Proceedings of the

International Marine Debris Conference

Derelict Fishing Gear and the Ocean Environment

AUGUST 6–11, 2000

HAWAI'I CONVENTION CENTER

HONOLULU, HAWAI'I

National Marine Sanctuaries

NOAA

Proceedings of the

INTERNATIONAL MARINE DEBRIS CONFERENCE
ON DERELICT FISHING GEAR AND THE OCEAN ENVIRONMENT

The Hawaiian Islands Humpback Whale National Marine Sanctuary and its partners acknowledge and thank Senator Daniel K. Inouye for his vision and support of the conference.

August 6-11, 2000

Hawai'i Convention Center

Honolulu, Hawai'i

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FOREWORD

The International Marine Debris Conference on Derelict Fishing Gear and the Ocean Environment was convened to address the Pacific-wide nature of lost and discarded fishing gear and its impacts on protected species, coral reefs, and the marine environment.

The conference attempted to address the problem of derelict fishing gear at its source. Evaluation of netting removed from coral reefs during multi-agency cleanup efforts in the Northwestern Hawaiian Islands indicated to National Marine Fisheries Service (NMFS) officials at the Honolulu Laboratory that the majority of recovered debris was not originating locally but rather from other fisheries operating in the North Pacific, including Asia and Alaska.

Bob Rock, Marine Debris Communications Committee

Artist Robert Lyn Nelson (left) and President of the Ocean Futures Society Jean Michel Cousteau (right) during the unveiling of the Conference poster.

Funding for the conference was provided by the U.S. Congress to the National Oceanic and Atmospheric Administration's Hawaiian Islands Humpback Whale National Marine Sanctuary. Congress charged the agency with the overall organization of the conference and with the directive to bring together a diverse group of individuals from industry, government, and the public sector to assess the Pacific-wide nature of derelict fishing gear and develop specific recommendations and strategies for action.

The conference convened in Honolulu, Hawai'i on August 6-11, 2000. Representatives from across the Pacific came together to share ideas and develop a list of recommendations and detailed strategies for action including Chile, Taiwan, Japan, Australia, New Zealand, American Samoa, and Micronesia.

Among the recommendations were calls for:

- an international action plan,
- greater attention to marine debris issues by members of the International Maritime Organization and various UN Regional Seas Programs, and
- public and private partnerships to assist in the implementation and compliance of international agreements and guidelines.

This proceedings document is a compilation of the papers, speaker presentations, and recommendations developed by the conference participants. We hope that the recommendations will be shared amongst colleagues and that collaborative multi-agency and international efforts will continue to produce solutions to this problem.

Naomi McIntosh
Conference Organizer
Honolulu, Hawai'i

ACKNOWLEDGMENTS

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CONFERENCE POSTER
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U.S. Senator Daniel K. Inouye

MAHALO NUI LOA TO ALL INDIVIDUALS WHO CONTRIBUTED THEIR TIME AND EFFORT

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Bob Rock, Marine Debris Communications Committee

Likeke Bell opens the Conference by blowing the pu (conch shell). Seated left to right on the platform are conference speakers Honolulu Mayor Jeremy Harris, Jim Cook (WESPAC), and James Coe (NMFS) and conference hosts Kitty Simonds (WESPAC) and Allen Tom (HIHWNMS).

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INTRODUCTION

On August 6-11, 2000 the Hawaiian Islands Humpback Whale National Marine Sanctuary, along with its multi-agency partners, sponsored the International Marine Debris Conference on Derelict Fishing Gear and the Ocean Environment. The objectives of the conference were to: (1) review sources and impacts of derelict fishing gear; (2) assess and identify new technology for mitigation and prevention; (3) establish international and national partnerships; (4) increase international and national public awareness; and (5) develop recommendations for future actions.

Bob Rock, Marine Debris Communications Committee

The Hawai'i Convention Center, scene of the International Marine Debris Conference.

To help stimulate ideas and recommendations on these matters, six issue papers were distributed to participants prior to the conference. The issue papers served to form a foundation for discussions within each of six separate working groups examining policy and legal issues, impacts of marine debris, source identification, industry considerations and actions, monitoring and removal, and education and outreach.

The conference was convened to bring together representatives from government and academia as well as environmental and industry groups to evaluate past, present, and future mitigation efforts. A total of 278 individuals participated from 20 countries and 15 states. Twenty-eight speakers were invited to give oral presentations and share their research findings on the scope of the derelict fishing gear problem and current efforts aimed at addressing the issue. U.S. Senators Daniel K. Inouye and Daniel K. Akaka, U.S. Representatives Neil Abercrombie and Eni Faleomavaega, and Under Secretary on Oceans and Atmospheres and Director of NOAA Dr. D. James Baker were among those invited to share their views on issues associated with marine debris. In addition and in conjunction with the conference, August 6-12 was proclaimed Marine Debris Awareness week in the state of Hawai'i by Governor Benjamin Cayetano. Mayor Jeremy Harris also proclaimed Marine Debris Education week for the City and County of Honolulu to urge all citizens to play an active role in solving the problems of marine debris.

Bob Rock, Marine Debris Communications Committee

International Marine Debris Conference participants enjoy a luau on the grounds of Bishop Museum.

Based on the issue papers and other papers presented at the conference, a list of recommended actions were developed for each of the six focus topics. Consequently, conference participants detailed thirty priority recommendations and strategies for future action. These recommendations underscore the importance of international cooperation in addressing the derelict fishing gear issue in the North Pacific Ocean.

What follows is a summary of the information, ideas, and recommendations presented and developed at the conference to reduce the impact of derelict fishing gear on the ocean environment.

Proclamation

WHEREAS, Hawaii is home to more than fourteen-thousand square miles of coral reef ecosystems that support over five-thousand marine plants and animals; and

WHEREAS, the coral reefs surrounding the Hawaiian archipelago represent nearly eighty-four percent of all coral reefs under the jurisdiction of the United States; and

WHEREAS, Hawaii has the fourth longest coastline in the United States and is surrounded by an economic zone that encompasses an area of more than nine-hundred thousand square miles; and

WHEREAS, Hawaii's coral reefs protect shorelines from waves and storm surges and provide refuge for juvenile fish and essential habitats for many species; and

WHEREAS, marine debris is harmful because it abrades reef corals, entangles seabirds, sea turtles and Hawaiian monk seals, and advances the introduction of alien marine species; and

WHEREAS, more than thirty-five tons of derelict fishing nets have been removed from the reefs and shorelines of our archipelago, and an estimated two- to three-thousand tons remain; and

WHEREAS, the International Marine Debris Conference will be held at the Hawaii Convention Center from August 6 through 12, 2000, to evaluate the ecological, economic, social and political influences of maritime sources of marine debris in Hawaii and the Pacific;

NOW, THEREFORE, I, BENJAMIN J. CAYETANO, Governor of the State of Hawaii, do hereby proclaim August 6 through 12, 2000, to be

MARINE DEBRIS AWARENESS WEEK

in Hawaii, and congratulate participating agencies for helping to protect our marine environment.

DONE at the State Capitol, in the Executive Chambers, Honolulu, State of Hawaii, this third day of July, 2000.

Benjamin J. Cayetano

GOVERNOR'S PROCLAMATION

OFFICE OF THE MAYOR
CITY AND COUNTY OF HONOLULU

PROCLAMATION

WHEREAS, debris that washes up on the shores of our beautiful islands takes its toll on marine life, coral reefs, and beaches; and

WHEREAS, the City and County of Honolulu has established a partnership with community groups and other government agencies to raise awareness and concern over the effects of marine debris; and

WHEREAS, thousands of volunteers have cleaned reefs and beaches to preserve Oahu's unique marine life, improve recreational areas, and support appropriate economic development; and

WHEREAS, the City also assisted in the removal of over 35 tons of fishing nets that damaged coral reefs and marine life at French Frigate Shoals; and

WHEREAS, as caretakers of the environment, we have a responsibility to ensure that future generations enjoy these ocean resources,

NOW, THEREFORE, I, JEREMY HARRIS, Mayor of the City and County of Honolulu, do hereby proclaim August 6 through 12, 2000, as

MARINE DEBRIS EDUCATION WEEK

in the City and County of Honolulu, and I encourage our citizens to support the International Marine Debris Conference and become more aware of the effects that marine debris has on our fragile environment.

IN WITNESS WHEREOF, I have hereunto set my hand and caused the Seal of the City and County of Honolulu to be affixed.

Done this 6th day of August, 2000, in Honolulu, Hawaii.

Jeremy Harris

JEREMY HARRIS, Mayor
City and County of Honolulu

MAYOR'S PROCLAMATION

INTERNATIONAL MARINE DEBRIS CONFERENCE ON
DERELICT FISHING GEAR AND THE OCEAN ENVIRONMENT

PARTICIPANTS' DECLARATION OF RESOLVE

Honolulu, Hawai'i • 6-11 August 2000

RECOGNIZING

- the harmful and persistent effects of accumulating derelict fishing gear and other marine debris on marine flora and fauna, ecosystem integrity, and vessel safety,
- that all stakeholders are shipmates and share responsibility for stewardship and conservation of marine resources,
- the exigency to enhance communication, cooperation, and sharing of ideas and resources among various resource users, groups delegated conservation and management responsibilities, conservation organizations, and the general public, and
- the clear requisite to galvanize the accomplishments of the Conference and spur progress in resolving ecological and economic impacts of derelict fishing gear.

REAFFIRMING

Reaffirming the "Fisherman's Pledge For a Clean Ocean" adopted by the North Pacific Rim Fishermen's Conference on Marine Debris in 1987, and emphasizing its importance as a tool to address the problem of derelict fishing gear in the marine environment;

RECALLING

Recalling the principles and obligations regarding marine pollution by lost or abandoned fishing gear as embodied in the FAO Code of Conduct for Responsible Fisheries, the United Nations Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks, the UN Convention on the Law of the Sea, Annex V of the International Convention for the Prevention of Pollution from Ships (a.k.a. MARPOL 73/78), and the Guidelines for the Implementation of Annex V;

RECALLING FURTHER

Recalling further, that in giving effect to these obligations, Parties should adopt and implement measures to minimize the loss and maximize the recovery of fishing gear with the strategic goal of eliminating adverse impacts of derelict fishing gear on the marine environment and vessel safety;

COMMITTING

Committing to the productive application of the efforts and recommendations of this Conference;

THE PARTICIPANTS OF THE CONFERENCE RECOGNIZE

The Participants of the Conference Recognize, that in analyzing the significant problem of marine debris, it is the responsibility of all States to take concerted action to prevent the discard and loss of fishing gear into the world's oceans and to endeavor to reduce the effects of derelict fishing gear through education, outreach, and removal programs;

CONSEQUENTLY

Consequently, and as a matter of priority, the Participants of the International Marine Debris Conference in Honolulu, Hawai'i (6-11 August 2000) recall the key recommendations of the Conference and resolve to diligently pursue those recommendations to:

1. Establish an International Plan of Action to prevent the discard, minimize the loss, and maximize the recovery of fishing gear;

2. Develop mechanisms to improve reporting of lost fishing gear and complying with international and domestic legal regimes to prevent and mitigate the effects of fishing gear loss;

3. Identify and quantify the adverse effects of ghost-nets, and other derelict fishing gear, and promote ongoing and new efforts to remove these sources of danger to marine life and vessels;

4. Identify the sources of derelict fishing gear with the objective of refining efforts to prevent loss and discard of fishing gear by targeting education efforts and engaging industry to develop outreach programs for these fishing communities;

5. Establish standardized protocols to map locations of commercial fishing and aquaculture activities using Geographic Information System (GIS) techniques;

6. Consider "effort-rationalization" management approaches as tools to reduce loss of commercial fishing gear;

7. Develop broad-based, private-public partnerships to fund programs to recover derelict fishing gear, to provide long-term funding for education and outreach activities, and to develop appropriate infrastructures for effective implementation and enforcement of measures to prevent discard and loss of fishing gear and the recovery of derelict fishing gear;

8. Alert government agencies to the urgency of addressing derelict fishing gear as national and international priorities and the need to bring this issue of concern to the attention of appropriate regional and international ocean governance institutions, organizations, and regimes; and

9. Promote the development of broad-based education programs, particularly those that may use emerging technologies, to (a) educate all stakeholders about derelict fishing gear impacts and programs that have been successful in resolving impact issues, and (b) disseminate information on initiatives and programs for prevention, mitigation, and monitoring of the impacts of derelict fishing gear.

THE ASIA-PACIFIC ERA: ENVIRONMENTAL CHALLENGES

Honorable Jeremy Harris, Mayor, City and County of Honolulu, Hawai'i

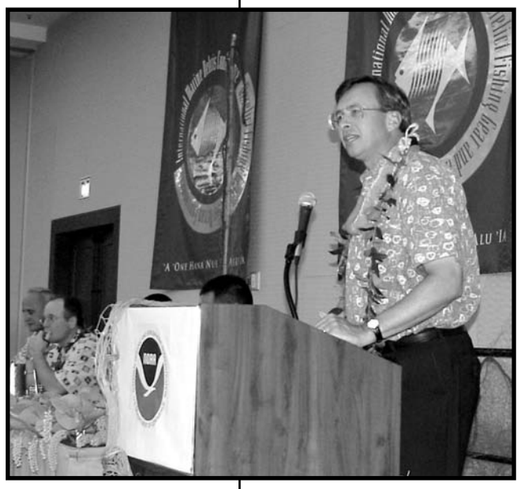
INTRODUCTION

Good morning and aloha.

As Mayor of the City and County of Honolulu, I am honored to welcome our guests from the four corners of the world who are here today as well as our local attendees. You know, when I look at the future of the Asia-Pacific Region, when I look at the challenges that we face as a region, coming to you as a marine biologist and an environmental scientist, I can't help but believe that our environmental challenges are great.

ENVIRONMENTAL CHALLENGES

Apparently, as we enter this new millennium, this new century, it's the environmental challenges that are so important. It's called the Asia-Pacific era that we're now entering, where most of the population growth will be here in our region of the world. And while that may be true, what goes along with that is economic growth, and that is going to result in an enormous series of environmental challenges that could, in fact, threaten the entire planet. And when you look at the kind of consumption and pollution that the United States generated when it went through a period of growth after the Second World War, and you consider that we were only five or six percent of the world's population, and then you look at the growth and increased consumption of natural resources that's going to be occurring in Asia over the next twenty years—it is truly staggering.



Bob Rock, Marine Debris Communications Committee

Honolulu Mayor Jeremy Harris delivers an address on environmental challenges.

As our world becomes more urban and as more people leave rural lifestyles and become part of urban megacities in Asia, the threat to our global climate increases. Air pollution from the consumption of fossil fuels and coal is now being detected even here in Hawai'i. Along with the pollution of our water with improper urban wastewater treatment facilities; the destruction of our ocean ecosystem as a result of over fishing; the destruction of our habitats in some coastal developed areas where we have poor coastal zone management regulations; and the destruction of estuaries—everywhere you look, you see enormous environmental problems on the horizon. One of those environmental problems is the increase in marine debris that is threatening our ocean resources. If there is one commonality throughout all this, it is that these are indeed regional and global problems. Pollution, whether it's air pollution, water pollution, or marine debris, knows no national boundaries.

CONSENSUS BUILDING

If we don't work together, if we aren't forming a consensus on how we're going to attack these regional and global environmental problems, we will not be successful. It's as simple as that. We've got to recognize that the management of our resources has got to transcend regional and national boundaries and interests. They are global interests; they are all of our interests. We are impacted from events in China here in Hawai'i. Our beaches are impacted by the actions of fishing boats in the Central Pacific. We are all one community and we've got to start behaving that way. As an environmental scientist, this is one of things that we have tried to do at the city level—recognize that as a city we have responsibilities for maintaining the quality of our environment here locally, as well as in the Pacific Ocean environment that surrounds us.

We are contributors to ocean debris; from all of the urban waste that runs off our island and all of the plastic wrappers that get thrown into our storm drain system, wash out into our streams, and with heavier rains wash out into the ocean. They litter our reef environment and impact the quality of the ecosystems there. They wash out into the open ocean and create other environmental damage. Two years from now that plastic wrapper that gets thrown out today into the storm drains on Kalakaua Avenue may end up strangling a green sea turtle miles and miles away from our shore.

We bear a responsibility. Locally, what we've tried to do is raise the consciousness of our people so they realize that they themselves are the prime polluters of our ocean. It's not the big industry. It's not some point source where the big pipe is going into the ocean and the valve can just be turned off to solve the problem. We are all responsible; from how we apply pesticides and herbicides to our lawn, to what we throw in that storm drain, to how we handle our household hazardous wastes. We are all responsible for the pollution of our streams and our ocean.

LOCAL EFFORTS

So we created teams of people who are out there working with the community. We have an Adopt-a-Stream Program where community groups, families, and organizations can get together and actually participate in the health and the maintenance of a stream in their community. They work with city crews, cleaning the stream, and removing the debris before it becomes marine debris at the next heavy storm. Of course, the city has stepped up its efforts with high technology to pump out the storm drains and to remove any kind of debris that enters our drainage system before it enters into our streams and our ocean environment. But it takes more than that. It takes an involved electorate and so we're putting ads on the TV; we're encouraging people to get involved; we're enlisting their help in

recognizing that they have a role to play. The end result has been, quite frankly, phenomenal; thousands of people are getting involved; groups are adopting streams in their area. We've even started an Adopt-a-Reef Program where people join with us to clean the reefs of material debris that has washed off of our urban environment.

The city also realizes that it has a role in joining with all of you in solving the problem of derelict fishing waste products that end up in our ocean environment. All you have to do is walk on one of our beaches and you will see that we are being impacted. Not only are endangered species being impacted, not only are our waterfowl being impacted, but tourism is being impacted. When tons of waste materials from fishing operations wash up on our beaches, that impacts our very economy here in Hawai'i.

ENVIRONMENTAL AND ECONOMIC POLICY

One of the other lessons to be learned is not only that we're all in this together, but that good environmental policy is good economic policy. That applies to all of these issues on the environment, and it particularly applies to the issue of marine debris. We have a vested interest to play a role in the solution to this problem. And I want to assure all of you that you can count on the city to be an active participant in any of the solutions that are derived from this conference. Our environment is our most important asset, especially here in Hawai'i, and our people recognize it. If we don't work together to protect it and preserve it, we will have very little to turn over to our children and their children.

CONCLUSION

I want to thank you all for being here today. I have issued a proclamation to bring special attention to this conference and to the work that you are doing here. I have proclaimed it "Marine Debris Education Week" in the City and County of Honolulu. I have urged all of our citizens to play an active role in solving the problems of marine debris and to recognize their responsibility in dealing with this regional and global environmental problem. I want to thank you for being here and recognizing that responsibility as well. On behalf of all of our citizens, thank you very much for joining us and good luck with your conference. Aloha.

• Transcribed from a speech given August 7, 2000.

WELCOMING REMARKS

Jim Cook, Chairman, Western Pacific Fishery Management Council, Hawai'i

Good morning. It's wonderful to see so many of our Pacific island neighbors here today and those of you who joined us from various places in the world. My special aloha to members of the fishing industry who have taken time out from their jobs and lawsuits to join us here this morning.

Two years ago, the Western Pacific Regional Fisheries Management Council hosted the first workshop on the population biology of the black-footed albatross, a species that nests in the Northwestern Hawaiian islands. The workshop was part of the council's strategy for dealing with unfortunate interactions between albatross and the longline fisheries.

During the workshop it became abundantly clear that serious though these fisheries interactions were, there were also other important sources of the tross's mortality including the ingestion of lightsticks, disposable lighters, and other plastic marine debris. The Western Pacific Fisheries Management Council subsequently contacted two other regional fisheries management councils in the Pacific to alert them of the albatross problem here in Hawai'i. They also asked the U.S. Department of State to alert Pacific Rim countries about this issue.

Fishermen throughout the world recognize that their livelihood depends on productive oceans. To further this cause, in 1987 we organized the North Pacific Rim Fisheries Conference on Marine Debris held in Kailua-Kona and in 1988 a workshop on fisheries-generated marine debris and derelict fishing gear held in Portland. Many of us had mounted the fisherman's pledge to a clean ocean on our bulkheads and have been involved in a number of other efforts this past decade to prevent and reduce the amount of derelict fishing gear in the ocean. You will undoubtedly hear more about these efforts during the week. But we in the industry also realize that the problem of derelict fishing gear lies beyond the resources of any one nation, agency, organization, or sector. It is a complex and difficult challenge that must be faced cooperatively.

While the magnitude of the problem is challenging, there is cause for optimism. Our gathering here today is one cause. Cooperative efforts between NGOs, industry, and government are key to solving problems in the ocean environment. The industry looks forward to working with all of you today to minimize the impact of fishing gear and to improve the health of the Pacific Ocean environment. Working together we can make a dramatic impact on this problem. Thank you.

• Transcribed from a speech given August 7, 2000.

A MARINE DEBRIS RETROSPECTIVE WITH CHALLENGES FOR THE FUTURE

James M. Coe, Acting Science and Research Director, Alaska Fisheries Science Center, National Marine Fisheries Service, Seattle, Washington

INTRODUCTION

Aloha and welcome to Hawai'i, the cradle of the marine debris movement, and to this great opala ohana, Hawaiian for trash get-together. I am very happy to be here and I hope you all are too. Because of my years as Director of NOAA's Marine Debris Program, from 1985-96, your organizers have asked that I provide a brief retrospective of the issue and give you my perception of the challenges you face in tackling fisheries sources of marine debris. Rather than show slides or overheads, my talk today will have a little audience participation. No dancing or anything, just a few questions and some key words for you to jot down.

I assert that Hawai'i is the cradle of the marine debris movement. So my first questions are how do we know if there is a movement or not and how do you know if you are a participant of it? I can help you with the answer. If you go to the beach, or if you go out in your boat, or if you go upcountry and you see trash on the ground and it bothers you, raise your hand. The point is, virtually all of you raised your hand! Certainly a large percentage of the public would have done likewise. Next, if you believe that there is still work to be done to solve the marine debris problem, raise your hand. It looks like all of you again. So we have a multitude of people who perceive a problem and want to work to solve it. In my mind that constitutes a movement.

You cannot have a movement without some history and since people make history, I wish to recognize three of the movement's founders. The first is Dr. Charles Fowler-he is sitting right in front of me-will you stand up a second Chuck? Chuck is the scientist who made the marine debris problem come alive in the early-'80s. His work on northern fur seals in Alaska brought real substance and urgency to the marine debris issue. I also wish to recognize Richard Shimura, Director of the NMFS Hawai'i Laboratory in the '70s and '80s. Richard chaired the first and second International Marine Debris Conferences in 1984 and 1989, both in Honolulu. He edited the reports of these two conferences, creating the information foundation for the movement. Finally I must recognize Ms. Katherine O'Hara, Pollution Program Director for the Center for Marine Conservation (CMC) through the '80s and mid-'90s. Kathy supplied the energy and creativity that transformed the marine debris issue into a broad, international movement. Her work is largely why many of you know and care about marine debris. My point is to show those of you who may be new to the movement that not only are we assembled in the cradle of the marine debris movement, we are standing on the shoulders of some very dedicated individuals, proving that individuals do make a difference!

PREVIOUS MARINE DEBRIS CONFERENCES

By request, I will review some of the principal marine debris conferences and symposia that took place in the last fifteen years or so. I will try to briefly recap the key issues and results of these meetings from my perspective and then focus on the real challenges to you at this the Fourth International Conference on Marine Debris.

The old adage, "What goes around, comes around" couldn't be truer in the marine debris world, especially in the North Pacific. Debris circulates around the ocean and the conferences on this issue seem to have completed their first circuit. This brings me around to 1984 when what I'll call the First International Conference on Marine Debris was convened here in Honolulu.

The title was the Workshop on the Fate and Impacts of Marine Debris (FIMD). The purpose was to bring together fishery biologists, fishery scientists, oceanographers, some population modeling types, and some folks in the fishing industry in an attempt to make an honest assessment of whether marine debris, particularly derelict fishing gear, was a problem worth people's attention. The question was, "Is there enough information to decide whether or not the constituencies represented at the workshop should do something more about marine debris?" Yes, it's trash and it's unsightly, but why do we worry about it in the fisheries context or why should the fishing industry or the fishery manager or the fishery biologist be worried about it? This 1984 Workshop concluded that even though the data were limited there was enough qualitative information to conclude that this was a problem that needed better quantification. This was a problem that needed policy and legal attention as well. The first international conference had several papers addressing the international legal circumstances. They recommended that the U.S. and the other Pacific Rim nations pursue the ratification and implementation of Annex V of the Convention for the Prevention of Pollution from Ships. This became one of the most far-reaching recommendations of the Workshop. Further, the FIMD first recognized and linked the roles of science, education, and mitigation actions in describing the actions necessary to begin to address the marine debris problem. One of the results of the workshop was that the U.S. Congress provided the funding for NOAA's marine debris program in 1985. It was called the Marine Entanglement Research Program (MERP) because it was housed in a research center, but its charge was science, education, and mitigation.

Shortly after the Workshop on Fate and Impact of Marine Debris, Dr. Douglas Wolfe and I organized a one-day workshop on marine debris as part of the Sixth International Ocean Disposal Symposium in Monterey, California. The papers were published as a special edition of a Marine Pollution Bulletin in about late 1987. These collections of papers were

written on solution strategies reaching beyond the fishing industry-based problem. This volume also included a paper by the late Dr. Archie Carr, a sea turtle biologist from Florida, about the problems of entanglement and ingestion by sea turtles. This paper detailed the very serious risks marine debris poses for all the sea turtles of the world and led NOAA's program to begin working to protect sea turtles.

The Pacific Rim Fishermen's Conference on Marine Debris was held in Kona, on the Big Island, in 1988. It was sponsored by fishing industry organizations from around the U.S., Canada, Japan, and Korea as well as by NOAA and other government agencies from these countries. The deliberations at this conference attempted to bring some sort of pragmatic treatment to the conundrum faced by the fishing industry and its various segments regarding how one can fish without generating lost fishing gear. The participants freely recognized that they were part of the marine debris problem and initiated the consideration of a wide range of solution strategies, including education programs, gear design, port-based recycling, and gear recovery-all issues highly relevant to today's conference. Further, and get out your pencils to write this down, this meeting recognized the importance of fisheries efforts to “minimize loss and maximize recovery” of fishing gear. Another simple concept that is highly relevant to the current conference charge.

Also in 1988 the White House Domestic Policy Council issued a set of orders to NOAA and the Department of Interior to jointly convene the federal Interagency Task Force on Marine Debris. While it's probably not of much interest to those who do not work for the federal government, that report laid out the rules and the policy prescriptions for how agencies are to behave relative to the purchase of persistent materials, the management of their wastes, the business of recycling, and the enforcement of the laws related to marine debris and solid waste management. Clearly the Task Force recognized the linkage between land-based sources of debris and solid waste management infrastructure. This was an important report, though few people saw it or took the time to read it. It contained a great deal of good advice for federal agencies that turned out to be good advice for industries, including the fishing industry. In that report, get out your pencils now-you need to write this down-it said to “minimize the loss and maximize the recovery of fishing gear.” Also, the federal report encouraged the development and broad support of a huge voluntary beach cleanup program. The Center for Marine Conservation took on organizing these and is still carrying on this activity on a huge international basis. The relevant lesson of beach cleanup is, when you pick up somebody else's trash, you will never again throw your own down. Further, data collected during the cleanups provide regular local and regional media attention to the ongoing marine debris problem.

Which brings us to April 1989 and the Second International Conference on Marine Debris in Honolulu, also chaired by Richard Shimura. NOAA did most of the fund raising, organizing, and international solicitation. But Richard chaired the meeting and produced the massive, two-volume report. In my opinion, this second conference was probably the greatest attempt we will ever see to assemble and review the global information available on the marine debris problem. The report became the information base for broadened activity, research, education, and mitigation worldwide. The review of the biological consequences of marine debris in this report is the most thorough to date.

During this period, and largely as a result of the international debates relative to the special area status of the Gulf of Mexico under MARPOL Annex V, a number of U.S. organizations-EPA, NOAA, CMC, Sea Grant-started a series of Caribbean Marine Debris Workshops. In general, the purpose of those workshops was to try to inform the Wider Caribbean islands and coastal states about their natural heritage and the threat to their economy from marine debris, especially from cruise ship activities. These workshops were the beginnings of a collective consciousness in the Caribbean region, particularly island nations, relative to the threat of marine debris and their ability to unite to deal with those problems. These workshops provided impetus that helped attract UN and World Bank assistance for programs to develop port and land-based waste management policy, regulations, and infrastructure in the Wider Caribbean region. By way of these activities the linkage of the marine and land-based waste management systems was recognized as a fundamental challenge in solving the marine debris problem worldwide. There have been five or six of these workshops. The most recent took place in Cozumel, Mexico about two years ago and focused on nautical tourism and port waste management.

The Third International Conference on Marine Debris took place in Miami in April 1994. As part of NOAA's program, I chaired, organized, and edited the book that came out of it. The conference in Miami attempted to integrate across all of the land-based issues, all of the socioeconomic levels from developed to undeveloped, and produce a set of practical recommendations. I don't think we succeeded, but we made real progress given the global state of knowledge and data to solve the marine debris problem. The socioeconomic papers from the third conference truly are first class and the whole volume is worth reading as an update on most marine debris issues. The book from the third conference is the last formal product of NOAA's Marine Debris Program. The Program ended in 1996 and there were no more conferences on marine debris until this one, which I have informally labeled the Fourth International Conference on Marine Debris.

CHALLENGES

Now, I will offer you some of my points of view relative to the challenges before this conference. If you look on the front of the conference brochure, you will find the charge to participants that reads, “Participants will propose an action plan to mitigate damage from derelict fishing gear and reduce impact on marine species and the environment.” Your focus is derelict fishing gear. We are not here to talk about land-based sources; we are not here to talk about plastic bags. We are not here to talk about stuff that falls from the sky or washes down the rivers. Derelict fishing gear is a very real problem. It is one of the unsolved problems from twelve years of fairly energetic attention by an awful lot of people on the whole marine debris problem. But first, please bear with me for a few minutes while I summarize what I perceive to be the key challenges to progress on the overall marine debris problem. It's a short list and you may want to jot these down. I will return to derelict fishing gear in a moment.

