid waste into marine debris educational materials and programs.

V. RECOMMENDATIONS

Conference participants set forth a number of priority recommendations. Examples of some of the primary recommendations are:

- broad international acceptance and implementation of the terms of MARPOL (73/78) Annex V, especially the provision of port reception facilities;
- recognition of the marine debris problem as a symptom of the worldwide solid waste disposal crisis;
- pursuance of technological and procedural solutions to the marine debris and solid waste problems while avoiding policies and regulations that may restrict solutions;
- expansion of marine debris and solid waste disposal education to people and institutions worldwide, recognizing regional and cultural differences in the perception of these problems;
- development of a set of standard methods for surveys of the amounts, types, and sources of marine debris;
- establishment of an international committee or organization to further collaborative research on the impacts of entanglement on living marine resources;
- design and implementation of baseline experiments to establish the lethal and sublethal impacts of persistent debris ingestion by sea turtles and seabirds;
- design and implementation of experiments to evaluate ghost fishing in gillnet and trap fisheries with high gear loss rates, developing mitigative measures as needed; and
- evaluation of the economic impacts of marine debris, both direct, as in vessel disablement and commercial fish loss, and indirect, as in aesthetic damage and solution costs.