Land-Based Sources

Worldwide, the majority of persistent wastes entering marine and aquatic systems emanates from land-based sources. We all need to recognize, prior to and during World War II, a huge amount of research and development took place. It resulted in the birth of an entire industry and the source of an entirely new collection of materials with vast, vast, practical implications. These materials are plastics. Because many of them are highly persistent, because they are cheap, because they are easier to use, because they are better than their natural alternatives, and because their uses are expanding, they are accumulating in the environment. I recall that about eight years ago the annual production of virgin plastics was on the order of 50 billion pounds a year, that's billion with a "B" and it is now probably 80 to l00 billion pounds per year. Production depends to some degree on the price of oil. I do not have an estimate of how much of it ends up as waste, but it's a pretty serious proportion, and as Mayor Harris pointed out, the urbanization of the global population results in an ever-increasing dependence on these synthetic materials. As people get further and further away from a rural culture-further and further away from the farm-they get closer to the supermarket and extensive dependence on plastics. I apologize for the digression. My general point is that waste management is not keeping pace with development. This is the largest and most problematic challenge to controlling marine debris.

Port Reception Facilities

Port reception facilities for vessel-generated wastes are lacking worldwide. They are required in most of the developed world, but not everybody uses them and they are not necessarily convenient or cheap to use. Much of the world does not have adequate port-based waste management infrastructure. When ships bring wastes back to port, what happens? It often goes directly or indirectly back into the water.

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National Will

Imagine if you will, a target, the bull's-eye being the focus of national will. Despite the fact that most people think marine debris is a bad thing and should be solved, it is my consistent observation that this issue never occupies the bull's-eye. It rarely ever falls dead center in the attention of nations or the will of a mass of people who have the desire to do something about it. After twelve years of trying to jawbone agencies, countries, industries, and people to work on this issue, you learn that marine debris is not a top priority. So national will is something that needs to be considered. What do you do about it? We didn't solve it before and I don't know what to do about it now. It is one of the most outstanding problems in addressing marine debris.

Derelict Fishing Gear

Finally, in my short list of unfinished business, we come (back) to derelict fishing gear. Consider this, and if you don't agree with these percentages, you can raise your hand and I'll ignore you. It is more or less accepted that 80% of the persistent debris of the ocean environment comes from land-based sources. That means 20% comes from maritime sources. You have cruise ships, transport vessels, military vessels, ferries, and you have fishing boats. For argument's sake let us agree that 10% of the maritime debris comes from fishing boats. That means about 2% of the persistent marine debris in the ocean comes from fishing boats.

Now we look at fishing gear versus other persistent gear that comes from fishing boats. If half of the persistent waste that comes from fishing boats is actually fishing gear, then 1% of the total marine debris is fishing gear. There is another step here. Fishing boats don't throw good fishing gear over the side. When they have waste fishing gear, they have a choice to retain it on board or jettison it illegally-a voluntary contribution to the debris problem. Fishermen also lose their gear in the legal act of fishing-an involuntary contribution to the debris problem. Clearly the voluntary contribution is fully addressed under MARPOL Annex V and its domestic implementing legislation and may consist of of $^1/_2$% of 1% of marine debris. The other $^1/_2$% of marine debris is derelict fishing gear, the target of this conference.

Fishing gear is capital equipment and it's legal to fish. Under the right regulations and circumstances you can go fishing and risk your capital equipment (gear) to catch some fish. If you are right, you make some money. If you are wrong, you may lose your gear and not be able to recover it. It could stay right where it was lost or it could float around in the North Pacific and end up in the Northwestern Hawaiian Islands. I do not mean to minimize the importance of derelict fishing gear as a marine debris problem. It clearly is the most biologically threatening of the debris types. In the North Pacific, where sea turtles, seabirds, corals, and the last monk seals on earth are at risk, it is a high priority problem.

PRESENTATIONS

Besides, quite obviously, 100% of the derelict fishing gear in the ocean comes from fishing vessels. Therefore, as a practical reminder, I would like everyone to write these two phrases down, “voluntary sources” and “involuntary sources” of derelict fishing gear. These are two very different problems. The involuntary source problem is really tough. We made very little progress on this during NOAA's twelve-year program.

In considering the approaches for dealing with the involuntary sources of derelict fishing gear, I am reminded of Shirley Laska's work on technical interventions for controlling marine debris. She showed us that we have two distinct options, intervention and remediation. Please jot these terms down as they may help you organize your action plan. Remediation is what you do after the derelict gear has done its damage. For example, the rehabilitation of entangled monk seals or sea turtles is a type of remediation. Intervention is the suite of activities that may reduce or eliminate the threat of damage by marine debris. The options for intervention in the generation and distribution of derelict fishing gear range from changing the risk-taking calculus of fishermen or potential fishermen; engineering harder to lose, easier to recover gear; recycling systems for recovered gear; bounty systems and bonds, etc. to actively gather derelict gear at sea. Choosing when and where it will be efficient to intervene is the greatest challenge you face-it presumes you know the details of fishing gear design and operation, the incentives of fishermen, the hazard profiles of each gear type in each environment, and the legal, economic, and social context of each fishery. As with all truly worthy problems, the devil is in the details.

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CONCLUSION

The final challenges are really pretty simple. To illustrate, if your full-time job is to deal with marine debris, please raise your hand. Out of about 200 people gathered at a conference on marine debris, we have just one person whose full time employment is focused on marine debris! Everybody is a member of the movement, but nobody is responsible for making progress—this is a particularly sad state of affairs. Take out your pencils and write down this question, “Whose job is it?” There is no one in Japan, no one in Turkey, no one in Australia. You may want to jot down the corollary question, “Who pays for it?” There is about $38 billion in the Heinz Trust, is there any for marine debris? There is about $6 billion in the Pew Trust, is there any for marine debris? There is $3 trillion or so in the U.S. federal budget that used to include $750,000 for marine debris; it's gone. I repeat, “Who pays?” And the final question we all should ask and answer is “What constitutes success?”

You have chosen to tackle a very real problem. If it were an easy one, we would have solved it years ago. I encourage all of you to actively participate in the conference workshops. Revisiting the issues may help you and questions I asked you to write down. I firmly believe that your work this week and in the future will revitalize the movement and make real progress in tackling derelict fishing gear.

Mahalo, thank you for listening and good luck with the tasks before you.

v Transcribed from a speech given August 7, 2000.

ORIGINS, TYPES, DISTRIBUTION, AND MAGNITUDE OF DERELICT FISHING GEAR

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Prior to beginning my formal presentation, I would like to take a moment to give special recognition to my other marine debris hero here today, besides Captain Terry Rice. He is somebody locally we all know, or know of, because he is the one who is always there removing marine debris, always taking the critical photograph, always remembering to have a video camera handy, always doing the right things. More than anyone else, he helped us identify the marine debris problem in the Northwestern Hawaiian Islands. Since he is generally soft-spoken, certainly modest, and does not frequently come up on stage, I'd like to introduce him to those here who do not know him except by his photographs and videos. He is, of course, Ray Boland. Ray please stand. Everyone, please join me in giving him a hand for his outstanding contributions. Thank you very much.

Intended as an introductory overview, my talk today will instead be a concluding overview describing some of the source fisheries around the Pacific basin, their gear types, and some of the oceanographic mechanisms responsible for the eventual distribution of derelict fishing gear.

BACKGROUND

Prior to the 1950s, most fishing gear was composed of natural fibers and fabrics such as manila, jute, sisal, hemp, cotton, and linen. These natural fibers were highly susceptible to environmental degradation and did not last very long in the marine environment. If they were lost, they generally degraded quickly and therefore did not pose a long-term ecological threat. With the introduction of synthetics to the fishing industry in the late- 1940s and 1950s, this started to change quite rapidly. By 1964, 95% of nets produced in Japan were of synthetic origin, and presently almost all commercial fishing gear is composed of synthetics. One of the principal advantages of synthetics is their high resistance to

environmental degradation. This resistance allows these materials to persist much longer in the marine environment and therefore poses the potential for long-term ecological damages.

Although most of our experience focuses on the impacts and problems of derelict fishing gear found entangled on the coral reefs and beaches of the Northwestern Hawaiian Islands, marine debris and derelict fishing gear pose similar problems throughout the Pacific, and indeed, the global ocean. As with many other areas, the derelict fishing gear found accumulating in the Northwestern Hawaiian Islands rarely originates from local fisheries. In this area, the only fisheries are small-scale bottom-fishing and lobster trapping activities, and pelagic longlining outside a 50 mile protected species zone surrounding all of the islands. Instead, the derelict fishing gear recovered in the Northwestern Hawaiian Islands originates from fisheries throughout the North Pacific Ocean and even the entire Pacific basin. The Northwestern Hawaiian Islands are not unique in this respect. Derelict fishing gear, no matter the location of the source fishery, will accumulate wherever the ocean currents take it. Of the derelict fishing gear found in the Northwestern Hawaiian Islands, surveys over the past four years show that the highest percentages of derelict gear consist of bottom and midwater trawl nets, pelagic and coastal driftnets, set nets and other gillnets, and miscellaneous line. Purse seine, troll, and longline gear is also found but the amounts are generally low.

PACIFIC FISHERIES AND GEAR TYPES

In order to discuss where derelict fishing gear originates, we first describe briefly and simply the types of fishing gears used around the Pacific basin and, in general terms, where the fisheries operate.

Trawling

Bottom trawl fisheries tow or drag large nets over the bottom to capture demersal fish in water depths from very shallow to depths as great as 350 fathoms. These fisheries occur primarily in areas with extensive continental shelves, such as the Bering Sea and much of the nearshore waters off the Pacific coasts of the Americas and the Asian continent. Bottom trawl gear is occasionally lost accidentally as the gear becomes entangled or snagged on the bottom. Since these nets are quite expensive (~$50,000 U.S.), fishermen try to avoid areas likely to foul their gear. Only when bottom trawls are irreparably damaged might a trawler consider purposeful discarding of nets. Midwater trawling uses similar gear, but the tows are conducted above the bottom and target midwater species. These fisheries also occur principally in productive coastal waters of the continental shelves around the Pacific Rim. The risks of loss of midwater gear are significantly decreased since the gear is not intended to encounter the bottom. Both bottom and midwater trawling gear remains attached to the vessel at all times.

Gillnets

Gillnets of various types are used to entangle fish and other marine species that inadvertently swim or drift into their relatively invisible mesh. Gillnets consist of a vertical curtain of nearly invisible mesh across a waterway. As such, gillnets represent a very efficient, but not very discriminating, fishing gear. This efficiency led to a significant pelagic driftnet fishery upon the high seas of the Pacific Ocean until public concerns over their indiscriminant fishing and high incidental catch rates led to international bans. Data from Japanese, Korean, and Taiwanese driftnet fisheries prior to the bans show that much of this fishery focused on the subtropical and subarctic fronts of the central North Pacific Ocean between the latitudes of 35° N and 45° N. These data show that the large mesh Japanese driftnet fishery occurred right up to the 200 nautical mile U.S. Exclusive Economic Zone surrounding the Northwestern Hawaiian Islands, where high numbers of large (~4,000 lb.) derelict driftnets are found fouled on the coral reefs and beaches. Many of the large pelagic driftnets lost during the heyday of the high seas driftnet fishery of the 1970s and 1980s appear to be still circulating around the ocean gyres. Although there remain reports of continued high seas driftnet fishing, this form of fishing has decreased significantly since international bans went into effect. Since driftnets are set free of their vessels, loss rates were sometimes quite high, particularly in areas with harsh weather or strong current shears. Coastal driftnets and set nets are still frequently used along coastal waters around the Pacific Ocean. Although these smaller nets are easier to keep track of than high seas driftnets, they are nevertheless occasionally lost or fouled upon the bottom.

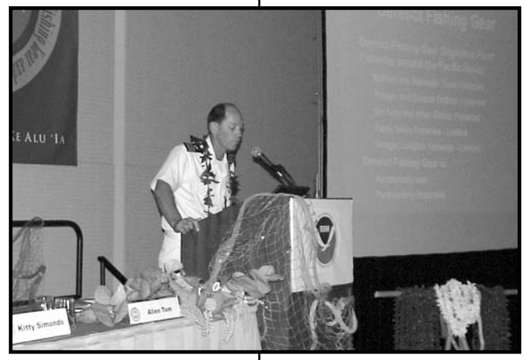
Troll, Purse Seine, Trap, and Longline Fisheries

Other major fisheries of the Pacific Ocean, such as troll, purse seine, trap, and longline fisheries, appear to make only a relatively small contribution to the derelict fishing gear problem. Troll fisheries tow lines with baited hooks or lures behind small vessels. The amount of gear lost from troll fisheries and the impacts of this lost gear are considered relatively small.

Purse seine fisheries attempt to surround schools of fish, predominantly tunas and other pelagic fishes, with large vertical curtains of the seine net and then close or purse the net around the encircled fish. Although the purse seine fishery is now again very large and expanding throughout much of the tropical Pacific Ocean (after lengthy closures of the fisheries due to concerns about dolphin takes), it is highly unlikely for fishermen to lose this gear since the net remains attached to the vessel throughout the fishing operation and the costs of the nets are very high. It is not unreasonable to assume that derelict purse seine nets or pieces of nets are likely to have been purposely discarded only after significant degradation or damage. In recent years, much of the purse seine fleet in the Pacific has set their nets around floating or moored fish aggregating devices.

ORIGINS, TYPES, DISTRIBUTION, AND MAGNITUDE OF DERELICT FISHING GEAR

Trap fisheries of many different types target lobsters, crabs, fish and other species. Although each trap fishery is different, most consist of setting baited traps or strings of traps along the bottom with surface buoys to mark their position for retrieval. Since trapping is predominantly a bottom fishery utilizing negatively buoyant traps, lost traps generally pose a local ecological threat as contrasted with the other more buoyant gear types that freely drift with the ocean currents when lost. The lines and floats used for gear retrieval, however, are sometimes lost and become a part of the derelict fishing gear more widely distributed around the Pacific Ocean.



Bob Rock, Marine Debris Communications Committee

CDR Rusty Brainard (NMFS) delivers information on the origins of derelict fishing gear.

The large pelagic surface monofilament longline fishery utilizes long lines (10 km-100 km in length) of baited hooks segmented with surface floats or buoys along the line to maintain desired fishing depths of the gear and to mark the location of the line for retrieval. This extensive fishery targets numerous highly migratory species such as tunas and billfish from 40° N to 40° S across the entire Pacific basin from west to east. Although longlining gear is sometimes both lost and discarded, most of the derelict longline gear tends to sink to the abyss, where impacts are poorly known. Lost floats and float lines would, of course, stay at the surface and become part of the floating derelict gear circulating with the ocean currents. Longline fishing gear does not represent a large percentage of the derelict fishing gear found during surveys in the Northwestern Hawaiian Islands.

Summarizing fisheries, there are many different types of fishing gear used throughout the Pacific Ocean. As one might expect, the types of gear most prone to accidental loss, such as bottom trawls and driftnets, are the most common types found during surveys of derelict fishing gear in the Northwestern Hawaiian Islands. In the case of trawl gear, the remote origin is particularly clear since there are no trawl fisheries within thousands of kilometers of the Northwestern Hawaiian Islands. The fact that the most common types of derelict fishing gear found are also the most likely to be lost supports the hypothesis that fishermen, in general, do not want to lose their gear. Fishermen are at sea to earn a living and cannot afford to lose expensive gear. Unfortunately, cost considerations may also be the reason that some fishermen do purposefully discard irreparably damaged gear. Very few harbors around the Pacific basin provide cost-effective means for discarding damaged gear. Some ports do not offer any means for legally discarding gear, particularly large nets. For fishermen barely making financial ends meet, it is not surprising that some might succumb to the temptation to reduce high shoreside disposal costs by discarding worn out nets and gear at sea. One obvious solution to this aspect of the problem would be for coastal states to support port disposal facilities and work to encourage fishermen to dispose of their waste properly.

PRESENTATIONS

DISTRIBUTION AND MAGNITUDE

Once lost or discarded, each type of gear poses different ecological threats. Negatively buoyant gear, like traps, longlines, and some weighted or snagged bottom trawls, sink to the bottom and become localized threats. Positively buoyant gear, like trawls, driftnets, and seine nets, are more likely to circulate with the ocean currents and be distributed from the region of their source fishery to regions far removed. On the surface, much of this gear continues to entangle and entrap fish, marine mammals, birds, and other species. At the surface, this derelict gear also poses a serious navigational and safety threat to vessels of all sorts.

There have been numerous methods of estimating amounts and distributions of marine debris and derelict fishing gear over the past two decades. In general, these methods can be simplified into the following categories: visual beach surveys, visual shipboard surveys, shipboard trawl surveys, diving surveys, and aerial and satellite remote sensing reconnaissance.

Beach Surveys

Beach surveys for derelict fishing gear are often a cost-effective way of providing valuable information on the prevalence of derelict fishing gear and for monitoring trends (Ribic et al., 1992). Beach surveys of derelict fishing gear in the Northwestern Hawaiian Islands from 1982 to 1999 were completed in conjunction with studies on entanglement rates of the endangered Hawaiian monk seal and show no decline in the amount of derelict fishing gear on these remote beaches (Henderson, in review). In association with the beach surveys of 1999, 12,500 pounds of derelict fishing gear was removed from the beaches of just two islands of the Northwestern Hawaiian Islands (Donohue, unpublished data). Slip and Burton (1991) reported that derelict fishing gear accounted for 29% of the debris found on the beaches of Macquarie Island in the Southern Ocean, despite the fact that this area does not support a regional fishery. In Australia, derelict fishing gear accounted for 2%-41% of the total debris on beaches (Slater, 1991; Edwards et al., 1992; O'Callaghan, 1993; and see Jones', 1994 review). Derelict fishing gear is also a notable component of beach surveys for marine debris in Mexico (Coe et al., 1996).

Shipboard Surveys

Shipboard sighting surveys for the assessment of marine debris distribution and amount consist of visually inspecting the ocean surface for floating debris. This method is particularly suited for medium to large derelict fishing gear items (see Ribic et al., 1992 and Hess et al., 1999), and requires dedicated or opportunistic vessels, good visibility, and favorable weather. Observers stationed on the flying bridge or other elevated sections of the ship visually search for debris items in strip or line transects. During strip transects, debris

items are counted on the side of a ship within a specified distance, commonly ranging from 50 m (Day and Shaw, 1987; Day et al., 1990a) to 100 m (Dixon and Dixon, 1983). During line transects all debris items visible are counted regardless of their distance from the ship. When the perpendicular distance of the objects to the ship can be accurately measured, the line transect method is preferable (Ribic, 1990; Burnham et al., 1985). Platforms of opportunity are often used as a result of cost constraints, thus the sampling area, height of the observer above the water, ship speed, etc. may not be controlled by the researcher. These factors affect the accuracy of the assessments (Mio and Takehama, 1988; Ribic et al., 1992). Furthermore, as the characteristics of the debris (size, color, buoyancy, and shape) affect its visibility to surveyors, accurate characterization of debris is not readily accomplished (Mio and Takehama, 1988).

Despite these challenges, numerous informative sighting surveys have been completed. Dedicated vessels combined with vessels of opportunity have been used in Pacific-wide surveys conducted by the Fisheries Agency of Japan from 1986 to 1991 (Matsumura and Nasu, 1997). Matsumura and Nasu (1997) reported derelict fishing net density to be relatively higher in the area of 20° to 30° N, 150° to 130° W of the eastern Pacific Ocean. They also noted a high density of derelict fishing nets on the Pacific Ocean side of Japan from 30° to 40° N, 140° to 150° E. The distribution of derelict fishing gear, other than nets, was found to have a wider general distribution, with the greatest densities (greater than 120 pieces per 100 square nautical miles) found from 25° to 35° N, 130° to 180° W. Mio et al. (1990) and Mio and Takehama (1988) previously reported a high-density area of derelict fishing nets northeast of Hawai'i during sighting surveys conducted in 1986. Day and Shaw (1987) also completed a multiple-year study in the Gulf of Alaska in 1984 and 1985. Other baseline studies have been conducted in the North Pacific (Dahlberg and Day, 1985; Ignell, 1985; Jones and Ferrero, 1985; Ignell and Dahlberg, 1986; Day et al., 1990; Shaw, 1990). Additional regional sighting surveys were conducted around the Pribilof Islands in the Bering Sea (Yoshida and Baba, 1985; Baba et al., 1988, 1990).

Trawl Surveys

Shipboard trawl surveys can be used to survey marine debris on the surface of the water or on the seafloor. Neuston-type nets can be used to sample small floating marine debris and larger nets can be deployed to sample debris that has sunk to the benthos (Ribic et al., 1992). The latter are useful for the assessment of medium to large derelict fishing gear items. Trawling techniques mimic those used for fishing, with the net deployed to sample or "catch" debris resting on the seabed (see Ribic et al., 1992). The mesh size of the net used determines the minimum size of debris that may be caught. Trawl sampling studies may be conducted opportunistically in association with commercial, experimental or managed

fisheries or with dedicated cruises targeting marine debris. The common occurrence of marine debris in benthic trawls on the continental shelf of the Northeast Gulf of Alaska was reported as early as 1976 (Jewett, 1976). Bering Sea fishing areas were also found to have greater amounts of benthic debris than areas not fished (Feder et al., 1978). More recently, Hess et al. (1999) investigated fishery-related items caught during benthic trawls to survey crab and groundfish resources around Kodiak Island, Alaska. In the three years of their study, fishery-related items comprised 46%, 42%, and 38% of the total benthic debris recovered. Fishery-related debris densities ranged from 4.5-25.0 items/km2. The debris densities reported by Hess et al. (1999) were between those reported by June (1990) for the Eastern Bering Sea (2-7.5 items/km2) and off the Oregon Coast (150 items/km2). Although shipboard trawl surveys have been used most extensively for surveying benthic marine debris, they cannot be employed in very shallow waters, on steep slopes, or in sea canyons.

Diver Surveys

Other methods investigated or proposed to survey benthic marine debris involve submersibles, towed camera systems, and divers. The cost and availability of manned submersibles and remotely operated vehicles (ROVs) have limited their use in marine debris surveys (Ribic et al., 1992). Divers can execute surveys for derelict fishing gear in areas too shallow to employ submersibles or ROVs, and where seabed topography restricts trawl surveys (Ribic et al., 1992). Furthermore, divers can remove derelict fishing gear from the substrate in a surgical fashion, reducing additional environmental damage to reefs during removal. Small vessels towing divers can be deployed from ship platforms at oceanic sites or from land-based laboratories for coastal surveys.

A large-scale project utilizing divers to conduct surveys for, and remove, derelict fishing gear in the Northwestern Hawaiian Islands began with a NMFS pilot study in 1996 (Boland, unpublished data). In 1996 and 1997, diver survey and removal techniques were refined allowing the removal of 10,000 pounds of derelict fishing gear from the shallow coral reefs. In 1998 and 1999, NMFS efforts were significantly expanded by partnering with a consortium of state, federal, and private organizations. The distribution, density, type, and organic fouling of derelict fishing gear were documented using snorkel divers towed in systematic parallel track survey transects behind small boats. Derelict fishing gear is subsequently recovered using small boats and snorkel and scuba divers. To date, over 77,000 pounds of derelict fishing gear has been recovered from the Northwestern Hawaiian Islands through these efforts (Donohue, unpublished data).

Oceanography and the Role of Remote Sensing

Once floating derelict fishing gear enters the ocean, it continues to circulate around the Pacific basin with the ocean currents until it either fouls upon shallow reefs or banks or eventually degrades. Due to the resistance of modern synthetics to degradation, it is believed that some derelict fishing gear continues to circulate with the currents for years or decades. In order to evaluate distributions of marine debris, it is therefore useful to examine the circulation patterns of the upper ocean. Looking at maps of the general circulation of the Pacific Ocean in general navigation or oceanography references, the upper ocean currents seem very simple and predictable. There are large-scale oceanic gyres with clockwise flow around the North Pacific and counterclockwise flow around the South Pacific (figure 1). Various currents around the Pacific are given names and appear to be well known.

In the long-term mean, these current maps are probably nearly correct. However, at shorter and shorter time scales from years to months to days, the motion of the upper ocean is now known to be extremely complex, with many different time and space scales of variability (figure 2). Oceanographers often track upper ocean currents using satellite-tracked drifters. These drifter tracks tell us that any particular piece of marine debris will not follow the mean circulation patterns, but will instead follow a complex trajectory driven by the combined effects of wind-driven currents, wave-driven currents, and thermohaline or density-driven currents. Kubota (1994) utilized a simplified numerical model to track virtual drifters (marine debris) around the North Pacific by computing these three types of currents. He forced the model using monthly climatological conditions (i.e., long-term mean January, February, etc.) of the ocean and atmosphere at relatively large spatial scales. After running the simulation for five years, his model found accumulation of marine debris in the region north of the Hawaiian Archipelago, where shipboard sighting surveys had found the highest accumulations of marine debris.

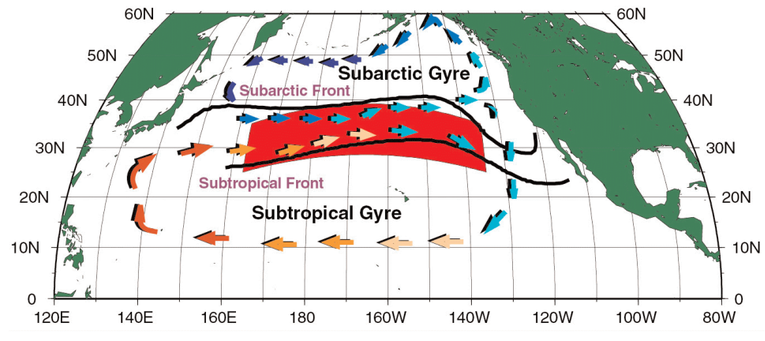
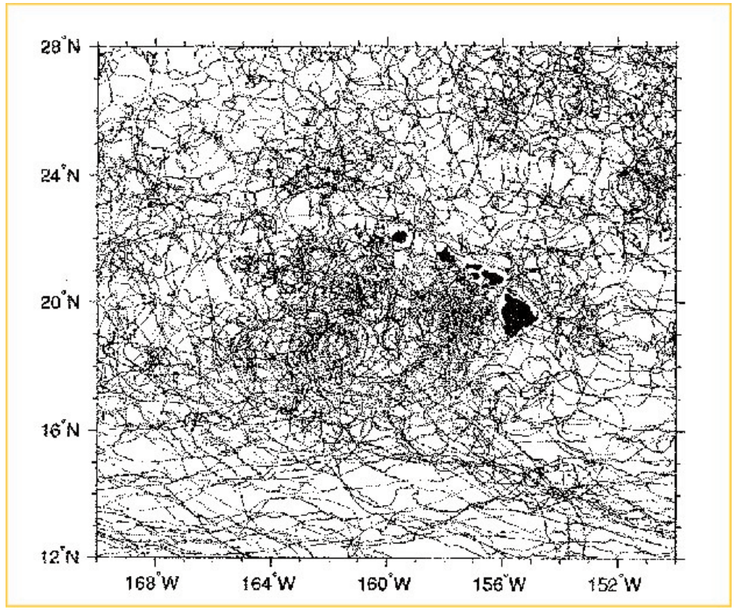


Figure 1
General ocean circulation patterns of the North Pacific

Figure 2
Composite diagram of satellite-tracked surface drifter trajectories around the Hawaiian Islands (Qui et. al, 1997).



More recently, we have been investigating the utility of remote sensing to monitor and assess marine debris. We have been developing methods to apply knowledge of oceanographic processes and use of satellite remote sensing of ocean surface properties to identify and monitor regions where derelict fishing gear and other forms of marine debris would most likely accumulate (Brainard et al., 2000).

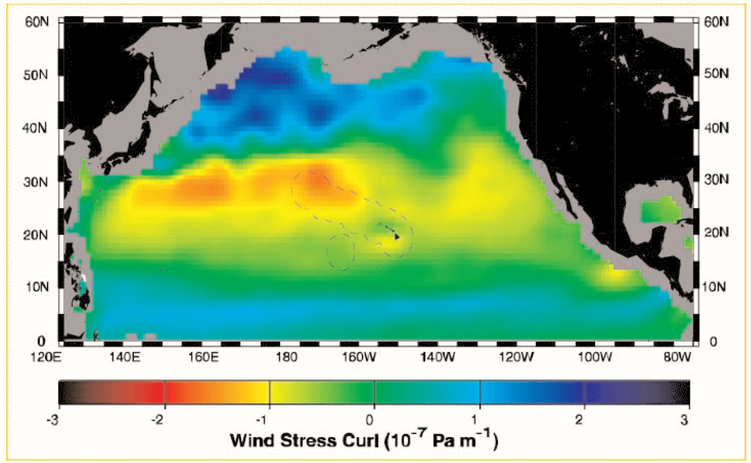


Figure 3
Climatological wind stress curl for Boreal winter (January-March). Regions of negative wind stress curl (red colors) indicate ocean convergence.

Using an array of satellite environmental sensors, oceanographers are now able to observe properties of the ocean surface with much improved spatial and temporal resolution. These properties include surface winds (QuikSCAT and other scatterometers), sea surface temperature (AVHRR and GOES), sea surface height and computed geostrophic currents (TOPEX/Poseidon), and ocean color or chlorophyll (SeaWiFS and earlier CZCS). With these modern tools, scientists are now better prepared to assess the extent of the threat posed by marine debris over the vastness of the global ocean.

Using high-resolution scatterometer winds to compute wind stress curl over the Pacific Ocean, we (Brainard et al., 2000) have confirmed and expanded upon Kubota's (1994) finding of a marine debris accumulation region centered north of the Hawaiian Islands (figure 3). Regions of oceanic convergence are most likely to accumulate marine debris while regions of oceanic divergence are least likely to accumulate marine debris. We have found regions of oceanic convergence to be highly nonstationary with pronounced seasonal and interannual variability. Convergence in the North Pacific is highest along the subtropical front in the western half of the basin during the winter months. In the vicinity of the

Hawaiian Archipelago, accumulation would be expected to be highest to the northwest and lowest to the southeast. During the summer, convergence is generally much weaker and more diffuse across the North Pacific with the region of highest convergence shifted to the eastern portion of the ocean basin several hundred miles off the California and Oregon coasts. The region of high convergence, or likely accumulation of marine debris, is strengthened and enlarged during periods identified as El Niño warming events in the tropical Pacific. During the 1992 and 1998 El Niño events, the region of convergence was observed to expand much further south to include the main Hawaiian Islands. This result partially explains the documented increase of marine debris found on beaches and reefs of the main Hawaiian Islands during 1998 (Brainard et al., 2000).

Presently, oceanographic knowledge and satellite observations of ocean conditions are being used to assist marine debris removal efforts by helping to locate areas in the Northwestern Hawaiian Islands and elsewhere that are most likely to have the highest concentrations of marine debris. From an oceanographic viewpoint, the coral reef ecosystems at Kure, Midway, Pearl, and Hermes Atolls are expected to have the highest average encounter rate of marine debris since these areas are more centrally located in the strongest mean convergence zone. Of course, bathymetry, reef structure, and local processes such as small-scale flow regimes and wave forcing also play a significant role in entangling debris on coral reefs and beaches.

These oceanographic analyses suggest that much lower accumulation rates of derelict fishing gear and other marine debris would be expected at most of the other tropical islands and atolls of the Pacific. Exceptions include the Japanese islands of the Ogasawara Archipelago, Kazan Group, and Minami-Tori, where moderately high accumulation rates might be expected. The same analysis predicted very low accumulation of marine debris in the U.S. Line and Phoenix Islands of the central equatorial Pacific; this was verified during a coral reef assessment cruise to these islands in March 2000 (Brainard et al., 2000b). A similar analysis is currently underway for the entire Pacific basin. Preliminary results indicate that wind-driven ocean convergence is less intense in the South Pacific Ocean. However, there appear to be broad regions of moderate ocean convergence, which may play a significant role in the transport and accumulation of marine debris. The utility of oceanographic analyses in other oceans to direct marine debris removal efforts should be investigated.

Michael Parke of NMFS Honolulu Laboratory is presently beginning a study to evaluate the effectiveness of using IKONOS satellite images to identify and quantify derelict fishing gear in the Northwestern Hawaiian Islands.

The IKONOS imagery is available with 1 m panchromatic and 4 m multi-spectral resolution. If he is successful in identifying individual pieces of derelict fishing gear, which are often much larger than the 1 m panchromatic image resolution, this new technology could greatly improve the efficiency of efforts to locate and remove marine debris from the coral reefs and beaches of the Northwestern Hawaiian Islands and elsewhere.

At-sea Removal

The removal of derelict fishing gear at sea, before it encounters reefs or damages wildlife, may be the most advantageous mitigation action once debris enters the marine environment. An ambitious proposal by the NMFS Honolulu Laboratory aims to investigate the feasibility of such efforts. Once the majority of the derelict fishing gear is removed from the coral reefs and beaches of the NWHI, Honolulu Laboratory scientists are proposing a comprehensive multi-agency program to begin removing derelict fishing gear at sea. By so doing, they hope to prevent much of the ecological damage that is now threatening the coral reef ecosystems and protected species of the region. This plan takes advantage of the fact that ocean currents and convergence processes do an efficient job of accumulating marine debris from around the Pacific Ocean into relatively well-defined zones. Combining satellite observations of winds, sea surface temperatures (SST), ocean color, and sea surface height, they believe they can identify general regions to direct aircraft and ships to interdict debris at sea. These regions of highest convergence would be along frontal zones of the order 100 km by 1000 km. These scales are well covered by satellite-based measurements. However, the oceanographic tools (e.g., SST, ocean color, and wind) are useful only for inferring likely positions; they do not have sufficient resolution to image the actual debris. The study by Michael Parke to investigate use of IKONOS imagery, if successful, could be expanded to evaluate whether this imagery could be used to identify individual large pieces of debris at sea. We also propose to evaluate the use of aircraft equipped with synthetic aperture radar (SAR) and/or hyper-spectral visible light sensors. These instruments should allow us to resolve scales less than 1 m, allowing individual pieces of derelict fishing gear on the ocean surface to be mapped. This information would then be transmitted to surface debris removal vessels. If provided with maps of areas of highest concentration, the vessels could then use helicopters to guide them to individual derelict fishing gear items for at-sea removal. Although this multi-level scenario presently may seem costly, at-sea removal would potentially be no more expensive per ton of debris removed than the existing methodologies and would have the significant advantage of removing the debris before it damages the coral reef ecosystems.

SUMMARY

In summary, derelict fishing gear in the Pacific Ocean originates from many types of fisheries throughout the Pacific basin. Based on surveys of derelict fishing gear in the Northwestern Hawaiian Islands, trawl fisheries and gillnet fisheries, particularly driftnets, appear to be the most dominant forms of derelict fishing gear found. This is not surprising since these two fisheries would be expected to have the highest rates of accidental gear loss. Preliminary evidence suggests that in addition to accidental gear loss, some derelict fishing gear appear to be purposefully discarded. Estimates of the magnitude of derelict fishing gear are based on beach surveys, ship-sighting surveys, trawl surveys, diving surveys, oceanographic observations, and satellite remote sensing. These surveys reveal that the ocean currents tend to accumulate marine debris in oceanic convergence zones. Using the combined information from surveys, oceanographic knowledge, and satellite and aerial remote sensing, future efforts to protect fragile coastal marine ecosystems by recovering marine debris from reefs and shoals, as well as at sea, will be greatly improved.

- Transcribed from a speech given on August 7, 2000

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ECOLOGICAL EFFECTS OF MARINE DEBRIS:
THE EXAMPLE OF NORTHERN FUR SEALS

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ABSTRACT

It is impossible to make a complete list of the environmental impacts of the current human population, a population that is a thousand-fold larger than the mean population of other similar-sized mammals. One set of influences has involved our use of the seas for food and the resulting changes in marine environments. Humans harvest fish at rates that are ten to one thousand-fold larger than the mean rates of consumption by other mammalian predators. Among the many consequences are the effects of the gear used. To accomplish harvests of such magnitudes we have developed new technologies, including the development and use of plastics to make nets. In spite of the durability of plastics, fragments of fishing gear are lost, torn away, or discarded. These fragments join debris generated elsewhere, including the effluents from rivers and streams that carry garbage lost or discarded in terrestrial settings, all of anthropogenic origin and destined to impact the marine environment.

Numerous studies have been published, and several symposia have been held, to characterize and measure the effects of marine debris. Plastics often accumulate in the digestive systems and cause the death of birds, turtles, and various filter feeding species. Many fish, birds, and mammals become entangled and die. This paper uses the effects of marine debris on northern fur seals (Callorhinus ursinus) that breed on the Pribilof Islands in Alaska as an example of the general problem of marine debris. Entanglement in marine debris by northern fur seals results in reduced growth rates, altered feeding behavior, injury, impaired maternal care, and mortality. The population level consequences of such factors were manifested in a decline that occurred in the late-1970s and early-1980s.

Much has been done to tackle the larger problem of marine debris. But if we were to consider all of the cases for marine species like that of the northern fur seal, studied or not, we would be left with an important question: Can we address the issues behind and beyond the problem of debris? They involve changes in the quality and quantity of food supplies, other aspects of fur seal population dynamics, and effects on other species. More research is needed and any conclusion regarding the effects of marine debris on any one species is not basis for neglecting research or management regarding other problems. Supporting the current human population results not only in the problem of marine debris, but in many other problems in both marine and terrestrial environments.

INTRODUCTION

Industrial fishing helps provide food for a human population that is well above the normal range of natural variation for population size among species of similar body size (Fowler and Perez, 1999). Having occupied more of the earth's surface than any other mammalian species, we rely on the fishing industry to supply significant portions of our food from the marine environment. Marine fishery harvests are being taken at rates that are one to three orders of magnitude more than the average consumption rates among other mammalian consumers of the same resources, mostly through commercial fishing (Fowler, 1999; Fowler and Perez, 1999; Fowler et al., 1999). Such harvests have numerous secondary or indirect effects, some of which show in the initial documentation of their effects on ecosystems (e.g., Pauly et al., 1998; Hall, 1999; Kaiser and de Groot, 1999). We have very little understanding of the consequences of such changes to the future of the various species involved, including ourselves. It is important to recognize that there are repercussions to what we are doing, especially those that may result in risks for future generations. These include the effects of the technologies that make such harvests possible.

One technology that has made it possible to harvest fish at current rates was the development of plastics, particularly those used in nets that were introduced in the 1940s and 1950s and became prevalent by the 1960s. Numerous review articles and books serve as sources of information about the effects of plastics in various environments, including their influence on various elements of the marine environment (e.g., Shomura and Yoshida, 1985; Alverson and June, 1988; Shomura and Godfrey, 1990; Coe and Rogers, 1997). Ghost fishing (Breen, 1990; Hall, 1999) has direct effects on species of economic interest as well as both their prey resources and predators. Entanglement and ingestion of plastic debris have been documented as factors contributing to the mortality of numerous species, including many marine turtles, sea birds, and marine mammals (e.g., Laist, 1997). Plastics from worn or discarded fishing nets are one of the main sources of debris involved in the entanglement of marine mammals.

Between the mid-1970s and the early-1980s the population of northern fur seals on the Pribilof Islands experienced a decline from which it has not recovered. This decline occurred a few years after a peak was observed in the portion of juvenile males seen entangled in the commercial harvest. Concern generated when the problem was first recognized and gave rise to a number of studies to examine the effects of marine debris on individual fur seals and attempts to measure the effect on their population.

The entanglement of northern fur seals is one of many examples of the kinds of environmental effects of a human population so abnormally large in comparison to other species. This particular effect is the result of the use of plastics in fishing, shipping, and other activities in support of this population and is one example of the many effects of commercial fishing in that regard.

EFFECTS OF MARINE DEBRIS ON NORTHERN FUR SEALS

Northern fur seals (as well as other pinnipeds around the world, Fowler, 1988; Laist, 1997) become entangled in marine debris of various types, nearly all of which ends up encircling their necks (with some around their heads or shoulders and upper bodies). Most is netting of various kinds (predominantly trawl net fragments, but also seine and gill net material), plastic packing bands, and twine or ropes of various kinds (see Fowler et al., 1994 and Stepetin et al. 2000 for an accounting of the kinds of items found on northern fur seals, and further references regarding this issue). Presumably, most of the entanglement occurs as a result of curious play with such materials (Bengtson et al., 1988) and is therefore a problem of greater consequence to younger seals than it is for the adults.

The history and details of the study of entanglement of northern fur seals, as summarized below, is documented in a variety of reports and documents, some of which are referred to in overview papers of Fowler (1987), Fowler et al. (1990) and Laist (1997). The monitoring of marine debris on northern fur seals continues (Stepetin et al., 2000), thus offering the opportunity for continued analysis in the future.

BEHAVIORAL EFFECTS

Being entangled in debris reduces the ability of fur seals to swim. Their activities are altered so that more time is required for finding food and for resting, resulting in less time for other activities such as returning to breeding colonies to nurse pups. In the process, feeding cycles and diving behavior are affected.

For example, Feldkamp et al. (1989) found that captive northern fur seals exhibited a marked reduction (75% for the circumstances of their study) in the time fur seals spend swimming when they are entangled (as compared to normal conditions with no debris to impede their movement through the water). Entangled animals spent more time resting (138% more in the Feldkamp study) than they did without debris.

Yoshida et al. (1990a) also conducted studies on captive northern fur seals in a marine aquarium and found that entanglement inhibited activity in general. In this study, debris of 1 kg and 2 kg masses were placed on two adult female fur seals and radio transmitters were attached with nylon harnesses, including one on a control seal. The behavior of all three seals was monitored with receivers that recorded their activity. Average total daily active periods were 9.6 h/day for the control, 4.1 h/day for the seal entangled in 1 kg of netting and 1.4 h/day for the seal in 2 kg of netting. Activity was similar among all three seals after removal of the debris.

Another behavioral factor affected by entanglement is the cyclic foraging patterns among both male and female northern fur seals. During the breeding season, females leave their breeding colonies to feed and then return to nurse their pups.

ECOLOGICAL EFFECTS OF MARINE DEBRIS:
THE EXAMPLE OF NORTHERN FUR SEALS

These are cycles that are repeated for a number of weeks after the pups are born (Gentry, 1998). A study of the effects of entanglement on females was conducted in 1985 (DeLong et al., 1988). Forty females were fitted with radio transmitters, all from the Zapadni Reef breeding colony on St. Paul Island in the Bering Sea. Twenty were entangled in 200 g pieces of trawl webbing of 23 cm mesh and the other twenty served as controls. These seals were then monitored continuously with a programmable receiver and chart recorder to determine whether they were present or absent from the breeding colony. Furthermore, visual scans were conducted daily between July 22 and October 13. The mean duration of the trips to sea for the entangled and control seals in this study is illustrated in figure 1. As can be seen, the feeding trips for entangled seals were roughly twice the length of those for the controls.

Similar work with juvenile males showed that they also exhibit altered feeding cycles (Bengtson et al., 1989). Cycle length was increased by being entangled, consistent with the results of studies on females, and more time was spent on land, an option probably not so available to females whose pups depend on them for food.

The diving behavior of entangled northern fur seals is also affected. For example, entangled seals do not dive as deep as they would otherwise. Bengtson et al. (1989) used data from time depth recorders attached to seals to compare the diving behavior of three entangled seals with that of three control seals, all juvenile males captured and tagged in 1986 on St. Paul Island. The debris on the entangled seals was, in all cases, less than 1 kg in weight. The results indicated that the entangled seals made about the same number of dives as did the control seals, but the entangled seals did not dive as deep as the controls did. When diving to any particular depth, the entangled seals spent more time during their dives than did the control seals. Thus, the depth and duration of dives was altered by being entangled, but no change in the frequency of dives was detected in this study. Entangled seals made longer and more shallow dives than seals without the effects of debris.

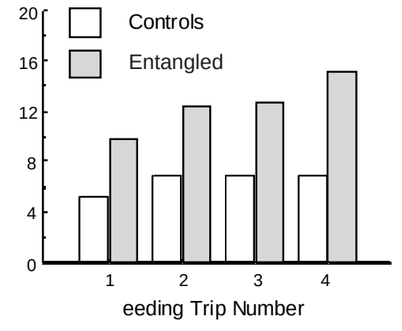

Figure 1
A comparison of the mean length of feeding trips for entangled female northern fur seals fitted with radio transm itters and for seals fitted only with radio transmitters, for the first four feeding trips in the study (from DeLong et al., 1988).

ENERGETIC DEMANDS

The energetic drain on seals caused by the drag of entangling debris is greater than the drag a seal experiences while swimming normally. Studies by Feldkamp et al. (1989) showed that fur seals of 4 to 17-months of age spent twice as much energy swimming at 1.1 m/s with 200 g of entangling trawl net compared to seals without debris. This is consistent with work on California sea lions (Zalophus californianus) in which it was shown that individuals entangled in 400 g pieces of net experienced a four-fold increase in energetic demands. As would be expected, both studies showed that energetic demands increase with swimming speed and the size of the entangling debris.

These conclusions are supported by the work of Yoshida et al. (1990b) who observed a decrease in swimming speed in relation to an increase in the size of entangling debris in their study with captive animals. Net fragments of six different sizes (0.5 to 3.0 kg) were placed on the necks of eight fur seals (two males, six females) in an aquarium and their swimming speed was recorded using visual observations of each individual while swimming over measured distances. Another measure employed in this study was that of the time required to capture fish. Consistent with the studies reported above, the time required increased in a relationship that was nearly a linear function of net size. The mean time to catch live fish for control seals was about 15 seconds whereas seals entangled in 3 kg of netting required an average of about 157 seconds. Thus, being entangled contributes to a decrease in foraging efficiency. Entangled seals spend more energy swimming, consume less in the time during which they forage, and have less energy available for swimming.

WOUND DEVELOPMENT

Of all the seals that get entangled, a few are entangled in debris that is sufficiently small enough for them to capture food, grow, and survive to be seen in studies to monitor entanglement. However, the resulting growth in body size of these seals produces pressure against entangling debris. The wear of movement, in combination with this pressure, results in growing wounds and infections. Fowler and Baba (1991) summarized the data on wound size for entangled male seals sighted in research on seals observed after 1983. Some of these seals were involved in studies in which the debris was purposely left on the animals (to estimate mortality caused by entanglement). Twelve entangled seals were initially sighted without observable wounds and then were resighted again in the following year. After one year of being entangled, three of these seals had no wounds, one showed the initial phases of wound development, and the remaining eight had full 360° wounds around their necks. Another eight had wounds that were less than 360° when first encountered and were then sighted on one or more occasions in subsequent years. All but one of these had developed full 360° wounds by the first (n = 5) or second (n = 2) year following the initial observation.

GROWTH RETARDATION

Based on the results of studies on energetics, it is no surprise that entangled fur seals either lost weight or there was a reduction in their growth rates; some of which may be attributable to the effects of wounds and infections caused by entangling debris.

Table 1 shows the weights of juvenile male seals taken in the commercial harvest of 1982 (Scordino and Fisher, 1983). The mean weights of all entangled seals with wounds were less than those for the controls (not entangled). In two cases, entangled seals with no wounds (ages two and three) showed mean weights less than the controls and in all cases the entangled seals with wounds showed mean weights less than entangled seals with no wounds. If there were no difference in growth, the probability of this combination of observed differences (or more extreme) occurring is less than 0.10. As reported in Scordino and Fisher (1983), there were cases in which entangled males were observed with very obvious stunted growth.

Table 1. Body mass (kg) of juvenile male fur seals of four different age categories taken during the commercial harvest of 1982, St. Paul Island, Alaska (from Scordino and Fisher, 1983).

	Age (years)			
Entanglement category	2	3	4	5
Controls	21.4	28.5	35.3	50.9
Entangled (no open wounds)	21.3	27.8	36.0	52.8
Entangled (with open wounds)	14.7	26.6	32.2	44.5

DeLong et al. (1988) also found indirect effects on the growth of pups whose mothers were entangled. In addition to monitoring the 40 adult females (20 entangled females and 20 control females), the pups from each of the two groups were also marked and weighed. The first weights for these pups were obtained in July at their first capture. Pups from each group were subsequently recaptured and weighed again in August and a third time in September. Pups nursed by control females gained a mean of 2.1 kg (n = 19) between the first and second weighing and 3.6 kg (n = 14) between the second and third. By comparison, the surviving pups of the entangled females gained an average of 1.2 kg (n = 12) and 2.2 kg (n = 7) for the same periods (figure 2).

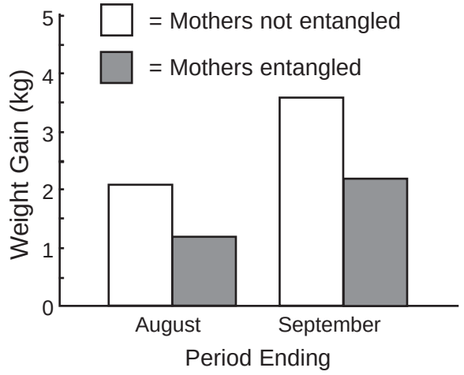

Figure 2
Comparison of the gain in mass observed from July to August, and from August to September, for two groups of fur seal pups: 1) those whose mothers were entangled (n = 12, 7), and 2) those whose mothers were free of entangling debris (n = 19, 14), (from DeLong et al., 1988).

MORTALITY

Individual northern fur seals die as a result of the effects of entanglement, as would be expected on the basis of the impacts reviewed above. Starvation, exhaustion, infection, greater vulnerability to predators, and diseases are all involved to one extent or another. Knowing this emphasizes the importance of assessing the extent of mortality rates, especially in view of its potential importance at the population level. Various studies have examined this issue for northern fur seals.

In the study by Delong et al. (1988), entangled females and their pups were monitored over the course of the 1985 season to determine the indirect effects of entanglement. DeLong et al. (1988) indicated that 3 out of 17 entangled adult female seals failed to return from their first trip to sea. Four failed to return after their second trip, and two more did not return after their third trip. Thus, over half (9 of the 17) failed to return within the first three trips to sea, a period of time less than about two months. By contrast, only one of the 20 control seals did not return, her failure occurring on the fourth trip to sea. Such observations can be explained either by behavioral changes or mortality. In either case the pups suffered higher mortality.

DeLong et al. (1988) conducted surveys and monitoring again in 1986 to test the hypothesis that adult female seals from the entangled group from the 1985 study would be resighted in the same proportion as seals from the control group. During weekly surveys conducted in July, August, and September of 1986, 12 females from the control group, and two females from the entangled group were resighted. Both of the females from the entangled group were animals that had lost their entangling debris during 1985; none of the 17 that retained their debris in 1985 were resighted in 1986.

DeLong et al. (1988) concluded that the females that did not return in 1985 either abandoned their pups or died at sea. Mortality probably prevented the observation of those not sighted again in 1986.

DeLong et al. (1988) also report significant indirect effects on survival of pups (before weaning and during the time that they depend on their mother's milk) that are attributable to the entanglement of their mothers. Of the pups born to the 17 females that retained their entangling webbing, only 6 were alive at the end of the study the first season, while 19 of the 20 pups from the control females survived. Thus, even when an entangled adult female is capable of returning to nurse her pup, the pup's chances of surviving are reduced.

Other studies of entanglement and its effects on the northern fur seal population involved juvenile male northern fur seals. Between 1985 and 1992, 153,850 juvenile male seals were sampled in surveys (referred to as roundups that involved sampling with replacement, Bengtson et al., 1988; Fowler and Ragen, 1990; Fowler et al., 1990; Fowler and Baba, 1991). Entangling debris was left on the sampled seals (n = 265) when they were encountered during the first three years of this study, and each entangled seal was tagged along with two control seals of similar body size. After the first three years, debris was removed from entangled seals when they were encountered. In years subsequent to the initial marking, the ratio of the proportion resighted for each group was used to calculate an estimated survival of both entangled and disentangled seals (Fowler et al., 1990). This survival was expressed as a fraction of normal survival (i.e., survival of the control seals). Figure 3 shows the declines in the portion of each group of seals resighted by year of recapture subsequent to their release.

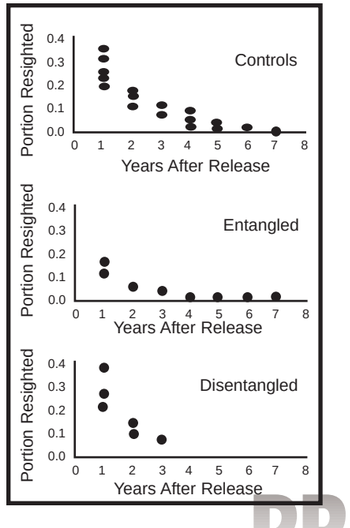

Figure 3
The fraction of seals resighted subsequent to release in samples from St. Paul Island, Alaska, from 1986 through 1992, that were never entangled (top panel), entangled (middle panel), or had entangling debris removed (lower panel), (updated from Fowler et al., 1999).

The relative rates of recapture clearly indicated a marked effect of entanglement on survival. Analysis of the data presented graphically in figure 3 resulted in an estimated survival for entangled seals that is about one-half that of the survival they would normally experience (an instantaneous mortality rate caused by entanglement of about 0.69, Fowler et al., 1990; Fowler et al., 1994). Disentangled seals experienced a survival about 93% of that for controls (Fowler et al., 1994), thus indicating that removal of debris has a marked effect in preventing mortality, but some residual effects of entanglement seem to remain, nevertheless.

POPULATION EFFECTS

Studies such as those above contributed to information to help measure the effects of entanglement among northern fur seals at the population level, and emphasized the importance of doing so. It became clear that the animals surviving to be observed in small debris represented only a small fraction of those that became entangled. Most had died and were never seen because almost all seals in larger fragments of net appeared to have either died or left the reproductive population after less than one year in the experimental studies reviewed above.

The timing of the decline between the mid-1970s and the early-1980s corresponded to a period during which the population effects of earlier entanglement would have been expected had there been population models such as were produced later (Swartzman, 1984; Fowler, 1982; Reed et al., 1987; French et al., 1989; Reed et al., 1989; French and Reed, 1990). This timing led to the concern that prompted the studies reviewed above and placed emphasis on examining population level effects in a variety of ways.

Several alternative approaches were employed to examine the degree to which mortality caused by entanglement has been influential in the dynamics of the northern fur seal population, especially that of the Pribilof population. These included: (1) various modeling studies; (2) several analyses of data on observed entanglement rates in correlation with population change; and (3) estimates of mortality rates caused by entanglement after accounting for various factors such as the unobserved entanglement and mortality involving large debris.

Modeling began with the work of Fowler (1982) where it was concluded that the effects of entanglement should be considered as a factor in the decline in fur seal numbers observed in the late-1970s. Swartzman (1984) and Swartzman et al. (1990) then developed models that showed the plausibility of mortality from entanglement as a primary cause of this decline. These models were more sophisticated than that of Fowler (1982) by including age structure (Fowler, 1987). Other modeling work (Reed et al., 1987; French et al., 1989; Reed et al., 1989; French and Reed, 1990) resulted in similar conclusions.

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They showed that entanglement-caused mortality could clearly account for population trends observed between the early-1970s and mid-1980s. This work also demonstrated the possibility that a decline in observed entanglement rates (even a 20% reduction) might result in a stabilizing of the Pribilof Islands population (the population has been relatively stable since the early-1980s following the peak in observed entanglement rates in the early- to mid-1970s). Thus, among the many alternative factors known to contribute to mortality, entanglement has been the only factor for which there was a demonstrable change with a magnitude and timing that corresponded with the decline. These modeling efforts clearly established the plausibility of entanglement as the primary factor contributing to the decline between the mid-1970s and early-1980s, keeping in mind that the effects of other factors continued to play their roles.

Other studies also support the conclusion that entanglement caused mortality was a primary factor in the decline of fur seals on the Pribilof Islands in the late-1970s and early-1980s. Some of these studies used information on correction factors to account for the variety of factors that prevent most mortality from being directly observed. These factors included age, to account for the fact that small entangled seals would not be seen (they could not return to the breeding islands if they were entangled and do not return under normal circumstances in any case). The most significant factor is the size of debris; as demonstrated in other work, seals entangled in large fragments of trawl netting cannot return to the islands to be observed during entanglement surveys. Further considerations involved the effects of sex, natural (nonentanglement related) mortality, and other characteristics of entangling debris (e.g., mesh size and type). Such factors were combined to estimate the mortality rate caused by debris within the fur seal population as a whole. These efforts resulted in an estimated entanglement-related survival of about 0.85 (an instantaneous mortality rate of about 0.16) among younger age groups. Thus, these studies indicate that there was an extra mortality rate of about 15% per year that was attributable to the effects of entanglement (Fowler et al., 1990). This estimate applied to conditions of an observed entanglement rate of about 0.4% among the juvenile males. The corresponding extra mortality of the higher entanglement rates observed in the early- to mid-1970s would be more than enough to explain the decline in population in the late-1970s. Such results added to the difficulty of ruling out the conclusion that entanglement was a primary factor.

Similar results emerged in studies of the correlation between the rate of change in the fur seal population and observed entanglement rates (Fowler, 1985; Fowler, 1987). The independent variable in most such studies was the entanglement rates observed a few years earlier when mortality would remove (or prevent the reproduction of) females that would normally have been recruited to the reproductive population. Figure 4 shows one such relationship, extended from earlier work to take advantage of more recent data and cover the period from 1967 to 1991 (for entanglement rates) and 1971 to 1996 (for rates of

change). Data after 1994 can not be used yet because rates of change beyond 2000 are not available. As predicted by earlier modeling work, the reduction in entanglement rates observed recently has corresponded with a relatively stable population (little change has been observed in the numbers of pups born in the Pribilof population of fur seals since the early-1980s). The entanglement rates observed in recent years have remained at about 0.2% (Robson et al., 1997; Stepetin et al., 2000), and such observation can be used in future correlative analysis when the corresponding rates of change are available.

The results of this component of studies on population effects of entanglement (as shown in figure 4) indicate that entanglement results in the equivalent of a mortality rate of about 15% spread over the entire population. This is seen in the difference between the rate of change at an entanglement rate of zero (8% per year increase) and that at the highest rates of observed entanglement (about a 7% or 8% per year decline).

Another correlative study looked at the mortality unexplained by the relationship between pup survival and juvenile survival (the first 20 months of life at sea, Fowler, 1985, 1987) between 1950 and 1965. This relationship appeared to break down in the late-1960s through the mid-1970s at a time when entanglement rates were observed to increase. Multiple correlation analysis resulted in an estimated additional mortality of 15% at an entanglement rate of 0.4%, again sufficient to have been the primary cause of the decline between the mid-1970s and early-1980s at the higher entanglement rates observed in the early-1970s. Other correlative studies are presented in Fowler (1985).

The consistency of results in the modeling work, the estimated mortality rates, and the correlation analyses led Fowler (1985, 1987) to conclude that the decline in fur seal numbers observed in the late-1970s, and the failure to recover in the early 1980s, can be attributed to the effects of entanglement. Much as the decline between the 1950s and late-1960s can largely be attributed to the effects of the harvest of females (York and Hartley, 1981). A similar conclusion was reached by Fowler et al. (1990). This conclusion comprises the basis for management action as mortality rates of 15% for fur seals cannot be within the normal range of natural variation of mortality caused by other species (e.g., Fowler et al., 1999). It should be obvious that the significant effects of entanglement are confined primarily to the period when observed entanglement rates are highest (i.e., the period between the early-1970s and early-1980s), although we cannot rule out lingering effects, nor that the low levels of entanglement observed currently are not having unmeasured effects.

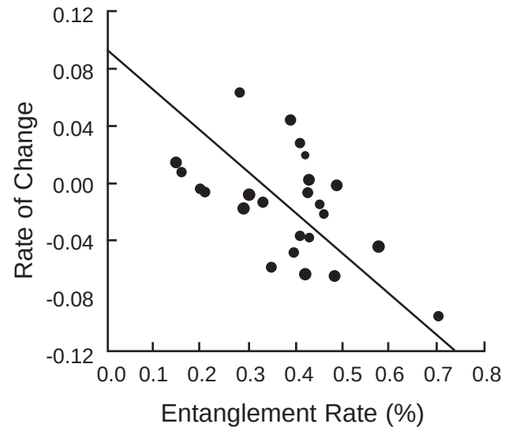

Figure 4
The correlation between the rate of change in numbers of pups born from 1972 to 1996 (based on a running mean of 3) and the entanglement rate observed among subadult male northern fur seals from 1967 to 1991 (i.e., with a lag of 5 years, based on data available at the National Marine Mammal Laboratory, Seattle, WA; see Fowler, 1987).

DISCUSSION

Commercial fishing is a complex process with many effects on the various species within marine ecosystems. There is little doubt that marine debris is one of these factors. The effects identified for fur seals and their population on the Pribilof Islands are not alone.

Although it is likely that the decline in the late-1970s may not have occurred without the effects of entanglement caused mortality, other factors can not be ignored. During the decline, other factors had their normal effects in contributing to natural mortality. Other factors may have involved other anthropogenic effects. For example, such factors could easily include a reduction in the carrying capacity (Fowler and Siniff, 1992), especially in the years following the more prominent effects of entanglement. In spite of its apparent prominence for a restricted period of time, it would be a critical mistake to ignore other effects of over fishing, contaminants, or global climate change, especially at times of low entanglement rates. Although the effects of the commercial harvest of female northern fur seals were probably greatest during the 1950s to the late-1960s (York and Hartley, 1981), lingering effects could well extend into later periods (Fowler, 1995). We cannot use information that indicates that entanglement was, and may still be, a serious problem to divert attention from such matters. Research on the effects of changes in the composition (Merrick, 1995), depletion, and redistribution of resources is imperative because their effects could easily be significant at any time. All problems that can be identified and measured need to be addressed to fulfill the tenets of adequate management (Fowler et al., 1999).

In focusing on measuring the effects of marine debris as one such problem, for at least one period of time, it is clear that the combined effects of factors such as wounds and altered behavior contribute to mortality and its resulting population-level effects for northern fur seals. From a management point of view, the burden of proof now lies not in proving that there are population-level effects, but that there are not (Mangel et al., 1996; Dayton, 1998). The same would be the case for the genetic effects of harvesting (Fowler, 1995), or a reduction in carrying capacity (Fowler and Siniff, 1992). Much is now being done to mitigate the problems of marine debris (e.g., Debenham and Younger, 1991; Coe and Rogers, 1997). In view of the information we have on northern fur seals, in combination with information on other problems created by marine debris, it is important to undertake management action, including beach cleanups, and the discarding of waste netting in ports (Debenham and Younger, 1991; Alverson and June, 1988). A wide variety of such efforts are in place, including educational programs to address the issue (National Research Council, 1995; Coe and Rogers, 1997).

The collective effects of marine debris are staggering in their magnitude if we consider all of the species that may be affected by marine debris, not to mention the problems observed in terrestrial settings. The role of plastics in the marine debris problem must be considered in the context of the good they serve (in many areas, e.g., packaging, medicine, fishing, entertainment, apparel, protective gear, and instrumentation). Ultimately, the following questions must be asked: Is the good outweighed by the long-term consequences of the global problems and in the marine environment in particular? What if these problems are only the small tip of a very large iceberg in parallel with the few surviving entangled fur seals left to be observed after the mortality experienced by so many others? Behind the magnitude of the problems observed is one very important factor: the magnitude of the human population. Plastics and other debris are, in part, the result of technology that has allowed (even promoted) the growth of the human population to its current size. Can the current human population be sustained in view of its many consequences? Only one of these effects is apparent in the small example provided by the effects of marine debris. And only one example of this larger problem is seen in the effects of a few kinds of debris on northern fur seals.

We have been fortunate with northern fur seals because their life history characteristics and breeding behavior have made it a convenient species for studying the effects of marine debris. In spite of the limitations of data on northern fur seals, our success in studying this species has been made possible by their annual return to the breeding islands where they are seen in large numbers. In these locations they have been available for field studies, particularly studies of the effects of marine debris. If we had the opportunity to study in equivalent detail the physiology, behavior, and population dynamics of all species similarly affected, it is clear that the extent and nature of the effects of marine

debris would be better appreciated. Affected species would include: filter feeders that filter microscopic plastic particles from marine waters; birds that use plastics to construct their nests and feed their young; and other species that are effected by ghost fishing, entanglement, and ingestion (Coe and Rogers, 1997; Shomura and Yoshida, 1985; Shomura and Godfrey, 1990). Such studies would need to be expanded to include the effects of chemicals released during the breakdown of plastics, and chemicals concentrated by plastics that have surfaces to which the molecules of such substances are attracted.

Based on what we have learned from the northern fur seal example, will we know how to solve the underlying problems even if we understood all that there is to understand about debris, and all of the species it affects? Short-term superficial attempts to solve the problem of debris have their own unintended consequences. For example the initial manufacture of plastics requires energy that results in carbon dioxide to contribute to problems such as global warming, and mitigation through recycling plastics only adds to such problems. Other alternatives pose other problems. Landfills to dispose of plastics require both energy and space, both of which we are using at abnormal rates compared to other species (Fowler and Perez, 1999). Incineration results in unwanted by-products. Every way we turn, there are consequences to our actions. These are seen, in their most painfully obvious way, if we contemplate giving up the use of plastics entirely. But the question remains: Is our use of plastics for their short-term benefits overshadowed by much larger long-term consequences that future generations will experience?

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I would like to thank the many colleagues with whom I have worked over the past two decades for their efforts in the research on entanglement and its effects on northern fur seals. A complete list of people is beyond the scope of this paper, but most are found as authors of the papers in the literature cited below. Society owes them a debt of gratitude for their help in understanding the magnitude of the problem of marine debris. I greatly appreciate their work and dedication. I would particularly like to thank Jim Coe, Gary Duker, Jean Fowler, James Lee, Rolf Ream, Bruce Robson, and Jeremy Sterling for insightful and helpful comments in their reviews of previous drafts.

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ECONOMICS OF LOST FISHING GEAR

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INTRODUCTION

"The homilies of economists never change."[2]

Six years ago at the Third International Conference on Marine Debris, the papers on economics made four important points: (1) debris on beaches decreases the prosperity of a community as well as the ecosystem (Smith, 1997); (2) moral suasion only goes so far (Sutinen, 1997); (3) a waste management model may be a good way to identify points of intervention for reducing the social costs of marine debris (Laska, 1997); and (4) a cost-benefit perspective has much to offer in attacking the issue of marine debris (Kirkley, 1997).

Aside from debris on the beaches, it did not seem-based on the conference report-that much quantitative information was available on the economic cost of marine debris, and that would seem to be the same today.[3] Hopefully we will learn to the contrary during this conference.[4]

Why does it seem that little has been learned about the costs of marine debris? I think it is because of the wide-open and elusive nature of the ocean, the long time horizons between loss and impacts, and the socialization of private costs into the commons that are our oceans. And because, if there is no change in institutional and regulatory structure concerning lost fishing gear, there is no behavioral change for economics to evaluate. I will identify some areas for further economic analysis later in this paper. A simple comprehensive accounting of the costs of marine debris would be useful, but this is an applications problem waiting for a public policy initiative.

In this morning's talk, I would like to summarize an economic perspective on lost fishing gear, but I cannot claim to be any type of expert. My "expertise," if you want to call it that, will be in applying economic and political theory, spiced with a little time using commercial fishing methods aboard a NOAA research vessel, and some familiarity with what are important economic and operational issues to fishing boat owners and captains. What I have to say won't be very brilliant. Hopefully, it will be helpful just to remember some first principles.

PRIVATE VS. SOCIAL COSTS AND BENEFITS

To begin, let us consider the direct cost of replacement of lost fishing gear to the vessel owner (a cost frequently shared by the crew). Lost fishing gear represents a negative externality in the production of seafood, and this negative externality is generalized to the rest of society. Avoiding the loss of fishing gear represents a specific cost to fishing vessels in terms of capital and operating expenses, allocation of labor time, the risk of retrieval, and opportunity cost of lost fishing time (during replacement or retrieval). The fishing vessel

owner and captain have to balance these costs with the benefits of avoiding this gear loss.[5] The social (economic) costs of lost fishing gear is much more dispersed, both in time and place, although when the cost is borne, it is frequently borne very directly.[6] More dispersed costs to the marine ecosystem and its users (e.g., beach-goers, endangered species, fouled props, pristine environments, ghost fishing) are frequently of a low cost per incident, but these incidental costs frequently accumulate to substantial losses. Indeed, at the previous marine debris conference, considerable effort was directed toward social costs of beach debris borne by the public as beach-goers (and it is in this area that most economic effort appears to have been directed). The economic valuation of endangered species, as was undertaken as a result of the Exxon Valdez accident, is another type of research that should contribute to knowledge of the social cost of marine debris (including lost fishing gear), as long as the physical and biological processes of the interaction between this debris and various endangered species are well understood.

POINTS OF INTERVENTION

The economic (and public policy) problem is how to equilibrate net benefits across various points of intervention in attacking this problem, and when to accept that doing further may not be worth the cost since it would be more efficacious to apply regulatory energy toward other issues. Since fishing is a process, it is critical to understand the mechanics, economics, and sociology of its activities and their interactions. On this, it would appear more research is warranted (i.e., at the upstream side of the equation) and this conference's industry panel may offer good information in this regard. One way to approach this would be to identify those physical and operational points in the fishing process where intervention is optimized. To do so requires more than the type of listing presented here.[7] As in any risk management model, it requires prioritizing the threats, evaluating the benefits and costs of intervention, and acting upon those evaluations.

These points of intervention would include (amongst others):[8]

- Choice of fishing gear (initial technology)
- Maintenance of fishing gear
- Conditions for using fishing gear
- On-board facilities for secure storage
- Fisheries regulations
- Shore-based facilities for storage and disposal
- At-sea or on-land retrieval

As Laska (1997) points out, given a particular type of human activity (a given that may be challenged in some circumstances), there are a variety of choices that govern the technology used in that activity and how that may contribute to marine debris. In terms of lost fishing gear, issues have been raised about its biodegradable properties, its needs for at-sea repairs or replacement (which may contrast with biodegradability), its long-term durability, including connections to floats, markers, etc., and a range of other gear properties that represent capital costs. The problem for the fishing vessel owner is how to balance up-front capital costs with ongoing maintenance and replacement costs.[9] Maintenance is also shared by the crew through expectations that they will keep gear up during steaming and down time, as well as through gear fabrication and breakdown following fishing trips and seasons. Clearly there are some real skill and motivation issues here and labor economic issues that economists have grappled with for many years in other fields. But in terms of both capital and maintenance costs, the fishing vessel owner is balancing the up-front costs with the costs incurred by gear loss. These include not only the direct cost of gear replacement and repair, but also of lost fishing time (and expected revenue) and occasionally of fouling one's own prop.

The next point of intervention involves the conditions in which gear is set and retrieved. One of the well-known examples of fishing gear loss is the misplaced transfer of cod ends containing the product of a trawl net from the catcher boat to a processing or transfer vessel. Obviously this represents a double cost to the fishing vessel: the need to replace expensive gear; and the lost income from the day's fishing. So there is every incentive for a fishing vessel owner and captain to minimize this risk. But such incidents remain and may represent a function of weather and seas, the tiredness of the crew and the myriad other factors featured in a complex fishing operation. In the lobster fishery, hanging up a string of traps on a bottom protuberance is a similar problem, or having one lobster boat setting its trap line across another's. For longline fishing, it may be the effect of a passing vessel cutting the line and a strong current taking the line away, or it may be a large shark or bill fish tangling the line into an inoperable ball. In each of these cases the problem for the vessel captain is how long to spend trying to retrieve this gear.

Then there is the question of how fishing gear is stored on-board. It should be clear that to the fishing vessel operator, there is every incentive to keep good gear secured since it is costly to purchase and to replace. But the same may not be true of gear in disrepair or remnants of gear. Fishing vessels tend to be rather tight quarters with useable space at a premium, and so the storage of gear remnants, like that of other on-board debris is at best a problem.

Similar concerns relate to the availability of shore-based facilities for the storing and disposal of fishing gear. While MARPOL makes a number of requirements in this regard, it was apparent to the participants of the 1994 marine debris conference that this remained a

problem. A quick look at the docks in Honolulu suggests this is still a problem. Clearly there is an incentive for fishing vessels to return their gear to land and reuse the gear in future fishing seasons (if there are to be future fishing seasons and if the cost of storing that gear does not exceed the price required to replace it whenever the vessel re-enters a fishery). And the incentive to return broken or destroyed gear or gear remnants relies more on moral suasion and the (apparently) low risk of a MARPOL compliance violation than on any purely economic motive.

These operational points raise questions about the governance regimes (regulations) affecting fishing operations. In a derby fishery, where the number of boats is greater than what the resource can easily sustain, there is a tendency for vessels to operate at a high intensity. Some of these disincentives to good fishing operations will tend to exacerbate gear problems. On the other hand, where a fishery management regime fosters a community of interest amongst its participants and allows for a more reasonable level of operations, then gear problems are probably reduced. The question, it seems, is to recognize the impact on the risk of losing gear at the same time that one considers other aspects of fishery management policy such as biological over-fishing, habitat destruction, and crew safety (each mandated by the Magnuson-Steven Fishery Conservation and Management Act in the U.S.).

Finally, there is the question of at-sea or on-land retrieval of lost gear. The cost of at-sea retrieval of lost fishing gear is a difficult calculus for fishing vessel captains, as previously indicated. But there is also the possibility of fishing vessels retrieving gear and gear remnants otherwise lost at sea by other vessels. After all, it is fishing vessels that are most prevalent at sea in conditions that are not restricted to simply steaming through, and it is fishing vessels that are most adept at stopping and turning and hauling material over the side in their routine operations.

Whether lost fishing gear (at least floating gear) can be efficiently retrieved while at sea by other vessels depends largely on the degree to which the gear can be tracked and found or where it accumulates. Similarly, retrieval of gear as it meets the land may also be an efficient choice if there is an organized approach to doing so (with due respect to the sometimes heroic efforts of my fellow marine scientists, I'm not talking about NOAA, NMFS, and the Coast Guard going into the gear retrieval business). Again, it is a question of the cost of gear retrieval, the basis for financing these costs and the net benefits that would derive from such retrieval.[10]

Clearly these points of intervention do not exhaust the possible list. They are provided as an impetus to identifying both upstream and downstream opportunities, and to identify different ways to intervene in the marine debris process. There is often a tendency within government to look to the regulatory solution, by which I mean the prohibition on this or that, as if regulations were free, or at worst, costly, to the violator. Regulations have a wide range of social costs, of which enforcement is but one; thus, it is important to look at a variety of ways for improving the internal incentives for reducing the quantity and impacts of lost fishing gear.

ECONOMIC METHODS OF INTERVENTION

There is a perspective in neo-liberal economic development practice known as "getting the prices right." It basically means equilibrating private and social costs (or minimizing social costs). Without engaging in the debate over the appropriateness of this approach to the Third World, it does offer quite a bit to the marine debris issue. In particular, because so much of the cost of lost fishing gear is socialized away from the source of the debris, the private cost of fishing gear and fishery products (i.e., seafood) is lower than would be appropriate if the full social costs were borne at the point of production. Therefore it would be nice if the full social costs were privately borne. If they were, it is likely that different choices would be made in the choice of technology, conditions of gear use and efforts at retrieval. And it is here that economics focuses on incentives (and disincentives) (i.e., what are the financial factors that might yield a change in behavior so that fishing gear is lost less frequently? When it is lost, can more resources be marshaled to mitigate its effects before it is too late?).

Based on the points of intervention previously identified, there are a variety of potential methods for economic intervention in the marine debris process. These include an explicit accounting of fishing gear use, deposits on new and replacement gear, and insurance. In these, it should be possible to determine whether the amount of gear actually lost by a particular segment of the fishing industry is worth the effort required to set up an incentive and disincentive system. To do so requires the explicit accounting of both gear use and the return of spent gear to the land. There are also institutional changes that may serve to maximize the incentives for gear retrieval. Finally, it is important to realize that the cost of these interventions may not be particularly great to individual vessel owners. They are not unlike oil pollution abatement insurance that many vessels already carry. But they will only be manageable costs if the incentive structures are sufficiently generalized. There are economies of scale in creating these forms of mitigation:

- Incentives for gear choice
- Costs of shore-side disposal
- Regulatory climate concerning fishing operations[11]
- Incentives for appropriate gear disposal
- Incentives for lost gear retrieval
- Liability for gear damage
- Insurance for gear removal

For economists, incentives (disincentives) generally devolve prices and other monetary instruments, as can be seen by the previous list. This does not preclude other forms of intervention, but it does stress that non-monetary measures generally have a range of hidden costs that reduce their effectiveness. Calculating the transactions and adjustment costs of non-monetary measures is important to insure that the costs and benefits are appropriately distributed amongst the interested parties, including fishing vessel owners and the general public.

SOCIO-POLITICAL OPPORTUNITIES

The problem of lost fishing gear also raises a number of issues concerning the institutional structure in which fishing occurs. The following provides a brief listing of the types of issues that need consideration:

- Recognizing the nature of the economic system
- Private incentives
- Regulatory regimes affecting fishing operations
- Communities of interest or disinterest
- Involving the fishing community
- Education and moral suasion
- Appropriate levels of enforcement
- Public/private partnerships
- International agreements

These represent opportunities for tackling this problem from a variety of perspectives. Each effort to do so will provide new information for subsequent adaptation of the institutional structure and incentive system. One should not underestimate these problems, however since the costs of marine debris are highly diffused through time and space.

CONCLUSION

Economic costs are lost benefits to society. Marine debris and lost fishing gear as a relatively small subset of that debris is but one of many environmental and social problems that the global community needs to consider. But while marine debris and lost fishing gear

may be relatively small in total, they may be substantial problems to particular localities. Such is the case of lost trawl nets in the Northwestern Hawaiian Islands. So the general conclusion is that to be effective, public policy on lost fishing gear must identify high net benefit points of intervention in the process by which fishing gear becomes lost and affects the broader society (and ecosystem). To implement this policy, it is critical for policy makers to reduce the divide between those who are downstream of lost fishing gear and those who are on the upstream side (i.e., fishermen). Involving the fishermen through a variety of institutional arrangements, whether they be economic incentives, joint educational panels, advisory groups, or simply the act of marine debris researchers walking the docks and talking to fishermen, will help insure that whatever is planned is actually implemented as intended and with the intended consequences.

[1] The following comments do not necessarily reflect the opinions or policy of NMFS or NOAA.

[2] Kirkley J., and T. McConnell. 1994. International Marine Debris Conference.

[3] An idea confirmed by conversation with economists involved in the previous International Marine Debris Conference and through an Internet source search.

[4] Indeed the working paper written by Mark Minton for this conference does a good job of identifying fishing industry initiatives over the past five years.

[5] A colleague who has spent considerable time on commercial fishing vessels suggests that captains and crews generally do not discard fishing gear and shards willy-nilly overboard. After all, they too are aware of the specific costs of fouling their props and over-the-side gear in the marine debris. What frequently occurs, however is that gear shards may be stacked in a corner of the deck, perhaps in the ubiquitous plastic barrels and tubs that frequent fishing vessels, and during rough weather, these stacks and barrels break loose and are swept overboard.

[6] Direct costs are borne through fouled propellers on a variety of ocean craft.

[7] Clean Ships, Clean Ports, Clean Oceans (1995) raises a number of these points as well.

[8] The idea for these points was borrowed from Laska, 1997.

[9] Fishing vessel owners frequently attempt to minimize replacement costs by requiring crew to pay for lost gear out of their revenue share.

[10] The first monk seal I saw in the wild was sleeping on a marine debris dump by the harbor on Midway Island, presumably not the best place for young seals, but perhaps okay for an old seal.

[11] e.g., open access quotas vs. limited entry tradable quotas.

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NAVIGATIONAL HAZARDS AND RELATED PUBLIC SAFETY CONCERNS
ASSOCIATED WITH DERELICT FISHING GEAR AND MARINE DEBRIS

Lane D. Johnson, USCG 14th District, Marine Safety Division, Hawai'i

IS THERE A PROBLEM?

When we hear the phrase "entanglement in marine debris" I would anticipate the majority of us picture in our minds aquatic marine life of some kind, fouled within derelict marine debris or fishing gear. Today, I would like to suggest we also consider that entanglement of propellers, rudders, jet intakes, and water intakes be taken seriously, and that some energy from this conference be channeled towards this less familiar entanglement topic.

AN ENCOUNTER WITH DERELICT FISHING GEAR

The following comes from an Albacore fishing vessel operator and one of his encounters with derelict fishing debris, April 2000, somewhere between 36° and 40° N Latitude and between 145° and 165° W Longitude.

"Last year was particularly bad for debris for the Albacore fleet. I imagine it was exacerbated by the La Niña current conditions that put us in the zone, although some previous years have been quite bad too. Several boats, including myself, encountered fouling en route from the West Coast (of the U.S.) to Hawai'i in April, mainly pieces of light web; 1-1/12" mesh, black tarred twine like I'd imagine is used in sardine seines or aqua-culture. One boat encountered some hefty pieces of trawl web. In the area between 36° and 40° N and 145° and 165° W (just South of the Mendocino Fracture Zone) there were frequent encounters with the same web and also a lot of mono-filament gillnet-web, about 3" mesh. This is particularly hard to cut once it is wound tightly onto a propeller shaft! In one incident where a fishing partner was stopped dead, after he had almost drowned, we think it was bad air in his scuba tank, I ended up swimming over to finish the job. Amongst the mixture of web and rope were two banding straps such as one finds around frozen bait boxes, with Korean characters printed on them. Whilst it is always hard to get fishermen to volunteer information, it might be possible to informally compile debris encounter information in our fleet; if you have any particular suggestions, I would be happy to help."

This encounter definitely raises concerned parties' interests and is an indicator that there may be a problem with derelict fishing gear as a navigation hazard and safety hazard.

THE "PROBLEM" MAY EXIST

This twin screw motor yacht caught a line during a routine trip for fuel. It wrecked propeller shafts, stern gear, and the flexible couplings on both engines. It was out of operation for a significant portion of a busy charter season. Drifting while disabled or having to go overboard with a knife to wrestle with a rope can have tragic consequences, even the most alert mariner cannot avoid submerged debris including lines or nets, especially at night. This device offers protection for vessels and their crew from a "stressful and potentially life threatening situation" as it is advertised.

Figure 1

Figure 1. Motor yacht in dry dock, propeller fouled by mooring line.

Figure 2

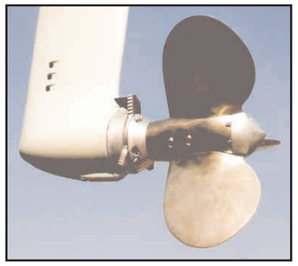


Figure 2. An installed line cutting device just forward of the propeller.

Figure 3

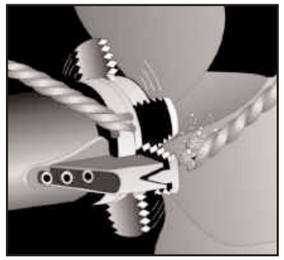


Figure 3. A diagram of an installed line-cutting device depicts the mechanics of how it is intended to function when in operation.

When industry designs devices such as these it is an indication that perhaps vessel fouling by marine debris is a problem worth researching.

MINIMAL PUBLISHED BACKGROUND

Studies on pelagic or offshore marine debris are not extensive but do exist in identifying both collection areas and types of debris. In the greater Pacific Ocean there are a few dated studies supporting the existence of increased marine debris north and northeast of the Hawaiian Archipelago. These studies are six years old and older.

Nets and lines that don't make landfall, accumulate in oceanic gyres and become the source of hazards to navigation and related public safety issues on the open ocean. Discussion in our research failed to uncover similar studies to identify the extent of this perceived problem. We found no historic statistics to aid us.

To help meet this gap or this draw for applicable datum sources, we fielded a survey to marine safety agencies and commercial entities in over thirty neighboring Pacific Ocean countries. We received replies from eleven countries.

HAZARD TO NAVIGATION SURVEY

This topic was in need of research. We chose to distribute a survey primarily to marine safety agencies within the Pacific region. We received replies from eleven Pacific Rim nations. Eight from the following countries were comprehensive enough to use in this report: Australia, New Zealand, Singapore, Philippines, Japan, China, Canada, and the United Sates.

Vessel classification societies, local insurance claim companies, Seattle Locks, Panama Canal, major marine insurance agencies, and Sea Grants were also given an opportunity to participate. This latter group accumulated only three responses and of the three responses, none had information to aid in the survey.

“Does marine debris pose a navigation hazard for commercial and recreational vessels in your nation's surrounding waters?” This was the first question presented in our survey. Scenarios that could qualify as navigational hazards and related public safety issues would include:

- Fouling or entanglement of a vessel's propeller, rudder, jet drives, or water intakes or restriction of vessel's ability to maneuver. If disabled or dead in the water with reduced visibility, such a vessel is in harms way from the track of a larger vessel, heavy weather, and increased sea states.

- Benthic or subsurface debris has the potential of fouling vessel anchors as well as equipment deployed from research vessels and fishing trawlers. These types of scenarios can put a vessel and its crew at risk.

Public safety scenarios that would most likely evolve from these encounters when vessels become disabled and remain so for extended periods due to distance, isolation, and communication complications and due to irreparable damage:

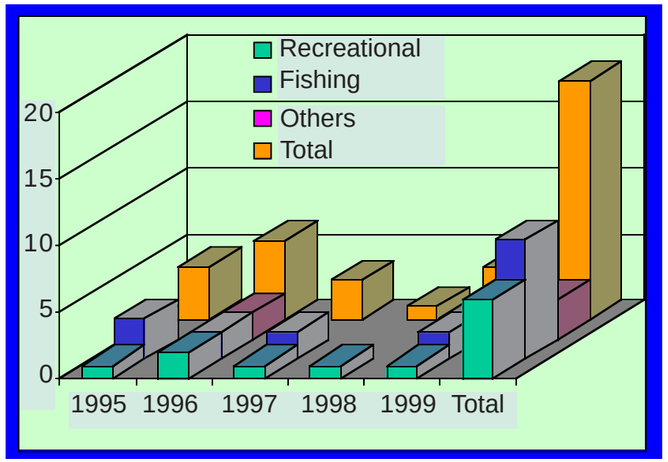
- May take on water around a damaged shaft seal.

- Must send an individual underwater to attempt to clear the debris. The sea state alone can make work in close proximity to a vessel's hull dangerous.

NAVIGATION CASES AND SURVEY RESULTS

From our eight solid responses many nations indicated two points: (1) the primary focus is to address this debris from an environmental hazard perspective and (2) many of our questions have not been tracked and were unknowns or best guesses. As a result, the perceived problem with hazards to navigation and safety remain an uncertain “yes” for most. The uncertainty is there because reporting mechanisms aren't established for mariners nor are recording mechanisms established for agencies and organizations.

JAPAN MARINE DEBRIS HAZARD TO NAVIGATION CASES



Japan, the country reporting the most data on this subject, and perhaps in the best position to answer this question from those countries and organizations surveyed, reports:

- The damage to the propeller related in all 18 cases represented in this graph.
- Australia reported five vessels and Canada's eastern shores reported fourteen cases on fishing gear. All other countries maintain no records.
- The cumulative damage for Japan, although incomplete, amounted to 6,700,000 Yen from 1995-1999.
- In 1992 Japan estimated their fishing industry spent $4.1 billion U.S. dollars in boat repairs resulting from damage caused by marine debris.
- Derelict fishing nets were stated as the most dangerous drifting objects for Japan.
- No specific action has been taken to address these eighteen cases from the past five years because the number of cases is not considered significant. However, Japan keeps a concerned watch on illegal ocean-dumping activity.

"What types of debris are responsible for hazard to navigation cases?" Our survey also asked this question.

- Japan reports - drifting fishing nets and ropes.
- Canada (West Coast) reports - lines, nets and logs. Logs become the major hazard of concern around British Columbia.
- Philippines report - plastic nets, bags, Styrofoam, rubber materials, logs, wooden ship remnants, other persistent debris.
- New Zealand reports - plastic strapping from fishing boats.
- United States - reports derelict fishing net and associated line, all sizes.

Other countries had insufficient information to report on this question.

ADDRESSING THE PROBLEM

- Continuous outreach and education are the focus or are a key interest for Australia, Philippines, New Zealand, and the United States, but not the only actions in place.
- The Philippine Coast Guard has led consistent cooperative government cleanup operations of affected waters.
- Hong Kong is establishing a sophisticated traffic management system to look after the inter-coastal traffic
- In Singapore, Flotsam retrieval craft are deployed, if necessary, on a daily basis to remove debris from the sea. Craft making the report are often asked to retrieve the debris as well.

Perhaps the larger question becomes, who has the responsibility for recovery of navigational hazards? The participants indicate that the coast guard has the lead in Canada's, Japan's, and the Philippine's waters. In Singapore the burden falls upon the port authority. In Australia and China, it is the maritime safety administrations. It is also suggested that none of these lead agencies take on the sole responsibility, so many seek outside assistance. Canada indicates that industry, in general, may not be as committed to debris control compared to the marine community.

RECOMMENDATIONS

- This field is in need of further research. Many past publications have suggested that vessel entanglement or propeller fouling is a field of concern in need of remedy or, at the least, a systematic study of not only issues related to public safety and navigational hazards, but to the economic costs associated with entanglement.

- It is suggested we, representatives of port countries, organizations, and industry collaborate and pursue the need for creation of an international offshore marine debris report form, and pursue incentive mechanisms for pelagic debris recovery and the systematic reporting and collection of this debris datum.

- We should consider seeking support from and engaging with established international committees.

- The International Maritime Organization (IMO) has a couple of outlets that may aide in this endeavor. As recently as March 2000, IMO's Legal Committee, 81st Session, met. Within this committee, the Draft Wreck Removal Convention was chartered with making provisions for international rules. More specifically, on the rights and obligations of states and ship owners in dealing with wrecks and drifting or sunken cargo that may pose a hazard to navigation and/or pose a threat to the marine environment.

- IMO also runs a spill and litter web page that is ideal for sharing information about your regional efforts.

ACKNOWLEDGMENTS

I would like to thank the planners of this gathering today: Mr. Daniel Ruseborn and Chris Woolaway under University of Hawai'i's SeaGrant Program for their resource support; the participants of our survey; Albacore fisherman Jeremy Brown from Bellingham, WA; National Marine Fisheries Service's Ray Boland and Chad Yoshinaga for their fine photos, some of which were used in this presentation; and to Mr. Paul Topping, Environment Canada's Marine Response Division, for background on Canada's offshore debris studies.

SOCIETY'S ROLE AND OBLIGATIONS AS STEWARDS OF THE OCEAN ENVIRONMENT

Honorable Daniel K. Inouye, United States Senator, Hawai'i

When this conference was first brought to my attention, I must confess that it took a few moments to register – "marine debris." That is a sophisticated way of saying rubbish in the ocean. Harmful rubbish and the need for trash collection. Now that registers and will resonate in our communities.

The task is daunting, but the message is simple: We must all work together to clean up, and pick up after ourselves to stem the tide of debris and destruction at sea.

Two decades ago, we did not know much about marine debris. This global conference reflects how much we have learned since then about the scale and importance of this problem. For example, we now know that the debris comes from all types of sources around the world, including ships and fishing vessels. But, it has also become clear that close to 80 percent of the rubbish in our oceans is washed, blown or dumped from shore. This debris moves through the world's oceans and into the most remote places, as well as onto our beaches.

While we have made some progress on reducing pollution from ships, a national or global solution to the marine debris problem is not yet within our grasp. Here in the Pacific alone we are faced with frightening statistics involving the entanglement and death of sea turtles, marine birds, whales, dolphins, fish, and seals, and the destruction of our precious coral reefs.

I am pleased to see representatives from across the Pacific, including Chile, Australia, Japan, Niue, Fiji and Micronesia, all coming together to develop a strategy to clean up our oceans and keep them clear of marine debris.

I am particularly pleased to learn about the efforts of the "Trash Busters," high school students who are committed to tackling this issue, and protecting our unique marine resources for future generations to enjoy. I commend these students for their dedication to this important cause.

I need not remind you, though, that marine debris is only one of a myriad of issues affecting our nation's coastal and ocean resources. We are faced with many challenges in the U.S. Exclusive Economic Zone (EEZ) and the global ocean on how best to fulfill our stewardship responsibilities. The key to effectively meeting these challenges is commitment–a

commitment to do what is necessary. A commitment to make and then implement difficult decisions, domestically and internationally. The solution will not come from government action alone–each community, each person must also commit to making these tough decisions a part of everyday life.

Healthy oceans are critical to our quality of life. They provide food, medicine, recreation, and energy. We have heard the statistics:

Priscilla Billig, Marine Debris Communications Committee

United States Senator Daniel K. Inouye of HawaiÔi keynotes a luncheon session with an address on "Society's Role and Obligations as Stewards of the Ocean Environment".

- one out of every six jobs in the United States is marine related;
- one of every two Americans live within 50 miles of the coast;
- more than 180 million people visit the coast each year, generating 85 percent of all revenues from tourism in this country.

Our oceans are a vital environmental, economic, and recreational resource, and must be treated as a national priority.

In the 1960's we took a first, and revolutionary step toward focusing federal attention on our ocean and coastal resources. At the time we faced increasing pressures on these resources, but lacked any federal controls on coastal population growth, marine degradation, or overfishing. In 1966, the Congress created the Stratton Commission, which laid the foundation for U.S. ocean and coastal laws, policy and programs that have guided our stewardship for three decades.

The world has changed significantly since the days of the Stratton Commission. Ocean and coastal issues are gaining in importance, but they have not received the attention and priority they deserve. The ocean management regimes developed over the last 30 years need to be reexamined and revamped if we are to keep up with the changing times.

It saddens me to say that critical ocean conservation and management programs have not been adequately funded. Oceans have been treated as "second class citizens" compared with the more glamorous, such as the space program. We have invested billions of dollars to explore outer space, but have starved our missions to explore and understand our ocean space.

SOCIETY'S ROLE AND OBLIGATIONS AS
STEWARDS OF THE OCEAN ENVIRONMENT

Some have criticized the Stratton Commission, alleging that its recommendations led our nation down the path to overexploitation of marine resources. I disagree. But, rather than debating the wisdom of actions taken over 30 years ago, I believe it is a better use of our time and energy to focus on the next 30 years and beyond.

Regardless of one's perspective, one point is clear and unrefutable: the days of "doing business as usual" are over. It is time to put down our polarizing magnets and work together cooperatively, based on rational deliberation rather than emotional sound bites, to achieve our common goals.

As a nation, we must renew our commitment toward developing an integrated national ocean and coastal policy for the U.S. EEZ. I am pleased to report that we are on the cusp of a new era in ocean conservation and policy – the Congress recently passed the Oceans Act of 2000, which the President is expected to sign into law this week. Under the Oceans Act, the President, in consultation with the Congress, will appoint an independent Ocean Policy Commission to develop a national action plan for the 21st century to explore, protect, and better utilize our oceans and coasts.

As we work to get our domestic priorities in order, let us not forget that the ocean knows no boundaries. Many of the issues concerning our ocean environment can only be truly resolved through international cooperation.

There are many examples where the U.S., in an effort to set the example for the global community, will impose restrictions on domestic entities to protect its marine resources. This may sound like a good first step, but if the foreign governments and private entities do not follow suit, the U.S. could end up imposing restrictions on its own citizens, while those of other countries continue to do "business as usual."

One of the most emotional issues pending before the Congress relates to the banning of shark finning in the Pacific. This is a prime example of where U.S. policy must be supplemented by strong action to encourage foreign countries to adopt similar restrictions. Our action alone will not protect shark populations.

The protection of sea turtles is another example where international cooperation is critical to protecting these endangered resources. In the Pacific, only Hawaii-based fishermen are subject to severe prohibitions and restrictions, based on longline interactions with sea turtles. But these turtle populations interact with fleets from all nations throughout the Pacific Ocean. Fair questions have been raised as to whether these restrictions will actually protect the turtle population when the lion's share of the catch in the area is by

unrestricted foreign fishing vessels.

Today, in Hawaii, an unprecedented partnership – the city, state and federal governments, private industry and non-governmental organizations, as well as international governments – are joining forces to remove derelict fishing gear in the Pacific. I have high hopes that the strategies developed from this collaboration will be replicated elsewhere.

I am convinced that it will be partnerships across government and private lines, and across domestic and international lines which will make the difference in the end. Might does not make right.

I submit to you that our nations must make a strong commitment to provide leadership in their own EEZs, as well as in the global ocean. Let us step forward to fulfill our responsibilities as stewards of our ocean environment. The distress call has been sent out. The S.O.S. – Save Our Seas.

A U.S. PERSPECTIVE ON MARPOL V: COMPLIANCE, ENFORCEMENT, AND IMPLEMENTATION

Paula S. Carroll, U.S. Coast Guard, Honolulu, Hawai'i

INTERNATIONAL CONVENTIONS

- Convention on the Intergovernmental Maritime Consultative Organization (CIMCO) (1948) - provided cooperation and opportunities among governments in regulating various shipping issues, including marine pollution. Established the Intergovernmental Maritime Consultative Organization, from which evolved the International Maritime Organization (IMO).

- Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter (1972 London Dumping Convention) - regulated deliberate at-sea disposal of land-generated garbage by dumping of industrial and low-level radioactive wastes, and the at-sea incineration of industrial wastes. Later resolutions either called for a moratorium or ended the dumping and incineration practices. The 1996 Protocol replaced the 1972 Convention and is much more restrictive.

- International Convention for the Prevention of Pollution from Ships (APPS) (1973); modified in 1978 (MARPOL 73/78) - regulates discharge of non-landbased pollution. Annex V deals with different types of garbage and specifies the distances from land and the manner of disposal. Requirements are much more strict in designated "special areas" but the most important feature of the Annex is the complete ban imposed on the dumping of plastics. Dumping plastics overboard in any waters anywhere is illegal at anytime!

- Third United Nations Convention on the Law of the Sea (UNCLOS III) (1982) - a universally agreed upon set of rules governing uses of the oceans. UNCLOS III provides the ground rules for each nation's approach to controlling shipborne wastes and the extent to which another nation's right to establish its own approach must be respected.

DOMESTIC LAWS

- Marine Protection, Research, and Sanctuaries Act (U.S. Ocean Dumping Act) (1972) implements the London Dumping Convention. It requires the EPA to closely regulate all materials taken from land for the purpose of dumping. The EPA prohibits ocean disposal of plastic materials produced onshore.

- Clean Water Act (1972) prohibits the discharge of solids in effluent from point sources. Its primary objective is to restore and maintain the integrity of the nation's waters.

- The Marine Plastic Pollution Research and Control Act (MPPRCA) (1987) amends the Act to Prevent Pollution from Ships of 1982 (APPS) and implements Annex V of the Protocol of 1978 relating to the International Convention for the Prevention of Pollution from Ships, 1973/1978 (MARPOL 73/78). It prohibits the disposal of plastic materials produced during routine shipboard operations.

BARRIERS TO COMPLIANCE

Two major barriers to compliance are: (1) the difficulties mariners have when attempting to comply with Annex V, such as adequate shipboard garbage handling and storage procedures, and adequacy and affordability of port reception facilities, and (2) the ease with which violators can avoid detection.

COMPLIANCE CHALLENGES

Compliance rates fall if enforcing agencies are not adequately resourced and committed to enforcement. Compliance rates also depend on factors other than government enforcement, such as levels of industry environmental consciousness and the public's disdain for marine debris on beaches.

The Coast Guard reports that penalties are large enough to be considered significant, but the fact is, the likelihood of getting caught is low. However, if compliance were cheaper than violating, then the economic theory is that mariners would comply. Economic incentives are possibly the most powerful compliance mechanism for the commercial marine industry, but no one reward or punishment will bring all marine segments, commercial and recreational, into compliance with Annex V.

The National Research Council's report "Clean Ships, Clean Ports, Clean Oceans" in 1995 suggests system improvements that the government and the port could undertake to increase compliance.

Vessel Garbage Management

Government can:

- Assist with technology transfer for maximum information exchange among all maritime sectors, including the U.S. Navy, and evaluate technologies for on-board garbage handling and treatment. The U.S. Navy, required by domestic law to comply with MARPOL V, is the world leader in developing technology to deal with vessel-source pollution.
- Ensure on-board storage procedures are safe, and develop guidelines on ship sanitation.
- Offer financial assistance to achieve compliance.

Adequate Port-side Garbage Reception

Ports and government can:

- Strengthen recycling programs.
- Transfer oversight to EPA waste management experts and state governments assuring standards are met under the Resource Conservation and Recovery Act (PL 94-580) (RCRA).
- Better integrate Animal and Plant Health Inspection Service and Annex V regulations.
- Address who should pay for garbage services and how, for example, by standardizing fees. If disposal rates were uniform and affordable, then compliance would probably rise.

Barriers to U.S. Enforcement of Annex V

The Coast Guard's annual report to Congress in 1992 cited two distinct weaknesses in enforcement:

- The difficulty in obtaining eyewitness accounts
- The limitations imposed on the prosecution of foreign vessels.

Enforcement Challenges

Drafters of Annex V intended signatory nations to use methods to encourage compliance and enable enforcement. One of the most difficult aspects of enforcement is proving U.S. jurisdiction. Even if the master admits that all garbage, including plastics, is discharged at sea, it is sometimes impossible to prove that the discharge occurred within U.S. waters. If circumstantial evidence against foreign-flag vessels is the only indicator, then it is often too difficult to establish the disposal location to proceed. And additionally, when garbage washes ashore from a vessel, the enforcement agency must prove which mariner caused the discharge—a very difficult task.

The U.S. depends on reporting of incidents and vessel boardings in port more so than at-sea surveillance. At-sea infractions are almost impossible to detect and difficult to prosecute unless there are witnesses.

In 1992 the U.S. expanded its port state control policy whereby it pursues direct civil or criminal action in all cases where jurisdiction can be established. If there is evidence of a violation that took place within the EEZ, territorial sea or internal waters, then action is taken. Penalties have increased, with a criminal offense upgraded to a felony, and port officials are authorized to withhold clearance for departure.

Coast Guard policy states: "As of July 1992, the USCG began taking enforcement action under U.S. law, including referral to the DOJ, for all suspected MARPOL Annex V violations occurring within the U.S. EEZ. Prior to July, USCG policy had been to forward cases involving vessels of signatory nations (unless the violation occurred within three nautical miles) to the flag state administration for investigation and enforcement. The policy shift

expanding coverage out to the EEZ became necessary because flag states were not taking adequate action in the cases forwarded by the U.S. Countries often failed to acknowledge receipt of the cases and many took little if any legal action against suspected vessels."

Current Coast Guard procedures for enforcing MARPOL V include:

- Animal and Plant Health Inspection Service (APHIS) inspectors report suspected Annex V violations to the Captain of the Port and, if resources permit, the Coast Guard also boards suspected vessels.
- At-sea boardings for Annex V compliance are conducted as resources permit, in conjunction with other routine boarding activities.
- In-port boardings for Annex V compliance are conducted as part of the Coast Guard's vessel monitoring program (port state control boardings or U.S. vessel inspections). Personnel verify APHIS inspections by sighting the PPQ Form 288 on board, and conduct a follow-up Coast Guard check for compliance with Annex V.
- If an APHIS inspection has not been conducted, particular attention should be given to shipboard garbage handling practices, use of plastics and any evidence of possible illegal discharges. The Coast Guard believes that vessel operators will prioritize Annex V compliance based on the level of interest expressed by the Coast Guard, the enforcement agency.

There has been a dramatic decline in MARPOL violations from 1993 to 1999. It is unclear if this decrease is a trend in compliance or an indicator of reduced enforcement. It is likely a combination of both. Compliance positives include increased public awareness, improved reception facilities in U.S. ports, use of incinerators, and the reduction/reuse of packaging. On the other hand, garbage does not get a public or government spotlight in comparison to oil or hazardous material issues.

The National Research Council suggests several methods to improve enforcement:

- Fully exercise port state control.
- Issue tickets in civil cases especially in the fishing and recreation sectors.
- Require ports provide receipts for off-loaded garbage and compare these to vessel logs.
- Enlist the assistance of other agencies (i.e., NMFS, MMS, State Marine Police) in reporting violations.
- Encourage ship operators to report inadequate reception facilities at ports.
- Increase public awareness to report illegal disposal through educational programs.
- Receive reports from all sources - private citizens, interested parties, environmental groups, other federal agencies, state and local agencies.

A U.S. PERSPECTIVE ON MARPOL V: COMPLIANCE, ENFORCEMENT, AND IMPLEMENTATION

Barriers to Implementation

The two greatest obstacles to implementation are: the undeveloped nature of comprehensive data collection and monitoring programs to establish baselines, and the lack of national leadership to coordinate all aspects of MARPOL V compliance, enforcement, and implementation.

Implementation Challenges

Implementation cannot rely solely on the government's ability to identify violators and enforce the law. Monitoring debris is an important aspect in determining practical interventions, but it is not well defined. There are systematic efforts to monitor, but the results are not detecting clear trends. Additionally, considerable amounts of garbage are generated and discarded by mariners, but the amounts are only estimated. The amount of garbage is just one factor related to garbage sources. Others of importance include the number of vessels (which reflect point source generation), the maritime sector, voyage duration, and the nature of the garbage. Plastic is a primary concern. Not only is it persistent, but abundant and the disposal of plastics is causing considerable harm. Environmental monitoring could be designed to determine fluxes of plastics through the marine environment as a function of time. This could be expanded to include fishing gear.

Another challenge is that data are available, but not in government-wide format. Agencies collect their own data and the systems are not compatible from agency to agency, plus the emphasis on data collection is sporadic. A joint CG/APHIS system could possibly help determine the direction of monitoring and enforcement.

In order to determine which interventions are effective and to enhance the scientific understanding of oceans, progress in implementation could be measured with comprehensive data collected over time on:

- Numbers of vessels discharging garbage at ports.
- Amounts of garbage discharged.
- Numbers of complaints about garbage reception facilities.
- Numbers of repeat violations by vessels and ports.

Better oceanographic and satellite data have improved the understanding of ocean currents and marine dynamics. As a result, the arbitrary disposal limits (12, 25, 200 miles) may not protect coastal areas. To allow dumping of some wastes at a "safe" distance from shore is clearly ineffective, since these wastes usually end up on beaches or remain at sea, posing a threat to aquatic animals and birds. Additionally, zero-discharge rules do not protect special areas fully. Debris can be transported over long distances and legally discharged garbage can drift into special areas. It is highly migratory.

Education is an effective intervention against the problem of vessel garbage, but it is not enough. The corporate culture perspective suggests crew behavior that reflects the values of employer corporations. Education and training efforts should target senior managers to foster organizational change. Another tack is that Congress could charter a foundation to coordinate a long-term, national program devoted to Annex V education and training.

Strong national leadership is critical to successful Annex V implementation. No lead agency exists to: coordinate the overall effort of developing on-board technology; monitor the adequacy of port reception facilities; inform marine sectors of compliance methods; or enforce the law. The NRC report recommends the formation of a national commission that could coordinate federal agency efforts, serve as the focal point for U.S. leadership worldwide, and increase standards of performance.

Waste reduction could be introduced as a management option. Most efforts (economic incentives, education, enforcement) have been interventions carried out after packaging and other items of non-degradable materials are already on board, versus proactive efforts of reducing waste generation before through source reduction of plastic packaging and the use of biodegradable containers.

Federal control capabilities vary by maritime sectors. The Coast Guard has direct regulation of cargo and passenger fleets but the fishing industry is less regulated, down to little direct control of recreational boaters. Interventions must be appropriate to the particular maritime sector and sustainable within resource limitations. No single implementation approach works across the board.

The following is a look at existing or recommended interventions for three sectors: (1) fisheries, (2) cargo vessels, and (3) the cruise industry.

Fisheries:

- Some have onboard observers, others assess catch at the pier. In both cases a survey mechanism could be implemented to gain information on the feasibility of net and gear disposal alternatives.
- Employee complaints and peer pressure offer indirect control.
- Port reception facilities that are considered inadequate for all garbage generated can be improved. The government may offer to subsidize modification costs, or guarantee loans for facility construction, or classify costs of port reception facilities as pollution-control devices for bond underwriting purposes.
- Technological interventions such as compactors, shredders and incinerators need to be tailored to conditions on fishing vessels with regards to size, placement, etc.

A U.S. PERSPECTIVE ON MARPOL V: COMPLIANCE, ENFORCEMENT, AND IMPLEMENTATION

- Fishing organizations may request establishment of reception facilities sized to local needs.
- Education to encourage voluntary compliance must continue.
- Enforcement, including vigorous prosecution and significant penalties, is important. If objectives are not met through voluntary compliance, then federal agencies should focus their enforcement resources on the most effective strategies (i.e., NMFS observers monitoring for Annex V violations in addition to their regular duties and requiring the reporting of fishing gear losses).
- International agreements between nations should encourage and require Annex V compliance.
- Develop interventions that encourage the return of used fishing gear to shore by requiring deposits on nets and lines, and promote recycling of fishing gear.

Cargo Ships:

- Ports seldom record garbage transactions.
- The Coast Guard exercises port state enforcement by directing U.S. action against more foreign-flag violators and fewer cases are being referred to flag states.
- Develop a possible international requirement that flag states issue certificates confirming ships' waste management systems meet or exceed some minimum criteria. IMO would issue these like IOPP certificates. A comprehensive capability to manage wastes would exempt vessels from off-loading at U.S. ports.
- The Coast Guard exerts control over public ports and operators of large private terminals through the COA program, but cost and convenience levels are not regulated.
- Alternative packaging and storage systems need to be developed that minimize use of plastics.

- Appropriate garbage treatment equipment could be designed for new ships and purchased, developed, and retrofitted on existing ships.
- Offer economic incentives to vessel owner/operators (i.e., return monies from recycling to the crews and revamp the inconsistent fee structure for garbage disposal).

Passenger Cruise Ships:

- The threat of public embarrassment over citizen reports of violations serves as an effective deterrent.
- A major barrier to compliance lies in port reception facilities, their adequacy, and convenience.
- Education of crew and passengers is a key intervention.

So what should we do to enhance compliance, enforcement, and implementation?

- Should we increase the effectiveness of the treaties by expanding existing enforcement agencies?
- How do we reduce the source or improve on-board storage?
- How do we encourage shoreside disposal/recycling of general vessel garbage and fishing gear?
- Do we increase port state control measures to ensure international compliance with MARPOL?
- Should we increase public education efforts targeting boaters, the ports, industry, and the public?
- Do we need more special areas?
- Should we increase technology sharing between communities and enhance garbage management systems?
- Within the Pacific region, who are the national agencies responsible for domestic and international implementation of MARPOL V activities?

These are issues for this conference. There is work to be done. The challenge for the participants is to produce an outcome-based action plan to effectively resolve these issues. If we leave here without positive action in this regard, then our time, in large degree, will have been wasted.

ACKNOWLEDGMENTS

I wish to acknowledge Ray Boland of the National Marine Fisheries Service for the background slide on underwater marine debris. I also credit the National Research Council's 1995 report for several of the ideas presented in this paper. I searched the web for current information but the NRC report was by far my most comprehensive source.

DERELICT FISHING GEAR MONITORING AND REMOVAL

Mary Donohue, Marine Debris Coordinator, University of Hawai'i, Joint Institute for Marine and Atmospheric Research and National Marine Fisheries Service, Hawai'i

INTRODUCTION

I want to thank the conference for inviting me to speak here today. I am going to be talking about derelict fishing gear—monitoring and removal. In fact, the majority of efforts aimed at removing derelict fishing gear are done in conjunction with monitoring or assessment investigations, and the mitigation to date has relied primarily on marine debris removal.

The methods that I'm going to describe today include: beach surveys, which may or may not have a removal component to them; shipboard sighting surveys, which almost never have a marine debris removal component; shipboard trawl surveys, which may or may not include debris removal; and diving surveys. I'll spend the most amount of time describing a diving project that the National Marine Fisheries Service, Honolulu Laboratory, in cooperation with a multitude of partners, is conducting in the Northwestern Hawaiian Islands to survey and remove derelict fishing gear from fragile coral reef ecosystems. Lastly, I'll touch upon the potential utility of remote sensing to both survey and increase the effectiveness of marine debris removal efforts.

BEACH SURVEYS

Beach surveys are really the most cost effective and widespread effort to remove marine debris from the littoral or shoreline environment, and the Center for Marine Conservation and other organizations have been extremely successfully in orchestrating them. These large-scale efforts usually are comprised of primarily volunteer personnel. They can be either beach-focused or ocean-focused (Ribic et al.), the latter of which is useful in derelict fishing gear monitoring. Ocean-focused surveys use debris washed ashore as an indication of the debris that's discarded or lost at sea.

A clearly stated goal is advantageous in these programs which not only allows the comparison between years of the same program, but also between various investigations. A rigorous sampling design is also advantageous when possible, for the same inter-annual and inter-investigation comparison. These surveys can document and remove small to large debris items, and information on type and accumulation rate can be generated. And, as I mentioned, most often removal is a large component of these types of efforts.

There are slightly different efforts conducted on some remote islands. They usually target larger debris items. For example, derelict fishing gear fragments like you see here washed ashore at French Frigate Shoals in the Northwestern Hawaiian Islands. These efforts are often carried out by governmental agencies and they, as well, require personnel on the beach. They are usually ocean-focused and, as in the former example, a rigorous experi-

mental and sampling design is advantageous for comparisons down the road. In these efforts, medium to large debris items can be documented, type and accumulation rate generated, and removal may or may not be included depending on the objectives of the study.

Some examples of these types of remote island surveys include the work of Theodore Merrill and Scott Johnson, who worked in the Aleutian Islands in Southeast Alaska. They monitored derelict trawl net fragments washing up on these beaches for a number of years. Also included is the work of John Henderson and colleagues at the National Marine Fisheries Service Honolulu Laboratory. John has been monitoring entangling trawl net fragments and other entangling fishing gear that washes ashore in the Northwestern Hawaiian Islands. There is other work as well. Professor Daniel Torres has been monitoring derelict fishing gear fragments in Cape Shirreff, Antarctica. These have been very fruitful studies.

Looking at debris that has washed ashore doesn't always give us accurate information on the proportion or types of debris that are discarded or lost. There can be differential fates associated with varied debris types. Some debris may degrade more readily in the ocean. While beach surveys have been very successful efforts, they don't always give an accurate picture of the debris population at sea. I'm going to cover alternative methods that can address that.

SHIPBOARD SIGHTING SURVEYS

To get information on open-ocean or pelagic debris one can use shipboard sighting surveys. These are just about exactly what they sound like. One needs, obviously, a ship which can either be a dedicated platform chartered for the sole purpose of conducting observational transects for debris, but more often, an opportunistic vessel is used. That is, observers are put on vessels conducting other business.

Shipboard sighting surveys can document medium to extra large debris items and information on type and density can be generated. It is difficult and not customary to remove debris during these surveys. As one can imagine, the ship is steaming along the transect line which is not going to tell us about the debris mired or rusting on the sea floor. Nevertheless, numerous sighting surveys have been conducted primarily by Japanese researchers in the North Pacific and have given us some very valuable information on pelagic derelict fishing gear distribution in that region.

SHIPBOARD TRAWL SURVEYS

To examine debris resting on the sea floor, some investigators have employed shipboard trawl surveys. This is basically just trawling for debris rather than fish. Again, one needs a ship platform. This can be dedicated or opportunistic as we discussed for the sighting surveys. Opportunistic may mean that the ship is conducting trawl operations to monitor

fishery stocks or conducting active fishing, and the debris that is captured in the trawl is documented. Large to extra large debris items can be recovered in this way and the distribution of the debris documented, as well as information on the amount of debris that comes up per trawl swath. Debris captured in the trawls is effectively removed, although there have been cases of the debris then being tossed back overboard after documentation. Trawl surveys, however, are not a method that I can envision being used for large-scale benthic marine debris cleanups. Furthermore, this method cannot be used in very shallow water, on steep sea slopes or sea canyons, on rocky or coral reef environments where damage to the substrate could occur, or where nets can be lost.

DIVING SURVEYS

That brings us to diving surveys for marine debris removal. I'm not going to discuss the use of manned submersibles or remotely operated vehicles today, although I think they warrant further investigation. Today, I'm going to talk about using human divers to survey for and remove derelict fishing gear. Divers can find medium to extra large debris items. They can work in very shallow reefs and on steep sea slopes. Distribution, density, and information on type of debris can be readily obtained. I'll also demonstrate to you that debris removal can be carried out very effectively using divers.

MULTI-AGENCY MARINE DEBRIS REMOVAL

In the remainder of my talk I am going to primarily focus on and share with you information on a multi-agency marine debris removal and survey project led by the National Marine Fisheries Service, Honolulu Laboratory in the Northwestern Hawaiian Islands. This is a project that has succeeded because of the commitment and support of a multitude of partners that span the private, public, and industry sectors of our society.

The Northwestern Hawaiian Islands, as expected, lie northwest of the main Hawaiian Islands. The work that I'm going to describe today has been completed at French Frigate Shoals, Lisianski Island, Pearl and Hermes Atoll, and Midway Atoll. We have plans this Fall to investigate Kure Atoll as well. One of the reasons this area is so critical and important to investigate is that, in fact, the Northwestern Hawaiian Islands comprise the greatest amount of coral reefs by area in the U.S.—69%.

Not only are the coral reef resources incredibly valuable and precious in this area, but we know that derelict fishing gear has negative consequences on this ecosystem. These include wildlife entanglement, including threatened and endangered species as well as damage to the coral reef substrate itself. We suspect that there might be ecological consequences because of substrate disturbance caused by derelict gear scouring and abrading reefs as it moves through the ecosystem. Also of concern is the potential of derelict fishing gear to act as a vector for the introduction of alien species.

The umbrella objectives of this multi-agency partnership are four-fold: (1) continue and expand interagency partnerships addressing debris mitigation efforts, and to date, this is debris removal; (2) refine and implement procedures for expanded cleanup efforts; (3) develop expertise for net identification; and (4) expand our accumulation rate and impact study sites, which we are presently doing.

So, how did we do this? It's quite intense logistically. This last Fall we focused on Lisianski Island and Pearl and Hermes Atoll. We had the support of two ship platforms, the United States Coast Guard Cutter Walnut and the NOAA R/V ship Townsend Cromwell. We had 14 United States Coast Guard divers, small boats and inflatable barges, scientists who could analyze the derelict fishing gear recovered, and 18 specialized large rubbish bins donated by Browning and Ferris Industries, Inc. The bins allowed us to store recovered debris safely on the deck of the Coast Guard Cutter enroute to Honolulu for disposal. The ships spent just shy of a month on site at the islands.

What we did is put divers in the water behind these small boats and towed the divers on manta boards. Divers are snorkeling, not using compressed air, and the divers are towed in a parallel track search pattern documented by GPS. You can see a boat towing the divers; they happen to be at the surface at that point, and you can see what it's like under water at the left there. Once debris is located, information is taken on the size, type, and construction of the debris. The location is documented using GPS and then the divers go to work carefully cutting the debris from the coral substrate. This is a fairly surgical procedure, the divers cut the debris so as to not damage additional coral and not injure other divers around them.

Once the debris is cut loose from the substrate it is loaded into small boats by hand. These boats then transfer their debris loads to the large support ships, primarily the Coast Guard Cutter, whereupon it is craned aboard the deck. Once onboard the support ship(s), the boatloads of debris, which often consist of numerous types of debris entangled with one another, are characterized. The debris is weighed in total and then the conglomerates are separated by type. Types of net recorded are monofilament gillnet, multifilament gillnet, seine net, knotless trawl net, and knotted trawl net. Specific measurements are noted on each type of net present such as eye size, twine diameter, and the like, which we hope proves useful in identifying source fisheries. Coral rubble is removed from the nets, and miscellaneous maritime line or rope is also separated out. Lastly, all of the various components are weighed individually.

Since this work began in 1996, over 35,000 kg of debris have been removed using these methods. This total includes approximately 4,500 kg of debris removed by the National Marine Fisheries Service Honolulu Laboratory in 1996 and 1997 from French Frigate Shoals

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and Pearl and Hermes Atoll. This preliminary work spoke to the scope of this problem. In 1998 the National Marine Fisheries Service Honolulu Laboratory, in hopes of increasing effectiveness and working cooperatively with other agencies and organizations, formed a multi-agency partnership to tackle the lethal problem of derelict fishing gear in the Northwestern Hawaiian Islands. During the first year of the partnership's activities, an additional 7,500 kg of lost or discarded fishing gear was removed from the coral reefs of French Frigate Shoals. This last year's effort, Fall 1999, focused on Lisianski Island, Pearl and Hermes Atoll, and Midway Atoll and recovered just over 23,200 kg of derelict fishing gear.

Our future plans for the multi-agency partnership include expanding international participation in cleanup and source identification efforts, revisiting cleaned sites to monitor accumulation rates, expanding our reference collection for source identification, and lastly, investigating the usefulness of remote sensing for increased operational efficiency. The last topic I'll discuss today is the potential utility of remote sensing to marine debris mitigation.

The remote sensing data I'll discuss here are almost exclusively satellite data. The two types of satellite data I'll touch upon today include: (1) oceanographic data, and (2) imaging data coupled with Global Information Systems (GIS). Oceanographic data tell us that the Hawaiian Archipelago is subject to debris set adrift throughout the North Pacific Ocean. In 1994 a Japanese researcher named Kubota, using a computer simulation model, explained how debris set adrift throughout the North Pacific is concentrated in an oceanic convergence zone near the Hawaiian Islands. Kubota argued this convergence zone is a result of synergistic oceanic surface currents, including the Ekman convergence zone, due to westerly and trade winds, geostrophic currents, and Ekman drift resulting from the atmospheric North Pacific subtropical high. More recently, Rusty Brainard and Dave Foley at the National Marine Fisheries Service Honolulu Laboratory have mapped this convergence zone using instruments mounted on satellites, producing results such as the map you see here. Brainard and Foley have confirmed the presence of a dynamic convergence zone which seasonally overlays the Hawaiian Archipelago. This convergence of oceanic waters, and the floating debris it carries, has been documented to exist further south in years characterized by El Niño events. Oceanographic data can describe where marine debris is most likely to be found, but it cannot locate actual debris items, say for at-sea recovery before the debris has an opportunity to encounter protected coral reefs and associated wildlife. To identify actual locations of marine debris remotely, the combination of satellite imaging and GIS may prove fruitful.

Recently, the U.S. NOAA Fisheries and U.S. NOAA Coastwatch have been investigating the use of satellite imaging to map and assess coral reef habitat in the Northwestern Hawaiian Islands. This imaging may also prove useful in mapping derelict fishing gear in this habitat. IKONOS satellite imagery, generated from a privately owned and operated

satellite, is being used to generate base maps, and with proper groundtruthing, may be able to identify derelict nets of approximately 2 m in diameter. While this imaging is currently very expensive for large scale marine debris mapping, the IKONOS imaging could potentially be used to generate a "spectral library" of net types which might then be able to be identified in-situ with less expensive satellite images. ASTER (Advanced Spaceborne Thermal Emission and Reflectance Radiometer) imagery may be useful in this regard. This instrument is flying on the Terra platform as part of NASA's Earth Observing System. ASTER imagery may have too course a resolution ability to identify derelict nets, but a spectral library developed using IKONOS imagery should be used to determine if reflectance signatures of nets can be identified in ASTER imagery, which is available at no charge. A final source of imagery may be the AVIRIS (Airborne Visible InfraRed Imaging Spectrometer) imager. This is a unique optical sensor that flies aboard a NASA ER-2 airplane approximately 20 km above sea level providing a ground resolution of 20 m. The main advantage of AVIRIS is that it is a true hyperspectral instrument that allows very precise spectral segregation, to possibly identify the reflectance signatures of derelict fishing nets. The disadvantages include the relative coarse resolution and the cost of the imagery for those other than co-principle investigators. The success of these methods will depend on the ability to correctly classify the spectral signatures of the nets and to be able to distinguish the nets from their surroundings. Since proper classification depends on verification through in-situ fieldwork; precise field mapping is a key component to the success or failure of such initiatives.

CONCLUSION

To conclude, numerous methods exist to monitor and remove derelict fishing gear. The appropriateness and effectiveness of these methods is dependent on such variables as the objective of the study, the substrate on which the marine debris to be removed is located, and the amount of funding available to execute the effort. To maximize the effectiveness of such endeavors, emerging technologies must be used in conjunction with the continued refinement of classic methods. Further, I hope that I've convinced you that diving studies for marine debris documentation are an option for areas inaccessible to other survey methods. Lastly, that divers can remove derelict fishing gear from fragile habitat with little additional anthropogenic damage, and that the use of divers for large-scale derelict fishing gear survey and removal efforts is feasible. Thank you.

• Transcribed from a speech given August 7, 2000.

SURFACE CURRENT CONCENTRATION OF FLOATING MARINE DEBRIS IN THE NORTH PACIFIC OCEAN: 12-YEAR OSCURS MODEL EXPERIMENTS

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ABSTRACT

To investigate the dispersal of marine debris (i.e., derelict fishing nets) by surface currents in the North Pacific Ocean, numerical experiments were performed using the Ocean Surface Current Simulator (OSCURS). For these experiments, 113 drifters were seeded uniformly over the North Pacific and their movements were followed day-by-day for two 12-year intervals beginning in 1965 and 1977. The number of drifters located within each of 12 areas were summed at yearly intervals. As time progressed, winds and currents preferentially accumulated the drifters in four areas comprising 28% of the initial grid area (113 cells, each 5° by 10° of latitude and longitude, respectively). The total number of drifters in these areas rose exponentially with an average gathering time-constant of 2.8 years, starting from 28%, reaching equilibrium (73%) after approximately two time-constants of the subtropical gyre (6 years). Statistical fits to the accumulations beginning in 1965 and 1977 embracing the 1977 North Pacific regime shift gave nearly the same parameters.

In the four accumulation areas, tabulations of marine debris surveys in 5° latitude by 10° longitude squares showed 52% of the debris, a difference attributable to continuous versus OSCURS' instantaneous releases.

BACKGROUND

The accumulation of floating marine debris in the North Pacific Ocean north of the Hawaiian Islands was investigated by Kubota (1994) using Ekman drift, Stokes drift, and geostrophic currents. We carry this study a step forward by computing the time evolution of the Ekman convergence and simulating trajectories of drifting debris for 12 years using the Ocean Surface Current Simulator (OSCURS) numerical model.

The OSCURS model adds water movement to the available indices of atmospheric or oceanic variability (e.g., Southern Oscillation Index, Pacific Decadal Oscillation, North Pacific index, sea surface temperature, sea level, Upwelling Index). Computations are done on OSCURS' 92 x 180 grid that covers the ocean area from the U.S. West Coast to China, and from 10° to 66° N (Bering Strait). By generating current vectors, OSCURS integrates the effects of atmospheric forcing on the ocean surface (mixed layer) over the time

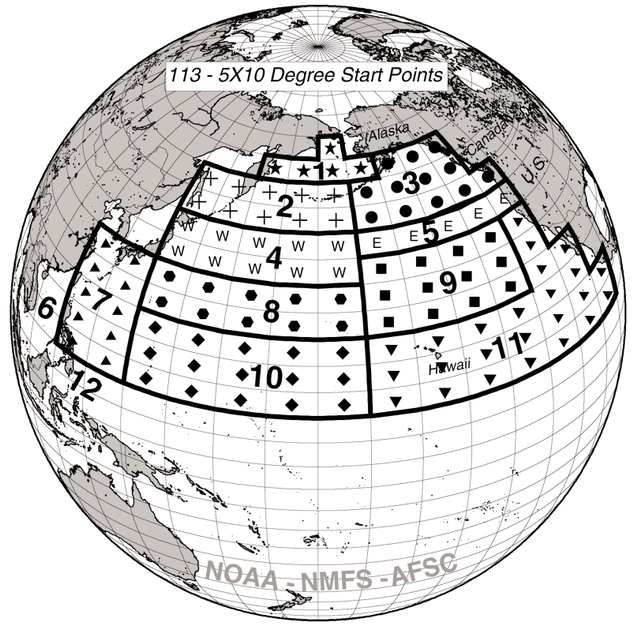
of drift. Following the methods of Larson and Laevastu (1972), OSCURS adds 2 surface current vector fields; the daily wind-driven surface current vector field and a constant long-term mean geostrophic current field (0/2000 db; see Ingraham and Miyahara, 1988). The daily surface currents are computed from gridded daily sea level pressures by applying empirical functions on a 90 km grid over the North Pacific Ocean; the geostrophic current field is computed from long-term temperature and salinity fields. The empirical function for current speed is c (cm/sec) = 5.8 (w1/2) (Larson and Laevastu, 1972), where w is the wind speed (m/sec), and the empirical function for the angle to the right of the wind increases from 20° to 31° with increasing wind speed (Weber, 1983). The current speed coefficient and angle of deflection to the right of the wind were previously tuned to reproduce 3 month-long trajectories of satellite-tracked drifters in the Gulf of Alaska (drogued at 20 m; Ingraham and Miyahara, 1989). The trajectories are also subject to a slip boundary condition at the coast, and are moved along by only the long-shore component of the wind plus the geostrophic current extrapolated to near shore. For further information, see the link to OSCURS on the Alaska Fisheries Science Center's web site at ***www.refm.noaa.gov/docs/oscurs/get_to_know.htm***.

EXPERIMENT

To investigate the time scales associated with the debris surveys of 1986–91 reported by Matsumura and Nasu (1997), we seeded drifters within the OSCURS grid. One particle was released in each of the 5° latitude by 10° longitude squares used to tabulate the referenced marine debris sightings. Figure 1 shows the locations of the 113 particles released on January 1, 1965 and January 1, 1977.

SURFACE CURRENT CONCENTRATION OF FLOATING MARINE DEBRIS IN THE NORTH PACIFIC OCEAN:
12-YEAR OSCURS MODEL EXPERIMENTS

Figure 1



Starting locations (10 symbols, 10 areas) for the 113 drifters released in the OSCURS simulations and locations of the 12 summation areas by number. Heavier lines show the 10 start areas (1–5 and 7–11) within the grid and 2 accumulation areas (6 and 12) outside the grid. These are the 12 areas in which the drifter count was tabulated yearly; note Areas 6 and 12 are out of the domain and start with zero while the total number in all 12 areas always sums up to 113.

With this experiment we sought answers to three questions:

1. Where would the drifters end up after elapsed times of 1 to 12 years? We ended the experiment after 12 years, time for the subpolar and subtropical gyres to rotate at least twice.

2. How fast do drifters accumulate? To summarize the results, we tabulated the number of particles yearly within 12 areas.

3. Did the results vary if the drifters were released in differing decadal climate regimes? To investigate this aspect, the particles were started before and after the 1977 North Pacific regime shift: 1965–1976 and 1977–1988.

RESULTS

Where do the drifters from each area go?

Figure 2 shows sample 12-year OSCURS' trajectories for the 5 drifters released in 1965 and 1977 in the Bering Sea, Area 1. The trajectories from the other 9 areas are shown in the appendix.

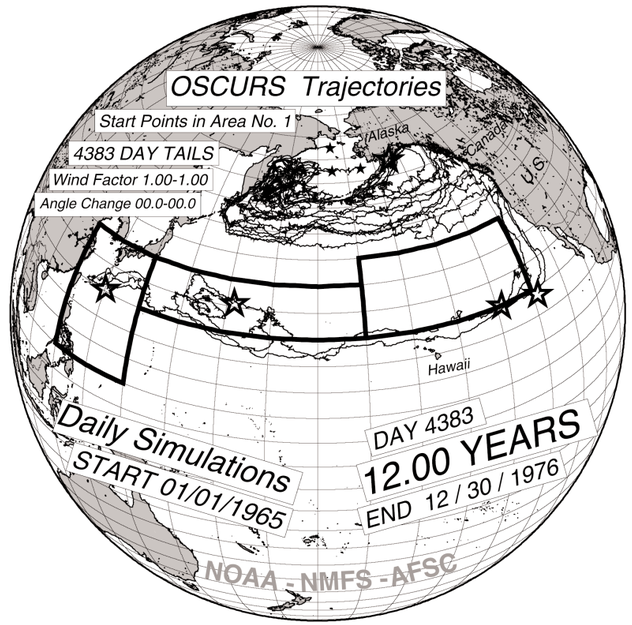
In general, these simulations show the Subarctic Region (north of 42° N) is an area of net loss and the Subtropic Region (south of 42° N) is generally an area of net accumulation. The greatest accumulation occurs in areas 7, 8, and 9 between 25° and 35° N along longitudes 120° E to 130° W. There are many interesting features, some shown for the first time, in the patterns of these long-term drift trajectories.

Five drifters started from Area 1 on January 1, 1977 (figure 2a) and moved quickly westward across the Bering Sea, then southward in the East Kamchatka Current. They then turned eastward for 2 years in the West Wind Drift, then separated in the divergence off the Washington coast. Two headed north around the Gulf of Alaska Gyre in the Alaska Current, then southwestward in the Alaskan Stream, and 3 headed south in the California Current, then to Hawai'i and the Philippines in the North Equatorial Current and into the "Western Garbage Patch". The same features were present in drifters from Area 1 that started about a decade earlier on January 1, 1965 (figure 2b) but a few more recirculated northward around the Gulf of Alaska prior to the 1977 regime shift.

Descriptions for the remaining drifters started in 1977 in Subarctic areas 2, 3, 4, and 5 and the Subtropic areas 7, 8, 9, 10, and 11, are as follows (see appendix for figures).

Ten drifters from Area 2 (Western Subarctic) and 12 drifters from Area 3 (Gulf of Alaska) also showed similar behavior. They started downstream of the Bering Sea drifters. One notable difference was the greater number of drifters from the western side that leaked to the south in the California Current compared to the apparently longer residence time for those released in the Gulf of Alaska.

Figure 2(a)

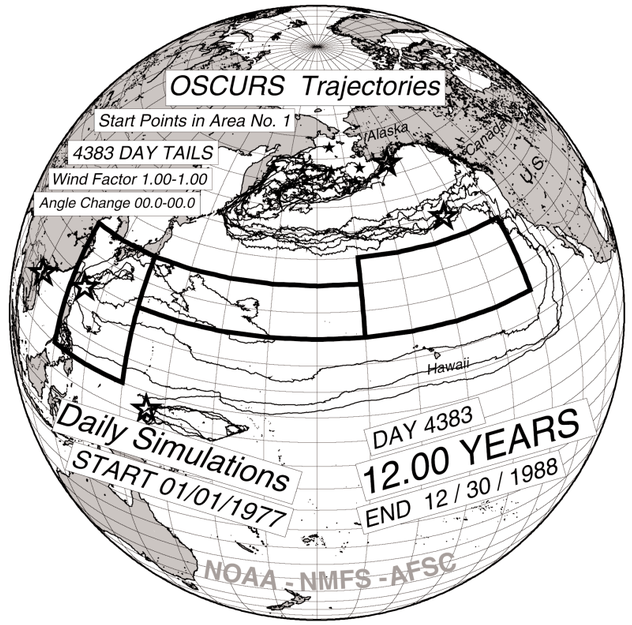


BERING SEA: 1965–1976

Figure 2(a). OSCURS trajectories (thin black lines) for 5 drifters starting in Area 1 (the Bering Sea) lasting 12 years (4383 days) beginning January 1, 1965 (drifter start points are solid stars and end points are large open stars).

Ten drifters from Area 4 (Western West Wind Drift) and 5 from Area 5 (Eastern West Wind Drift) drifted primarily southward in the California Current when they reached the North American coast. They finally accumulated within the garbage patch Areas 7, 8, and 9 or left the grid toward southeast Asia (Area 6 or 12). None of the 10 drifters from Area 4 went northward; 1 of 5 drifters from Area 5 drifted north. There is a tendency for drifters released in the eastern side of the West Wind Drift to be retained within the Subarctic Region.

Figure 2(b)



BERING SEA: 1977–1988

Figure 2(b). OSCURS trajectories (thin black lines) for the drifters starting in Area 1 (the Bering Sea) lasting 12 years (4383 days) beginning January 1, 1977 (drifter start points are solid stars and end points are larger open stars).

A major feature appears when examining the drifters released within the Subtropic Region (Areas 7, 8, 9, 10, and 11). Drifters seeded in Areas 7, 8, and 9 all remained within these 3 areas or took the westward exit from the grid to the China coast, where they do not rejoin the North Pacific circulation due to predominant year-round easterly winds. Ten drifters from Area 7 (Western Subtropic) drifted eastward at first then recirculated to the south and west tending to stay in the west or the Western Garbage Patch. Only a few escaped the grid to the west and south, but none leaked northward to the Subarctic. Ten Area 8 (Western Garbage Patch) drifters circulate slowly clockwise distributing themselves fairly evenly east-west and again none leaked to the Subarctic. Twelve drifters from Area 9 (Eastern Garbage Patch) seemed to have a long residence time there before repeating the pattern of the Area 8 drifters. Long-term drifters appeared to reside longer on the same side of the Subtropic North Pacific Ocean in which they originated.

Drifters from Area 10 (Western Trade Winds) swiftly exited westward to the Philippines where they dispersed off the grid to China or to the north and eastward in the Kuroshio Current. From there, they proceeded slowly eastward to the Western or Eastern Garbage Patch or recirculated in the Kuroshio Garbage Patch. One of the 15 drifters escaped to the north and traveled around the Gulf of Alaska Gyre.

The drifters from Area 11 (Eastern Trade Winds) consistently moved fastest across the entire Pacific under the persistent northeast and easterly trade winds. They then dispersed much like the Area 10 drifters with 2 out of 24 traveling to the north into the Subarctic Region.

Next we switched from the Lagrangian (following the drifters) to the Eulerian (changes at a fixed place) perspective for analysis of the number of drifters accumulating over time in each area. Figure 3 shows the locations of the all of the 113 drifters after 3, 6, and 12 years following releases in 1977.

Figure 3(a)

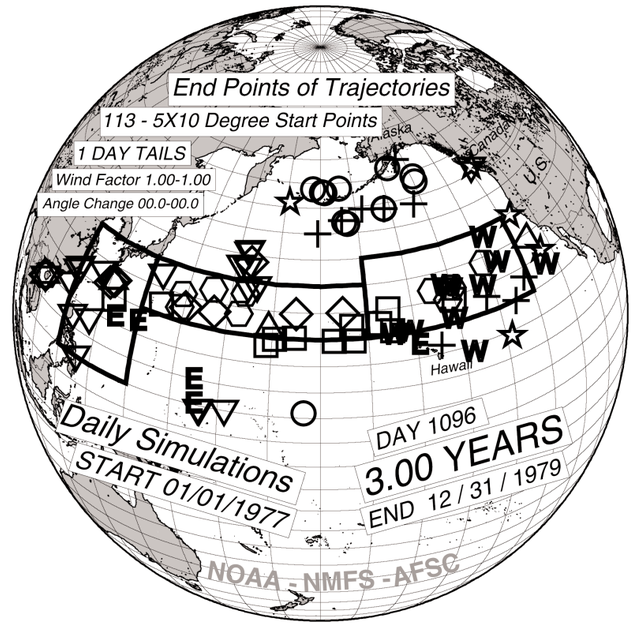


Figure 3(a). Locations of 113 OSCURS drifters 3 years (1096 days) after release (for initial distribution see figure 1). The symbols and letters correspond to the 10 areas in which drifters were released. Heavy lines outline accumulation Areas 7, 8, and 9.

Figure 3(b)

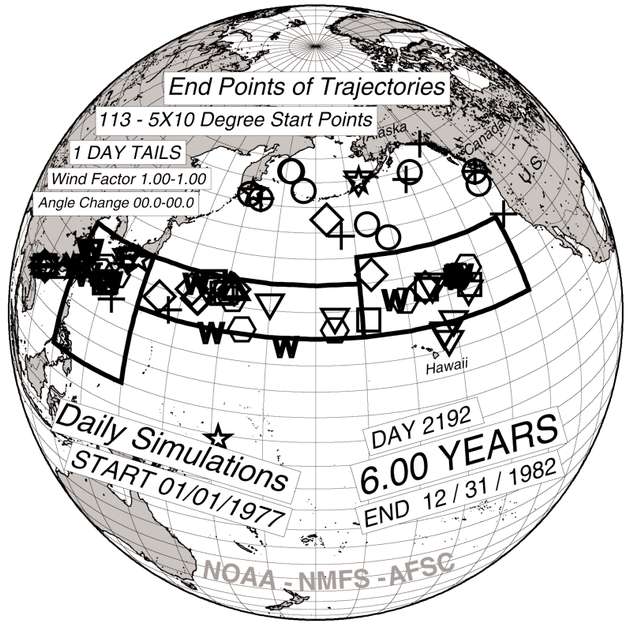


Figure 3(b). Locations of 113 OSCURS drifters 6 years (2192 days) after release (for initial distribution see figure 1). The symbols and letters correspond to the 10 areas in which drifters were released. Heavy lines outline accumulation Areas 7, 8, and 9.

Figure 3(c)

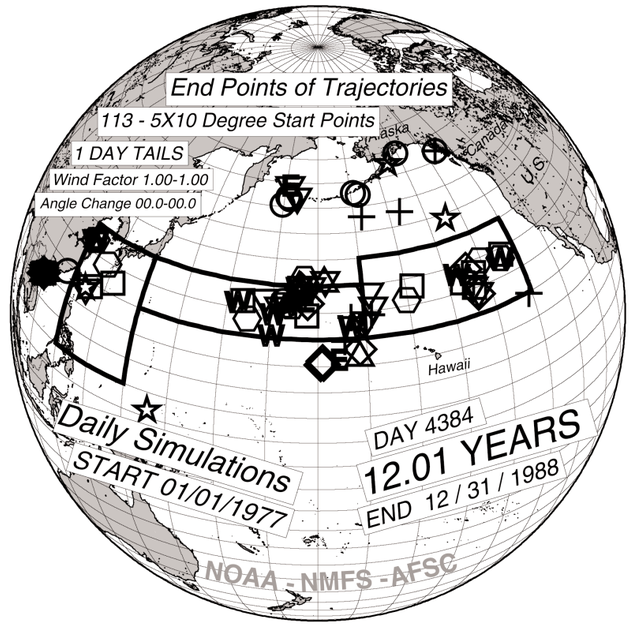


Figure 3(c). Locations of 113 OSCURS drifters 12 years (4384 days) after release (for initial distribution see figure 1). The symbols and letters correspond to the 10 areas in which drifters were released. Heavy lines outline accumulation Areas 7, 8, and 9.

It is clear from figure 3a–3c that within 3 years many of the drifters have migrated from the Subarctic Region to the Subtropic. This process continued with most of the changes evident by year 6 and only minor changes by year 12. This process of exponential accumulation is quantified below. Irrespective of whether they were released before or after the climate shift in 1977, the drifters tend to accumulate in Areas 6, 7, 8, and 9.

Drifter Time Scale

To quantify the accumulation, we tabulated the percentage of OSCURS drifters versus year in 4 obvious accumulation areas (Areas 6, 7, 8, and 9). Figure 4 shows the percentage of the 113 drifters in the 4 regions versus time for the 1965 and 1977 releases.

Figure 4

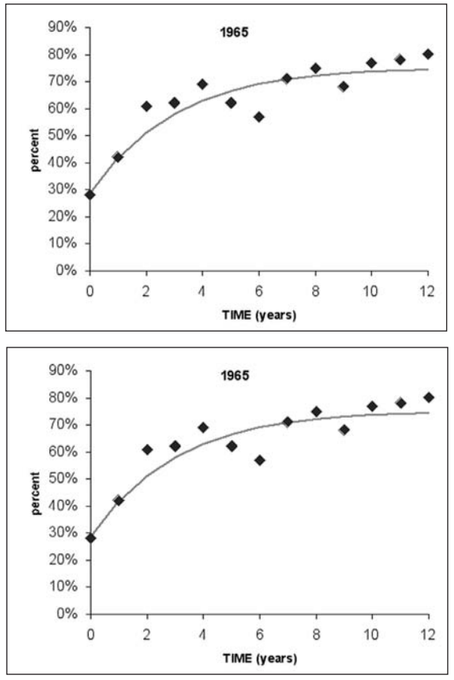


Figure 4. Percentage of 113 seeded drifters accumulating in four North Pacific Areas (6, 7, 8, and 9; see figure 1) versus year after release in 1965 and 1977. Smooth lines represent exponential model fits. Note that after 12 years, a total of 74% of all drifters are found in these four areas, whereas at the beginning of the experiment, only 28% started there.

The well-behaved nature of accumulation versus time suggests an exponential behavior. Statistical fits to the 1965 and 1977 releases provided parameters to the equation P = Pe – Piexp[-t/T], where Pe is the equilibrium percentage accumulation, Pi is the increase in percentage accumulation between the initial release and equilibrium, T is the gathering time-constant for drifter accumulation, and time (t) is expressed in years

1965-1976: P = 75% – 47%exp[-t/3.0] **(1)**

1977-1988: P = 71% – 45%exp[-t/2.6] **(2)**

On average, these four areas accumulate 43%–47% of the drifters above the initial 28% initially found there. In other words, after 12 years these 4 areas accumulate 71%–75% of the total drifters initially spread uniformly over the North Pacific Ocean. The remaining 20%–28% spread over all other areas.

The time-constant (2.6–3.0 years) indicates the time at which approximately 56%–62% of the 113 initial drifters are found within the four regions. After two time-constants (5.2–6.0 years), approximately 66%–74% of the drifters are found within the regions. At equilibrium percentages (71%, 75%), the number of drifters entering and leaving the accumulation regions are about equal.

In terms of areal coverage, the OSCURS experiment begins with 113 rectangles with one drifter released at the center of each rectangle. Areas 6–9 contain 28% of the rectangles, but end up accumulating 71%–75% of the drifters. In other words, currents and winds gathered about three-quarters of the drifters into 28% of the area.

1965 vs. 1977

Equations 1 and 2 provide a quantitative basis to compare the drifter releases before and after the 1977 regime shift.

The equilibrium percentages (Pe: 71%, 75%) differ by approximately 4%, and the percentage increases (Pi: 43%, 47%) differ by 4%. The time-constants differ by 15%. This agreement suggests secondary variations in accumulation before and after the 1977 regime shift.

Model vs. Observed Accumulation

To evaluate the field data, we compared the OSCURS results with those from the marine debris surveys by Matsumura and Nasu (1997). To do this, we summed the debris data (figure 5) that was within the OSCURS grid, then subtotaled the amount within Areas 6–9. Assuming the debris surveys represent the equilibrium condition, we compared debris with the OSCURS result, after 8 years.

Figure 5

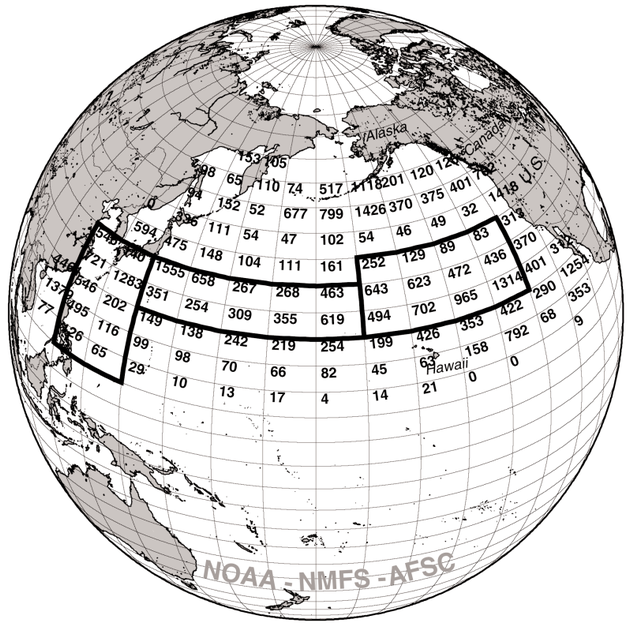


Figure 5. Accumulation Areas 6–9 (dark lines outline Areas 7–9; Area 6 is to the west) and the number of sightings of total marine debris per square nautical mile in 5° latitude by 10° longitude squares reported by Matsumura and Nasu (1997).

The four OSCURS areas (6–9) account for 52% of all marine debris reported by Matsumura and Nasu (1997) and 74% of the OSCURS drifters accumulate there. How do we compare a continuous release with the OSCURS instantaneous release? The marine debris result of 52% is about that obtained after 2 years accumulation of OSCURS drifters.

Table 1. Comparison of OSCURS drifters and marine debris surveys. OSCURS results equal the average of years 8–12 for the 1965 and 1977 releases.

Areas of North Pacific Ocean	Marine Debris Surveys	OSCURS Drifters
Total in Areas 6–9	52%	73%
Total in other Areas (1–5; 10–12)	48%	27%

DISCUSSION AND CONCLUSION

If we eliminated the sources of marine debris in this North Pacific Ocean area, the OSCURS model results show the time scale on which flotsam would accumulate. After about 6 years some 86% of it would have accumulated in the mid-latitudes with only 13% in the remainder of the North Pacific. Of course, while this accumulation proceeds, the debris degrades through processes not included in OSCURS. So, as the accumulation occurs, debris is disappearing through physical and chemical degradation.

In our experiment, we asked how surface currents and winds would redistribute an instantaneous uniform coating of marine debris distributed over the North Pacific Ocean. The time-constant, 2.6–3.0 years, is a fundamental parameter for debris accumulation in the North Pacific. This is about the time for currents to transport drifters one way across the North Pacific since both the subpolar and subtropical gyres have periods about double this value.

By analogy, we think of our experiment as observing particles in a pot of water on the stove. Before the heat is applied, the particles lie quietly, sprinkled over the water. As the water heats, convection cells begin to aggregate the particles between the cells. The time-constant is when the particles are noticeably aggregated; after two time-constants the accumulation is nearly complete. For the North Pacific, two time-constants about equal the rotational period of the two gyres.

Why do Areas 6–9 accumulate drifters? Areas 8 and 9 lie in the subtropical band in which Ekman wind effects consistently drive drifters from the north and south. Region 6 effectively traps particles because the Trade Winds drive them there, but once there, they cannot escape through the island archipelagos.

Could our results be due simply to randomness? We think not, primarily for this reason. Results for 2 time frames (before and after the North Pacific regime shift) were essentially the same.

Why do our results differ from the marine debris surveys? The comparison is not straightforward because we simulated an instantaneous release whereas the surveys reflect a continuous supply. Furthermore, in our experiment the particles do not degrade over time where presumably some marine debris disintegrated to the point of non-detection.

Many other experiments can be envisioned: OSCURS runs for continuous flotsam releases along the coastlines; releases along container vessel tracks; releases where fishing nets get loose. Would our results change for drifters having substantial windage? See figure 6 for examples of selected container spill flotsam (Ebbesmeyer and Ingraham, 1992 and 1994). These, and many additional questions we hope to answer in the near future.

Figure 6

Figure 6. Selected container spill flotsam: Nike sneaker (part of 1990 spill) found on the windward side of Oahu Island, HI in 1993; Toys (plastic beaver, turtle, frog, and duck) like many recoveries at Sitka, AK in autumn 1992; professional hockey glove found on Vancouver Island, Canada in January 1996; and "Tommy Pickles" doll head found off the Washington coast in the summer of 2000.

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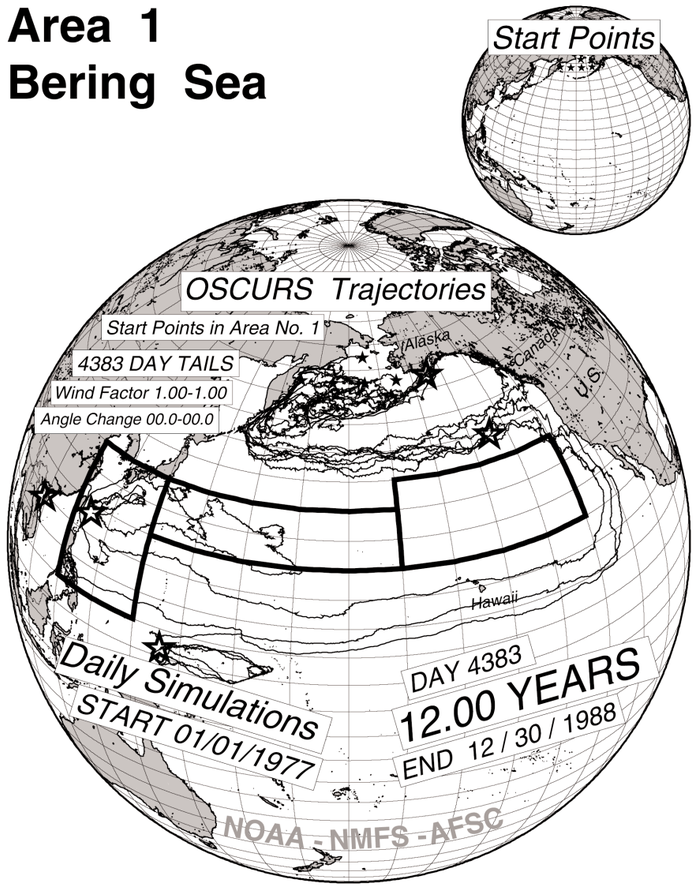
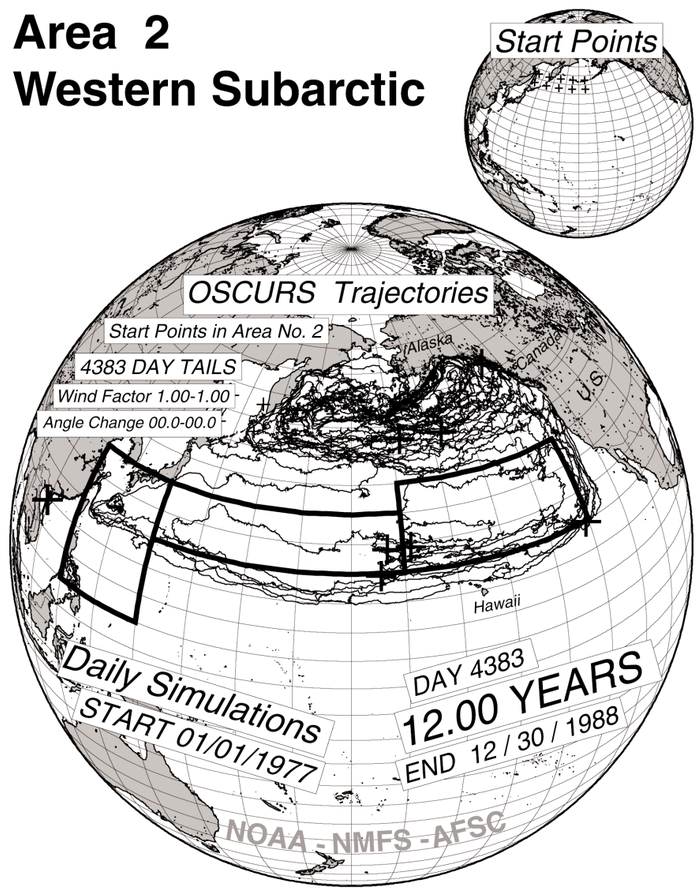
Appendix Figure 1



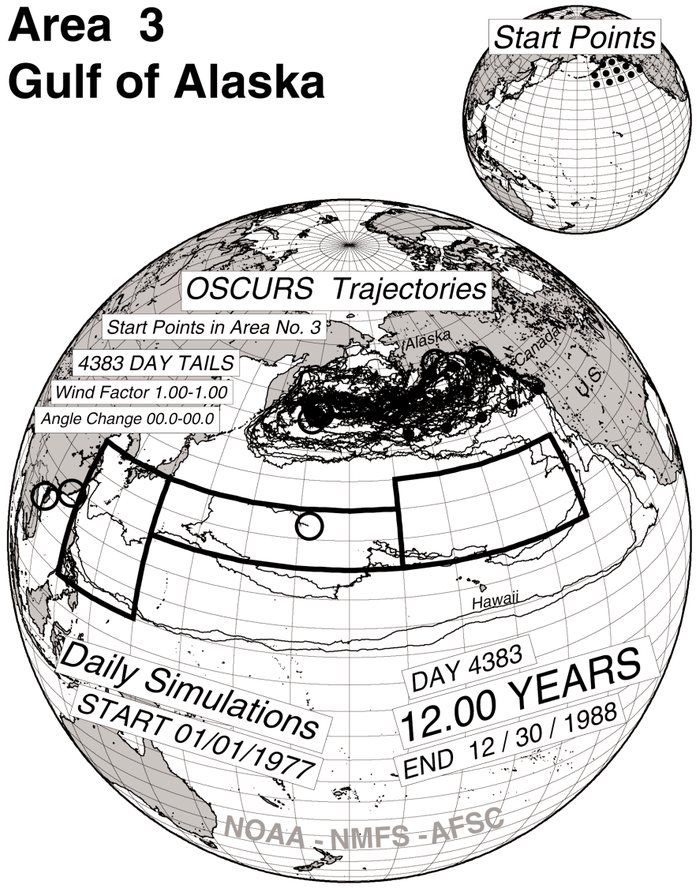
Appendix Figure 1. Start points (small solid stars) and subsequent 12-year drift trajectories for 5 drifters each started in the center of a 5° by 10° square from Area 1, Bering Sea. End points are larger open stars.

Appendix Figure 2



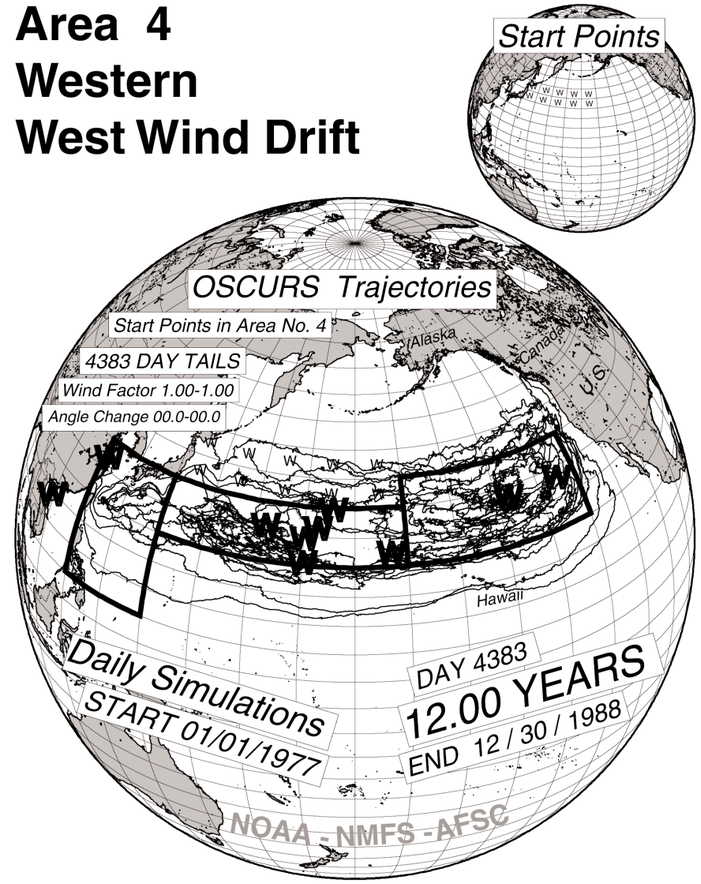
Appendix Figure 2. Start points (+) and subsequent 12-year drift trajectories for 10 drifters each started in the center of a 5° by 10° square from Area 2, Western Subarctic. End points larger bold plus signs.

Appendix Figure 3



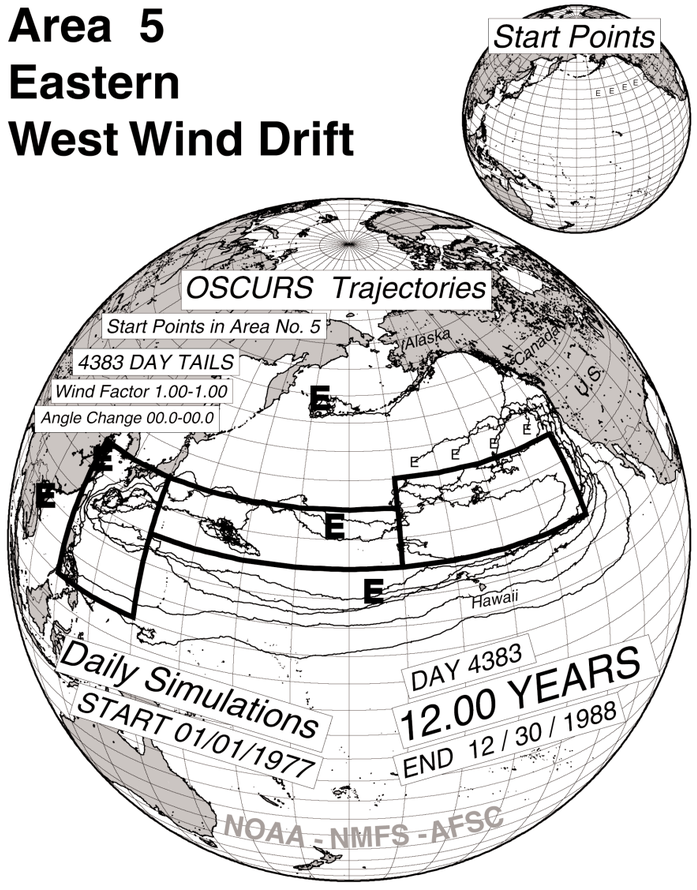
Appendix Figure 3. Start points (solid circles) and subsequent 12-year drift trajectories for 12 drifters each started in the center of a 5° by 10° square from Area 3, Gulf of Alaska. End points are larger open circles.

Appendix Figure 4



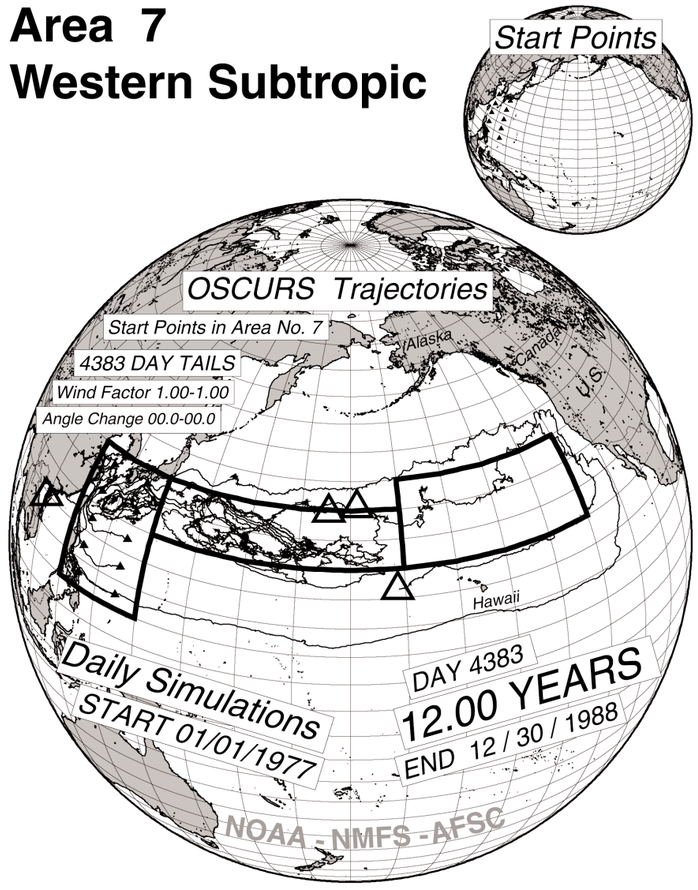
Appendix Figure 4. Start points (W) and subsequent 12-year drift trajectories for 10 drifters each started in the center of a 5° by 10° square from Area 4, Western West Wind Drift. End points are larger bold Ws.

Appendix Figure 5



Appendix Figure 5. Start points (small E) and subsequent 12-year drift trajectories for 5 drifters each started in the center of a 5° by 10° square from Area 5, Eastern West Wind Drift. End points are larger bold Es.

Appendix Figure 6

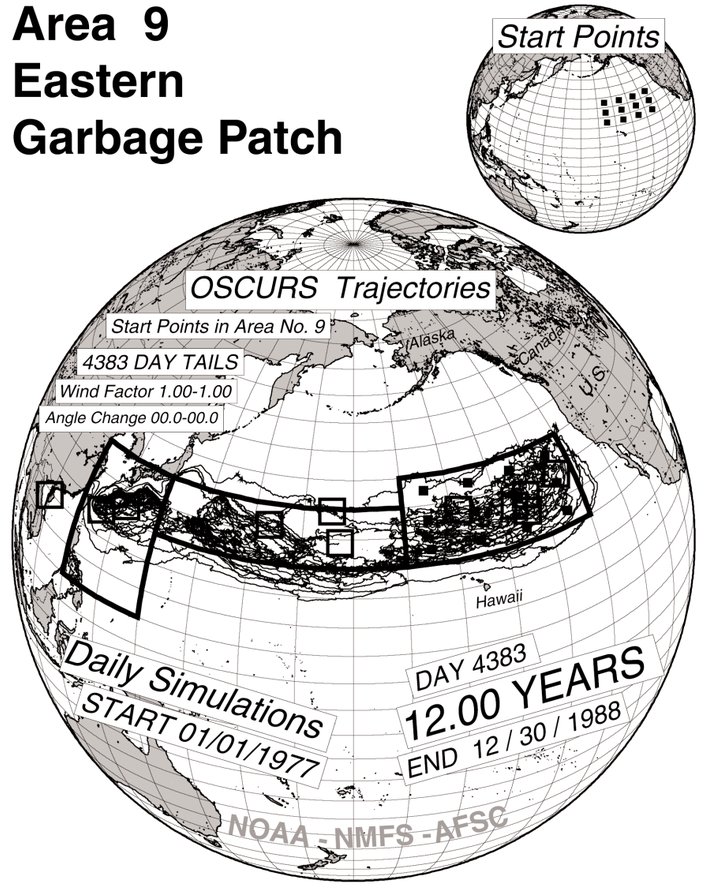


Appendix Figure 6. Start points (solid triangles) and subsequent 12-year drift trajectories for 10 drifters each started in the center of a 5° by 10° square from Area 7, Western Subtropic. End points are larger open triangles.

Appendix Figure 7

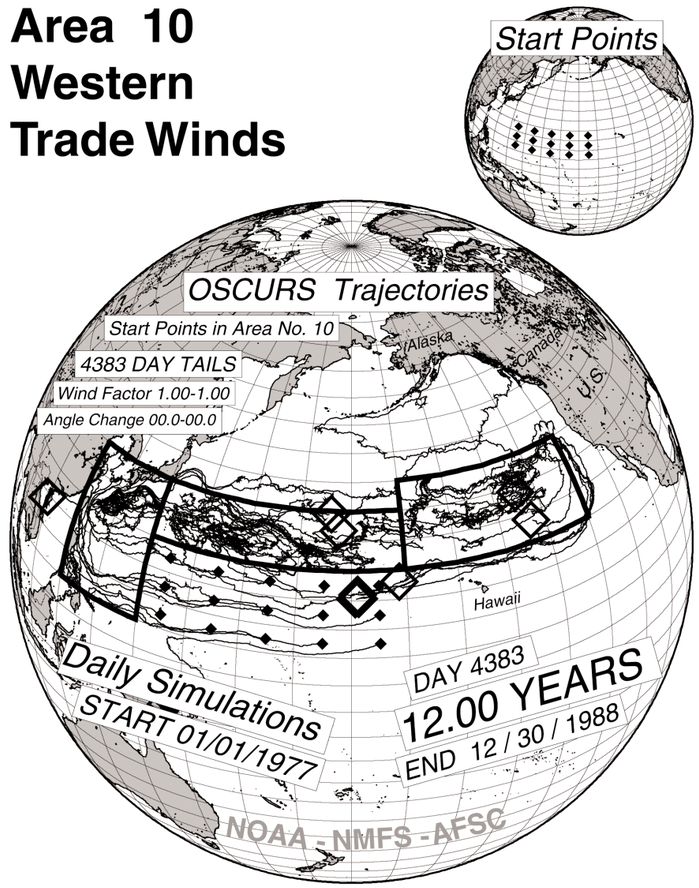
Appendix Figure 7. Start points (small solid hexagons) and subsequent 12-year drift trajectories for 10 drifters each started in the center of a 5° by 10° square from Area 8, Western Garbage Patch. End points are larger open hexagons.

Appendix Figure 8



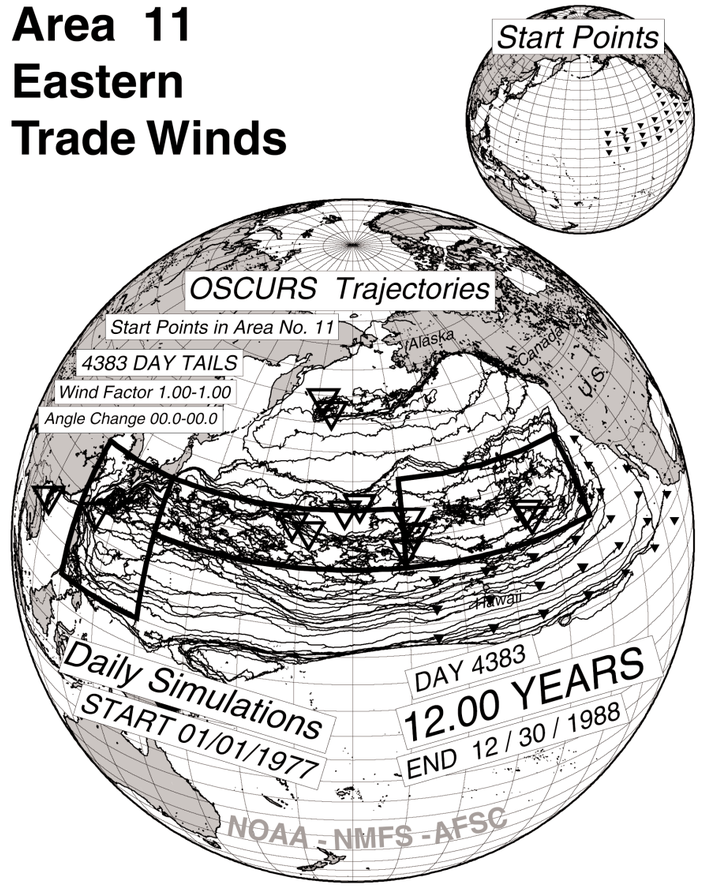
Appendix Figure 8. Start points (small solid squares) and subsequent 12-year drift trajectories for 12 drifters each started in the center of a 5° by 10° square from Area 9, Eastern Garbage Patch. End points are larger open squares.

Appendix Figure 9



Appendix Figure 9. Start points (u) and subsequent 12-year drift trajectories for 15 drifters each started in the center of a 5° by 10° square from Area 10, Western Trade Winds. End points are u.

Appendix Figure 10



Appendix Figure 10. Start points (t) and subsequent 12-year drift trajectories for 24 drifters each started in the center of a 5° by 10° square from Area 11, Eastern Trade Winds. End points are larger open inverted triangles.

MARINE DEBRIS MONITORING AND DATA COLLECTION ACTIVITIES CONDUCTED BY THE CENTER FOR MARINE CONSERVATION

Charles G. Barr, Program Manager, Center for Marine Conservation, Virginia

INTRODUCTION

Human-generated trash and debris has been a recognized marine pollution issue since the late-1960s and early-1970s (Ribic, et al., 1992; Coe, 1997). Over the past two decades, scientists, conservationists, policy makers and the general public have realized a need to understand the nature of the debris in order to examine ways to reduce and eliminate the problem. Marine debris has been identified as coming from two general sources: land-based debris and ocean/maritime based sources. It is a common belief by many that the primary source of marine debris is from ocean-based sources, when in reality, studies show that 60%–80% of the debris accumulating on our shorelines is land-generated (CMC, 1998). Though ocean-based debris has historically accounted for less than 15% of the total number of items found during the Center for Marine Conservation's International Coastal Cleanups (CMC ten-year data analysis), the nature of the debris is of great concern. Ocean-based debris in the form of abandoned nets, ropes, and monofilament fishing line made of strong, durable, synthetic materials poses a severe threat to wildlife, degrades habitats, and threatens human health and safety.

The Center for Marine Conservation (CMC) has long recognized the threat to the environment posed by marine debris pollution, and has been involved in the monitoring of marine debris for over fourteen years. CMC's International Coastal Cleanup (ICC) program is the world's largest volunteer effort designed to remove debris from the shorelines, waterways, and beaches of the world, and at the same time, collect and catalogue important information on the nature and quantity of the debris. CMC is also engaged in a comprehensive five-year scientific study on marine debris called the National Marine Debris Monitoring Program (NMDMP), funded by the U.S. Environmental Protection Agency (EPA). The NMDMP is a statistically valid marine debris survey designed to detect trends in marine debris occurring on the coastal shores of the U.S. It is the goal of both programs to shed more light on the nature of marine debris and develop means to address the sources and activities that contribute to marine debris pollution.

HISTORY

Since mankind set sail upon the oceans hundreds of years ago, the oceans have been a dumping ground for human-generated trash and debris. Just as waste generated on land was disposed into open landfills, garbage generated at sea was simply discharged overboard (National Research Council, 1995). This debris provoked little concern as an environmental issue due to the fact that the trash was composed of materials that easily decayed or degraded.

Since the 1950s, the nature of the trash and debris began to take on a new character with the development of plastics (MMC, 1990). Over the last fifty years, society has embraced the benefits and use of plastics. Its strength, durability, light weight, versatility, ease of production and handling, and low cost were quickly utilized by industry for manufacturing and packaging, making plastic preferable over other materials (ITF, 1988).

By the early-1980s, it was becoming increasingly apparent that the changing nature of marine debris was posing a significant threat to marine life, mariners, and beach goers as well as becoming an economic burden on oceanfront communities. Plastic and synthetic materials, when disposed or lost at sea, injured and killed many forms of marine life, including marine mammals, through entanglement and ingestion. At least 267 marine species were affected by entanglement and ingestion (MMC, 1995; Farris and Hart, 1995). Marine debris also became entangled in the propellers of boats or clog water intakes of marine engine cooling systems, thus disabling boats and leaving its passengers stranded. The health and safety of beach goers was also threatened by sharp glass, metal, and plastic, along with medical waste. And beach communities, whose economic base is driven by a steady influx of tourism, lost millions of dollars due to lost tourism and increased beach cleanup maintenance (National Research Council, 1995). It was increasingly becoming recognized that marine debris had become a major pollution issue.

In order to understand the impacts and significance of any pollution problem, it is necessary to identify its composition and sources (IOC, 1991). Prior to 1986, an estimate of the types and quantities of debris effecting our coastal areas and shorelines was unknown. In September of 1986 in Texas, the Center for Marine Conservation (formally Center for Environmental Education) launched its first large-scale beach cleanup campaign and marine debris survey. The purpose was to remove debris from the environment and to document the types and quantities of debris plaguing our nation's beaches. The event proved to be such a success in collecting information on marine debris and heightening public awareness that the program has continued annually through to the present.

Prompted by the recognition of the threat posed by marine debris pollution, and armed with marine debris data collected through CMC's International Coastal Cleanups, the U.S. government ratified and enacted important marine debris legislation. In 1987, the U.S. Congress ratified Annex V of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). This important set of legislation was aimed at addressing marine debris pollution at its source. Annex V, which became effective in 1988, prohibits the at-sea disposal of plastic waste and regulates the distance from shore that all other solid waste materials can be dumped. Also enacted in 1987 was the Marine Plastic Pollution Research and Control Act (MPPRCA, Public Law 100-220, Title II), which

extends MARPOL Annex V legislation to all navigable waterways of the U.S. Though this legislation is important, enforcement has been difficult and costly.

In 1989, the National Oceanic and Atmospheric Administration (NOAA) and the National Park Service (NPS) agreed to conduct a five-year pilot study developing standardized methods for quantifying marine debris. In addition, the EPA and other Federal Agencies established a working group to monitor marine debris status and trends as directed by the MPPRCA (section 2204). The MPPRCA required that the EPA, NOAA, and the U.S. Coast Guard (USCG) form "Citizen Pollution Patrols" utilizing volunteers to monitor, cleanup, and prevent ocean and shoreline pollution.

In 1990, the EPA was instructed by Congress to assess the effectiveness of marine debris legislation and other methods to control debris. The EPA and CMC joined in the effort since the most geographically comprehensive and continuous set of marine debris data had been collected and compiled in CMC's International Coastal Cleanup Database. The International Coastal Cleanup Database has provided a means to assess and review the nature and characteristics of marine debris pollution over the past fourteen years. The marine debris information gathered during the annual International Coastal Cleanup surveys, though useful and valuable, is a non-scientific means of collecting information that, at best, provides a snapshot into the nature of marine debris. It was apparent that a standardized method of monitoring marine debris was needed to statistically determine if existing legislation was working to reduce the debris in our oceans.

In 1990, Congress appropriated funds to the EPA for the development of demonstration programs to utilize volunteers in monitoring and removing marine debris from selected beaches in New Jersey and Maryland. As part of the program, CMC, in conjunction with the EPA, began to test a statistically valid methodology designed by Ribic (1991) for determining trends in marine debris. Beach sites were selected in Maryland, New Jersey, Texas, and Alabama and volunteers were recruited and trained in the program protocol. As a result, a methodology was developed by a working group comprised of representatives from NOAA, NPS, CMC, USCG, the Marine Mammal Commission (MMC), and selected scientists and was reviewed by all federal agencies that monitored marine debris. The resulting methodology has led to the development of National Marine Debris Monitoring Program (NMDMP) currently being conducted by CMC with funding from the EPA.

INTERNATIONAL COASTAL CLEANUP

The Center for Marine Conservation's annual International Coastal Cleanup (ICC) is the world's largest volunteer effort designed to remove debris from inland and coastal shorelines and collect data on the quantity and nature of marine debris. The program is also designed to educate the public on marine debris issues and effect positive change resulting in the reduction and eventual elimination of marine debris pollution. The ICC has been held annually since 1986 and cumulatively has involved over three million volunteers in over one hundred countries bordering every major body of water on Earth.

Each year hundreds of thousands of volunteers worldwide scour the shorelines collecting debris and cataloguing information on the nature and quantity of the items. The information collected by the participants in the ICC not only provides documentation on the nature of marine debris items but also provides insights into regionally significant sources of the debris.

BACKGROUND

The Center for Marine Conservation's first beach cleanup and debris survey occurred in 1986 along the coast of Texas in response to growing concerns over the large amounts of debris appearing along the Texas shorelines. The initial event was called the Texas Coastal Cleanup, and drew approximately 2,800 volunteers. The volunteers collected nearly 7,900 trash bags with 124 tons of debris from 122 miles of coastline. The success of the initial beach cleanup event encouraged CMC to make the activity a yearly event. The beach cleanup also provided an opportunity to collect information on the nature and quantities of debris appearing on U.S. shorelines. By 1989, the beach cleanup had grown to 24 U.S. states, 2 U.S. territories, and sites in Canada and Mexico, with the participation of 65,000 volunteers. Fourteen years after its inception the ICC, in 1999, had expanded to 78 countries with the participation of over 774,000 volunteers who collected 8,439,000 pounds of debris from over 11,300 miles of shoreline.

Volunteers have collected information on the types and quantities of debris since the inception of the ICC in 1986. The purpose of data collecting and recording has been twofold: first, to document the nature of the debris, and second, to quantify and track the amount of debris being found. The result has been the development of the world's largest marine debris database; the International Coastal Cleanup Database that contains information from fourteen years of beach cleaning activities.

METHODOLOGY

The International Coastal Cleanup (ICC) is a three-hour event that takes place annually on the third Saturday of September. In the event that the ICC needs to be postponed or rescheduled, local event coordinators have until the end of October to complete the activity. Each country, U.S. state, and U.S. territory has a designated survey coordinator responsible for the organizing of volunteers for the event. CMC provides ICC materials such as data cards, trash bags, and other support materials to help make the event a success. Volunteers conduct their cleanup activities and debris surveys along their local coastal

beaches and the shorelines of rivers, lakes, and streams. Since many volunteers repeatedly participate in the ICC, many of the same locations are annually cleaned and surveyed.

The ICC is a loosely structured survey designed to make a snapshot assessment of the types and amounts of debris found on cleanup day. The ICC does not employ a scientific protocol to be followed by the volunteer participants. Due to differences and inconsistencies in the method of data collection, users of the ICC information gathered during these events are cautioned in comparing data from year to year and from site to site. Variability in the cleanup sites occurs from year-to-year, and from site-to-site. For example, one location may have 1,000 volunteers cleaning ten miles of shoreline, while another location may have only five volunteers cleaning one mile of shoreline. Though the marine debris data collected during the ICC events does not lend itself to statistical analysis, it does provide important and useful information on the nature of marine debris worldwide.

The ICC data card standardizes the information to be collected by the event volunteers. On the day of the event, volunteers are provided with an ICC data card and asked to provide information on their efforts and the items that they find during the activity. Volunteers are asked to provide information on the number of people working together on the data card (usually one person is designated as a recorder in a group of people), number of trash bags filled, total distance they clean, and total estimated weight of debris collected. Over the years the number of items on the data card have varied and changed to reflect changes in societies' packaging and technologies. The original 1986 Texas Cleanup data card listed only 34 items. Today, the ICC data card lists 81 specific items commonly found as debris with space to record unlisted items. Items are grouped in eight major categories according to their compositional make-up (i.e., plastic, foamed plastic, glass, rubber, metal, paper, wood, cloth). Volunteers are instructed to use tally marks or "tick-marks" as they count the various items and then total their quantities based on their counts. Information is also recorded on the data card regarding entangled animals (specifying the form of entanglement) and items with foreign labels. Volunteers are also asked to record any peculiar items. Space is provided for volunteer comments/observations during the cleanup.

Upon completion of the beach clean up activity, data cards are returned by mail to CMC for processing. Each year, thousands of data cards are then received from all over the world. In 1999, approximately 25,000 cards were returned from volunteers. Each data card that is received is carefully reviewed before its information is entered into the CMC database. Any questionable amounts of debris are screened and checked. This requires the manual recounting of all the count tick marks to verify the totals being reported by the volunteers. The card review process is very labor intensive and may even require contacting local site coordinators or the individual volunteer who recorded the initial information to verify the findings. If recorded totals are written in by volunteers without verifying the count tick marks appearing on the card, an underestimate is substituted for quantity of that item. Once the cards are thoroughly checked and interpreted for accuracy, the information is then manually entered into the database.

FINDINGS

With over ten years of collecting information on marine debris through the ICC, what is the data telling us? As stated earlier, caution must be used in how we interpret the ICC data. The data offers us, at best, a snapshot of the types and quantities of marine debris being found on our beaches and the shores of our waterways. By examining the data collected from year to year, we can recognize patterns in marine debris at the local, regional, national, and global levels. The analysis and interpretation of the ICC data can be used to effect positive change in our societies' waste handling practices as well as encourage policies and laws that can better address solid waste management.

An overview of the past ten years of ICC data collected in the U.S. shows how the event has grown over the years and that the data suggest that progress is being made in reducing marine debris. In an examination of U.S. ICC data from 1990 to 1999, we see a substantial decline in the amount of debris being found and collected by volunteers. In 1993, volunteers cleaned and surveyed 4,498 miles of shoreline resulting in 1515.11 debris items collected per mile. By 1999, volunteers had cleaned over 7,000 miles of shoreline and were reporting only 587.49 debris items per mile (figure 1).

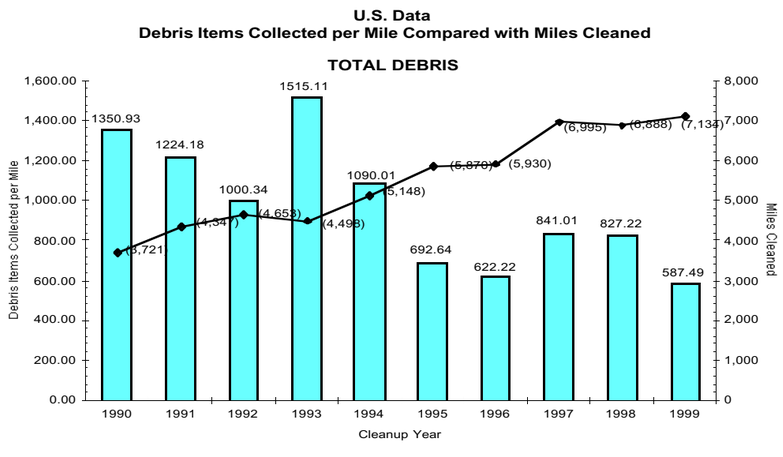


Figure 1

PERCENT COMPOSITION OF MARINE DEBRIS

The ICC data card separates the list of debris items by material composition (i.e., plastic, foamed plastic, glass, rubber, metal, paper, wood, cloth). After examining over ten years of ICC information, 1988–1998, it was not surprising to find that plastic consistently constituted the greatest percentage of all debris found in the U.S. Plastic items composed an average of approximately 60% (low of 53.19%; high of 64.54%) of all items found during the annual ICC beach cleanups and surveys. In 1997, five regions reported plastic percentages above the worldwide average: Black Sea (82.53%), Indian Ocean (69.99%), North Sea (65.79%), Wider Caribbean (64.27%), and the Pacific Ocean (62.95%). Central Europe was reporting the lowest percentage with 42.79% (CMC, 1997).

It is interesting to note that the calculations for percent composition of plastics do not include the numbers of cigarette filters found during the ICC surveys. Cigarette filters are considered a plastic item, however, their great abundance would skew the percent composition information if their numbers were to be included.

Paper, metal, and glass constituted nearly equal percentages based on composition from 1988–1998. Paper constituted an average of 11.43% of all items. Metal constituted an average of 10.28% of all items. Glass constituted an average of 10.72% of all items.

Wood, rubber, and cloth constituted the lowest percentages based on composition and were closely grouped from year to year, 1988–1998. Wood constituted an average of 2.80% of all items, while rubber constituted an average of 2.23% of all items, and cloth constituted an average of 1.32% of all items.

THE DIRTY DOZEN

Each year a list is compiled of the twelve most abundant debris items collected along the world's shorelines, waterways, and underwater. The list known as the "Dirty Dozen" has shown relatively little change over the past ten years.

1999 ICC Dirty Dozen-International

	Items	% of total debris collected
1.	cigarette filters	13.27%
2.	food bags/wrappers (plastic)	8.11%
3.	plastic pieces	6.17%
4.	foamed plastic pieces	5.05%
5.	paper pieces	4.21%
6.	glass pieces	4.08%
7.	caps/lids (plastic)	3.60%
8.	other plastic items	3.12%
9.	beverage bottles (plastic)	2.71%
10.	beverage bottles (glass)	2.70%
11.	straws	2.65%
12.	beverage cans	2.48%

Cigarette filters are consistently the most abundant debris item collected each year. Though wrapped in paper, the filter fibers are made of cellulose acetate, a synthetic polymer, and are therefore classified as a plastic. Cigarette filters are not just an aesthetic problem. They have been found in the stomachs of juvenile birds, sea turtles, and other marine life.

SOURCES OF DEBRIS

The sources of marine debris can generally be divided into land sources, ocean/waterway sources, and general sources. Debris items originating from land-based sources are the result of activities related to littering, beach users, surf fishing, picnics, landfills, manufacturing plants, sewage treatment plants, storm drains, and combined sewage overflows (CSOs). Ocean/Waterway-based sources of debris are the result of activities related to littering (from piers/docks/boats), recreational boating, recreational fishing (from piers/docks/boats), commercial fishing, merchant vessels, military/research vessels, and offshore oil/gas platforms. Many items that are found during the annual debris surveys come from sources we consider general source items. Items are designated as general source due to the potential of multiple usages being responsible for generating these items. Items classified as general source items cannot be traced to a specific activity or sole source.

DEBRIS SOURCE INDICATOR ITEMS

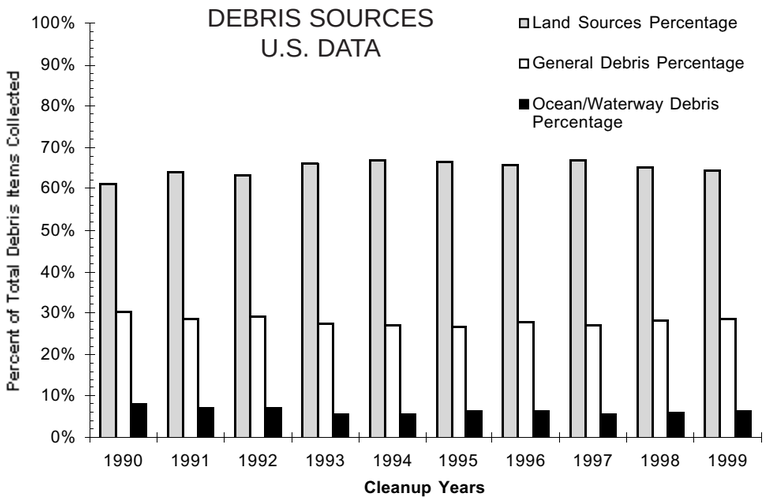
Land-based Sources include food bags/wrappers (plastic), beverage bottles (plastic), caps/lids (plastic), cigarette butts, cigarette lighters, cups, utensils (plastic), diapers, six-pack holders, straws, syringes, tampon applicators, toys, cups (foamed plastic), fast food containers, plates (foamed plastic), beverage bottles (glass), balloons, condoms, bottle caps (metal), aerosol cans, beverage cans, pull tabs, wire, paper bags, cups (paper), newspapers/magazines, plates (paper), lumber pieces, and clothing/pieces.

Ocean/Waterway-based Sources include salt bags (plastic), trash bags (plastic), bleach, cleaner bottles, milk/water gallon jugs, oil, lube bottles, buckets, fishing line, fishing lures, floats, fishing nets, hard hats, light sticks, pipe thread protector, rope, sheeting longer than two feet (plastic), strapping bands (plastic), vegetable sacks, "write protection" rings, buoys, egg cartons (foamed plastic), meat trays, fluorescent light tubes, light bulbs, gloves (rubber), food cans, crab/lobster traps (metal), crab/lobster traps (wood), crates, and pallets.

General Sources include other plastic bags, other plastic bottles, plastic pieces, sheeting two feet or shorter (plastic), other plastic items, packaging material (foamed plastic), foamed plastic pieces, other foamed plastic items, food jars (glass), other bottles/jars (glass), glass pieces, other glass items, tires, other rubber items, other cans, 55-gallon drum s (rusty), 55-gallon drums (new), metal pieces, other metal items, cardboard, cartons, paper pieces, other paper items, and other wood.

When we examine a break down of the U.S. data (1990–1999) by percent of total debris items collected with regard to sources per year, we see great consistency from year to year (figure 2). Land-based sources of debris have ranged from 60%–70% each year, while general-sourced items have ranged from 25%–30% each year, and ocean/waterway-based sources of debris have ranged from 4%–8% each year.

Figure 2



If we examine the data collected regionally by U.S. states, we can identify areas that are exhibiting higher than average amounts of debris by source. For example, in New York and New Jersey from 1989 to 1995, the U.S. ICC data consistently indicated greater amounts of Land-based debris in the form of sewage and medical waste. In 1999, U.S. ICC data indicated higher than average Ocean/Waterway sourced debris related to commercial and recreational fishing being reported in Alaska (12.3%), Washington (16.9%), Texas (15.1%), and Hawai'i (8.6%).

Though the great majority of the debris collected and recorded during the ICC emanates from Land-based sources, the Ocean/Waterway-based sources of debris constitute some of the greatest risks to wildlife. Each year during the ICC, volunteers are asked to report discoveries of any entangled wildlife and the form of entanglement. Reports of entangled, dead animals have included invertebrates, fish, amphibians, birds, reptiles and mammals. Over the past five years (1995–1999), a total of 841 animals have been reported dead and entangled in debris during the ICC. Monofilament fishing line accounted for 385 dead and entangled animals. Discarded monofilament fishing line has consistently been the leading cause of recorded animal entanglement deaths since the beginning of the ICC data collection. In addition to monofilament fishing line, the following debris items are responsible for the most numerous animal associated deaths due to entanglement over the past five years: fishing nets (138); nylon rope (105); plastic bags (95); string/ribbon (64); and fish/crab traps (54). The durability and strength of monofilament fishing line, nets, and rope present the greatest threat to wildlife and require an increased effort to prevent these materials from being discarded at sea.

ADDRESSING THE PROBLEM OF MARINE DEBRIS

It is evident from information collected annually through CMC's International Coastal Cleanup that marine debris remains a worldwide pollution issue. With inspiration from CMC's International Coastal Cleanup, environmental groups around the world have begun taking action to reduce and prevent marine debris in their home waters.

Here in the U.S., CMC has developed and implemented a variety of programs designed to address marine debris at its various sources:

- CMC's Model Communities Program is designed to help communities develop workable solutions to specific marine debris issues. Successful approaches can then be replicated in communities around the country.

- CMC's Million Points of Blight storm drain stenciling program is designed to heighten public awareness of the problem of non-point source pollution. Communities stencil local storm drains with the message "Don't Dump—Drains to Waterway."

- CMC's Good Mate Recreational Boating and Marina Program is an education and training program for marina staff and recreational boaters designed to increase awareness of the potential impacts of everyday boating activities. Five key pollution issues are addressed: (1) marine debris, (2) fuel and oil, (3) sewage, (4) boat maintenance, and (5) storm water runoff.

The information and data collected from the ICC has proved to be an important tool in cataloguing and documenting the nature of marine debris worldwide. The ICC has also served as a valuable mechanism to heighten public awareness of the problem of marine debris pollution, while at the same time, empowered local citizens to take direct action in helping to solve the problem. Marine debris, however, continues to be a major form of pollution. Continued monitoring and research is required in order to effectively reduce and eliminate the environmental threats posed by marine debris.

SCIENTIFIC DATA: NATIONAL MARINE DEBRIS MONITORING PROGRAM

The National Marine Debris Monitoring Program, coordinated by CMC and funded by the EPA, is a scientifically valid marine debris study examining the occurrence of thirty specific marine debris items occurring on U.S. coastlines. The program is designed to answer two specific questions: Is the amount of debris on our coastlines decreasing? What are the major sources of the debris? Trained NMDMP volunteers monitor selected beaches for marine debris and conduct beach cleanups every 28 days over a five-year period. The NMDMP takes the idea of beach cleanups a step further by standardizing marine debris collection using a scientifically valid protocol to determine the status and trends of marine debris pollution.

BACKGROUND

The establishment of the NMDMP monitoring sites was started in the spring of 1996 after a five-year pilot program designed by a working group composed of representatives from CMC, EPA, NOAA, the NPS, and selected researchers. The workgroup concluded based on the results obtained during the pilot program. The goal of the NMDMP is to be able to measure a 30% change in 30 selected marine debris items on U.S. coastal shorelines, with a Type I error rate of 0.10 and power of 0.84. This will require the monthly sampling of 20 beach sites per 9 coastal regions, for a 5-year period (Ribic, 1991; Ribic et al., 1992).

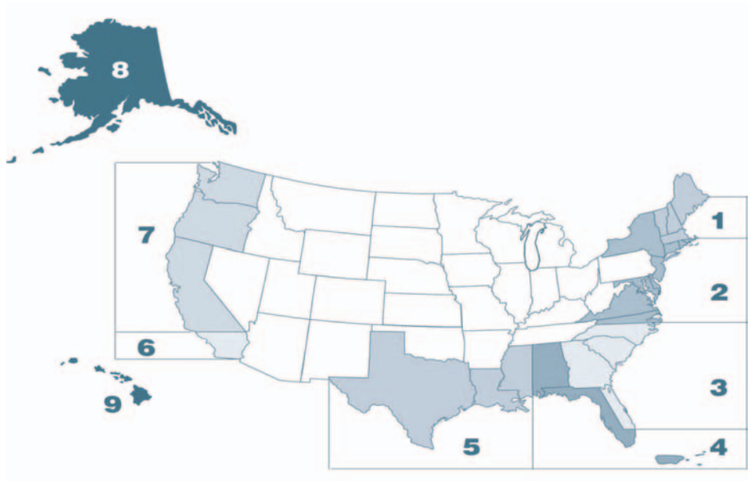
The NMDMP began with the establishment of 40 randomly selected marine debris monitoring sites along the Gulf of Mexico in 1996. Over the past four years, the NMDMP has expanded its coverage to over 130 sites located along the East, West, and Gulf Coasts including Alaska, Hawai'i, Puerto Rico and the U.S. Virgin Islands. The protocol for the NMDMP calls for 180 marine debris monitoring sites to be set up along the coastal U.S. and monitored by hundreds of trained volunteers coordinated by CMC.

METHODOLOGY

The U.S. coastline has been divided into nine regions (figure 3) based on available information on the types of marine debris found there and the prevailing currents. Twenty marine debris monitoring sites per region are randomly selected from a comprehensive list of beaches, which fit the NMDMP criteria. Each beach must be of low to moderate slope, composed of sand to small gravel, have a length of at least 500 m (1/3 mile), have clear direct access to the sea (not blocked by breakwaters or jetties) and must be accessible to volunteers year-round. Care is also taken to select beach sites that will not impact any endangered or protected species such as sea turtles, sea birds, marine mammals, and sensitive beach vegetation. At each designated study site, trained volunteers conduct beach cleanups and marine debris surveys every 28 days.

NMDMP Survey Regions

Figure 3



Region 1: U.S./Canada border to Provincetown, MA
Region 2: South of Cape Cod, MA to Beaufort, NC
Region 3: Morehead City, NC to Port Everglades, FL
Region 4: Port Everglades, FL, Puerto Rico, and U.S. Virgin Islands to Gulf Shores, AL
Region 5: Dauphin Island, AL to U.S./Mexico border
Region 6: U.S./Mexico border to Point Conception, CA
Region 7: North of Point Conception, CA to U.S./Canada border
Region 8: Alaska (southern coast and Aleutian Islands)
Region 9: Hawaiian Islands

NMDMP DATA COLLECTION

Data are recorded on the NMDMP data card by the volunteer survey teams. Information is recorded on 30 specific debris indicator items grouped into three general categories of debris: (1) ocean-based, (2) land-based, and (3) general sources.

Ocean-Based Source Indicator Items: gloves, plastic sheets (1 meter), light bulbs/tubes, oil/gas containers (>1 quart), pipe-thread protectors, nets (5 meshes), traps/pots, fishing line, light sticks, rope (1 meter), salt bags, fish baskets, cruise line logo items, floats/buoys.

Land-Based Source Indicator Items: syringes, condoms, metal beverage cans, motor oil containers (1 quart), balloons, six-pack rings, straws, tampon applicators, cotton swabs.

General Source Indicator Items: plastic bags (<1 meter), plastic bags (1 meter), strapping bands (open), strapping bands (closed), plastic beverage bottles, plastic food bottles, plastic bleach/cleaner bottles, other plastic bottles.

The 30 specific items listed on the data card will provide the information needed to measure the changes and trends in the amount of debris appearing on the U.S. coastline. Additional items may also be tracked that are specific and meaningful to local regions (i.e., plastic mesh bait bags in New England, fluorescent light tubes in the Gulf of Mexico). The data, which are collected by each volunteer survey team, are sent back to the CMC's Atlantic Regional Office in Virginia Beach, Virginia where the data are added to our national database.

As with any scientific study, quality assurance (QA) is practiced to ensure that all data collected are reproducible and comparable. It is the responsibility of each monitoring site survey director to follow QA procedures during the survey set-up, volunteer training, and data collection. Throughout the course of each year of the study, survey directors are instructed to randomly select four dates on which to conduct a QA procedure. The QA procedure requires the survey director to follow behind volunteers taking note of any debris items that were overlooked. Collected debris is reinspected and a new data card is completed with "QA" labeled on top. The original data card and the QA data card are returned to CMC for a calculation of percent error.

The data from this study will be analyzed at the end of the five-year study and will yield a more in-depth understanding into the nature and trends of marine debris in the U.S. Data will be examined both on a national basis as well as regionally. The program is currently in the final stages of the establishment of marine debris monitoring sites and the training of volunteers. To date, over 130 marine debris monitoring sites have been established along the coastal U.S. The initial analysis will begin on a regional basis upon completion of the first five years of data collection. Final analysis on a national level will occur once all nine regions have been established and operating together for a five-year period. Once five years of data collection on a national level is complete, analysis will begin to examine trends in marine debris as well as an examination of the major sources of the debris.

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STEWARD OF THE OCEAN: NAVY POLLUTION PREVENTION AT SEA

Larry C. Baucom, United States Navy Director,
Environmental Protection, Safety, and Occupational Health Division,
Office of the Chief of Naval Operations, United States Navy, Virginia

INTRODUCTION

I am pleased to have the opportunity to represent the U.S. Navy at this international conference on marine debris and I thank the Hawaiian Island Humpback Whale National Marine Sanctuary and the National Oceanic and Atmospheric Administration for inviting the Navy to this important gathering.

As the military service responsible for protecting our nation's access to the sea and access to our overseas trading partners and allies, it is natural that we should play a strong role in ensuring that man operates in harmony with our natural environment, the sea. The Navy is and should, by its nature, be a key partner in the efforts to reduce and recover marine debris, and it is our strong desire to continue to be part of the solution to this complex issue. We should set the example for others who use the sea—including the navies of other nations—in pollution prevention, elimination of harmful debris in the oceans, and assisting where we can in the cleanup of marine debris (including derelict fishing gear).

THE NAVY'S ROLE

Let me begin by explaining what my office does for the Navy. As the director of environmental protection, my mission is: to interpret environmental regulations; to ensure compliance and accomplishment of environmental planning and assessment of the impact of our operations; training and research-and-development programs; developing policy guidance for use by the Atlantic and Pacific Fleets; and working to ensure our operators are able to train the way they intend to fight, sustain fleet readiness, and remain in harmony with the environment. To be successful in addressing our many challenges, I have developed a comprehensive four-part strategy which applies equally to addressing pollution prevention, compliance, restoration projects, and natural resources conservation issues, and can have application for marine debris.

Elements of Strategy

- Complying with applicable laws/in place/enforceable consistent with what you're trying to do.
- Focusing technology and research programs to increase knowledge and understanding.
- Developing consistent policy, procedure, and methodology along with user-friendly tools for our operators to accomplish their tasks.
- Actively cooperating and engaging in strategies with regulators, public, NGOs, and Congress to enhance mutual knowledge and understanding of important issues.

PROTECTION AND PREVENTION

I would now like to discuss a little of what we are doing today to protect the ocean environment and avoid pollution from ships. Actually, the Navy has participated in the cleanup effort of derelict fishing gear, and to start, I'll give two quick examples.

Example #1

Right here in Hawai'i, Navy divers worked with the Coast Guard, NOAA, the Center for Marine Conservation, and state and county agencies in 1998 to clean up nearly 13,000 pounds of derelict fishing gear and other debris that had washed up on French Frigate Shoals. In the process, the Navy divers discovered seventeen green sea turtle hatchlings trapped on Tern Island. The divers removed debris and cleared a pathway for the turtles to the ocean, so they could begin searching for food, helping to ensure their survival.

Example #2

Last year in South Carolina, sailors from Naval Weapons Station Charleston collected approximately 1,500 pounds of derelict fishing debris from local waterways as part of their annual Beach/River Sweep. Other examples abound and I'll mention some later in my talk.

Technological Advancements

Looking at the larger scope of society's responsibilities as stewards of the ocean environment, of which Senator Inouye spoke, the U.S. Navy is fully committed. In the areas of marine debris control and pollution prevention, we have worked hard and continue to invest a great deal of effort. My topic focuses on the Navy's technological advancements in these areas.

An increased awareness among scientific and legislative communities, notably the Marine Mammal Commission and the National Marine Fisheries Service, led to collaboration among marine debris experts in the mid-1980s. By 1987, Annex V to MARPOL and the Marine Plastics Pollution Research and Control Act were passed into law. The Navy implemented a program to develop and retrofit solid waste handling technology for all of our vessels, and by the mid-'90s, common practices such as discharging plastics and other wastes were being eliminated.

We now go to great lengths and considerable expense to offload all wastes to shore reception facilities when in port anywhere in the world. When at sea we treat oily water to less than 15 parts per million, hold all plastics, and discharge only processed solid waste. Black water and gray water discharges are restricted by law and Navy regulations. To ensure that our sailors understand the laws, we provide training and give them effective, easy-to-use tools, such as this device. We call it a whiz wheel, and it covers all the restrictions on discharge at sea.

In years past, the Navy's and other service's strategy for diverting pollutants from the environment was an "end cap" solution. We would clean up contaminants generated by our ships and bases and look for a safe place to process and dispose of the waste. Although

this effort improved our waste stream in the short term, in time we found that it wasn't enough. The cost of collecting the waste, shipping it to processing facilities, and actually disposing of it was very high. In addition to the obvious costs, there was no light at the end of the tunnel; our waste stream would continue to flow and we would have to continue to pay to deal with it.

With a huge investment in research, the Navy embraced a new, more effective strategy over the past several years. We now review our processes from beginning to end, finding opportunities to reduce and eliminate pollution throughout the entire life cycle of the equipment. These efforts have made it possible for us to keep the environment cleaner, reducing the need for regulator-initiated cleanup and creating the opportunity for payback through recycling avenues and greatly reduced purchase of raw materials and hazardous substances. In fact, the hazardous materials we do use are tracked from cradle to grave to ensure no contamination of the environment.

The Plastic Waste Processor
Heat compresses and melts plastics, including food-contaminated plastics, into a 20" stable disk for storage onboard until the plastic can be offloaded ashore. Result: zero plastics discharge into the sea. [Show plastic disk] This colorful disk, known officially as a compress melt unit (CMU) and unofficially as a "plastic pizza," contains bottles, bags and other plastic materials used aboard ship. While underway, our modern aircraft carriers can generate over 300 of these disks each day. We're partnering with industry to research ways that these disks can be recycled or used in the construction industry.

PRIME Program
To reduce the total amount of plastics in the supply system, the Navy also established the Plastics Removal In Marine Environments (PRIME) office in 1990, which has evaluated over 350,000 items used on Navy vessels with the aim of reducing or replacing items to eliminate plastic waste. These changes have resulted in the elimination of over 500,000 pounds of plastics previously taken on board Navy ships each year.

The Metal and Glass Shredder
Shreds and breaks up metal and glass, which can't be retained on board for recycling, into small pieces that are placed in a burlap bag and discharged at sea. Result: no floating debris. The burlap, metal, and glass sink rapidly to the bottom where the burlap dissolves and the metal and glass are slowly assimilated into their natural elements.

STEWARD OF THE OCEAN:
NAVY POLLUTION PREVENTION AT SEA

The Solid Waste Pulper
Grinds paper, cardboard, and food waste into a benign, biodegradable slurry that is discharged at sea. Studies have shown that the pulped material quickly assimilates into the environment and biodegrades.

WRAPS Program
The Navy established the Waste Reduction Afloat Protects the Sea (WRAPS) to reduce the amount of total solid waste brought on ships. The goal of WRAPS is to reduce the amount of cardboard, paper, and packing and shipping supplies and containers that accumulate onboard. WRAPS coordinates with vendors to reduce the amount of packaging accompanying supplies purchased by the Navy and is evaluating ongoing efforts to replace paper documents used on vessels with CD-ROMs and electronic form preparation.

Parallel Plate Oil Water Separators
Existing Navy ships are equipped with parallel plate oil water separators that meet current standards. Next generation oily waste treatment will meet even stricter performance criteria through the use of Navy-developed effluent polishers that use membrane ultrafiltration technology to produce a cleaner effluent.

To prevent damage to marine ecosystems by accidental oil spills, the Navy has many mechanisms in place, both ashore and at-sea, to prevent the accidental release of oil into the environment and to provide a rapid response and cleanup action in the event of a spill. In addition to the well-established compliance programs on the installation level, Department of Defense (DoD) is a member of the National Response Team (NRT) established under the National Contingency Plan. Navy is the DoD Executive Agent for the NRT and possesses one of the world's largest inventories of oil pollution response equipment with response capability available from a worldwide network of installations. In the event of large-scale oil spills from whatever source, trained operators, mechanics, and supervisory personnel deploy from U.S. response centers with the appropriate equipment. For example, Navy fleet skimmers collected half of the oil recovered from the Exxon Valdez spill in Alaska.

Collection and Holding Tanks
Our existing fleet has been outfitted with (sewage) collection and holding tanks. The tanks are sized to retain all sewage while transiting within three nautical miles of land. The tanks will also collect graywater in port for offload to shore reception facilities including pier sewers, trucks, or barges.

Many other pollution prevention initiatives were prototyped on USS Carl Vinson. I served as her Commanding Officer from October 1994 through January 1997. I'll briefly describe some of the P2 processes and technologies we pioneered for the Navy.

The Aqueous Parts Washer
A self-contained unit that cleans small precision parts without the use of hazardous solvents.

The Electronic Particle Counter
Effectively "scans" machine fluids to determine the need for replacement, rather than "changing the oil every 3,000 miles." It succeeded in reducing hazardous waste generation by 50%.

The Hydraulic Fluid Purifier
Filters water and debris out of used equipment fluids, eliminating the need to dispose of the waste fluid and reducing the requirement for purchasing new fluids.

For our new ships we are currently developing a new waste treatment system that will employ biological treatment in conjunction with membrane filtration. Lab tests are encouraging and we anticipate this technology will be available to support our new DD-21 destroyer program.

Ultimately, the Navy is planning to design and build environmentally sound ships from the keel up. These ships will have minimum use of hazardous material and will treat or destroy all wastes on board. The resulting independence from shore waste offload facilities should dramatically reduce costs at ports and ensure the minimum possible impact on the marine environment.

THE FUTURE — WHERE WE ARE HEADED AT SEA

So rather than resting on our laurels, we are aggressively looking towards the future for a more effective and environmentally sound manner to address the shipboard solid waste stream through the development of state of the art advanced solid waste incinerator technologies, initially for our large platform ships. The development of this new shipboard technology will improve our solid waste processing capability by enabling our ships to more efficiently dispose of solid waste while at the same time helping us steer towards the Navy's ultimate goal of a zero discharge ship.

Pertinent Navy Success Stories

The Navy's recycling and cleanup programs have been significant in reducing potential plastics and other debris from entering local waterways, and subsequently coastal and marine areas. At the same time, Navy participates in numerous coastal and river cleanups, which are often coordinated by our natural resources managers.

International Coastal Cleanup
In 1991, the Navy began participating in the International Coastal Cleanup, sponsored by the Center for Marine Conservation. Starting with a pilot effort in Texas and Virginia, the Navy expanded participation in the program to bases in Florida and California in 1992. Since then, it has expanded nationwide as a voluntary program with high public support. Similar cleanup efforts have included the St. Johns River cleanup by NAS Jacksonville and NAVSTA Mayport, "Save the Bay" cleanups by bases in Norfolk area, Patuxent River, Dahlgren, etc., and similar efforts in Puget Sound coordinated by NSB Bangor, NAS Whidbey Island, and other overseas activities as well.

U.S.S. MY SCHOOL Program
Another contribution by the Navy was the development of the U.S.S. MY SCHOOL curriculum for fourth through sixth-graders. The Assistant Secretary of the Navy (Installations and Environment) funded the Center for Marine Conservation to produce this curriculum in celebration of the 1992–1993 Year of the Gulf of Mexico. The curriculum promotes a hands-on science approach to learning about marine debris and how it affects the health and safety of the world's oceans and beaches. Using their imagination, children convert their school into a ship; the cafeteria becomes the ship's gallery and each day the classroom becomes a place to think about how to come up with real hands-on solutions to marine debris.

School Partnership Program
Under the Chief of Naval Operations Personal Excellence Program, the Naval Pacific Meteorology and Oceanography Center partnered with the Moanalua Intermediate School in Honolulu, Hawai'i to initiate a program to educate school children about the environment. The program included periodic beach cleanups, a week in the classroom teaching environmental sciences with a focus on marine debris, student production of a "public service announcement" on marine debris, and participation in the International Coastal Cleanup, "Get the Drift and Bag It Day."

MCB Hawai'i Helps Clean Up Ghost Nets
"Ghost nets" are a constant threat in Hawai'i's near-shore waters. Averaging 300 feet in length, they drift in and impact reefs in three significant ways:

1) Smother, entangle, and kill the coral.
2) Transport alien species from reef to reef.
3) Entangle other marine life, including protected species.

Since 1998, Marine Corps Base Hawai'i (MCBH) has worked with state and community volunteers to remove over 5,000 pounds of net debris each year in Kaneohe Bay alone. These cleanup activities are an annual Earth Day event.

CONCLUSION

As you might expect, we are very excited about the current accomplishment of and the opportunity for our pollution prevention technologies and other Navy initiatives to continue to preserve our oceans and the overall environment. As we continue our vital missions, we are committing dollars and resources to making sure these "clean and green"efforts continue and grow.

As our technological abilities to preserve the environment improve and evolve within the Navy, we are experiencing a cultural shift as well. The young sailors who work aboard our ships and our shore facilities today have an ingrained, special appreciation for the environment that my generation is just now coming to grips with. These men and women grew up with recycling in their home communities. They are familiar with terms like "sustainable agriculture" and "e-commerce" and the environmental advantages those approaches bring. They expect the products they use and the vehicles they drive to be environmentally friendly.

These young sailors represent a new generation of seafarers, raised in homes and educated in schools where they have learned to value and protect our environment. Great lessons to be learned by all generations.

I hope and believe that this new, prevailing attitude will help the Navy as we strive to be good stewards of the ocean and environment while performing our crucial job of defending this nation.

Thank you for the opportunity to address you today, and I hope I have provided some insight into the technological solutions and strategies the Navy is using to do its part in preserving the environment and helping to solve issues such as those discussed at this conference. Thank you.

PLASTICS AND THEIR IMPACTS IN THE MARINE ENVIRONMENT

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INTRODUCTION

I want to thank the organizers of this conference for providing me with the opportunity to address this gathering. My research specialty is polymer science and engineering, particularly the topic of plastics and the environment. I think it is important to closely monitor the impacts of introducing plastics in to the fragile marine ecosystem and to study the various technical mitigation strategies that are available to minimize any damage due to plastics in the world's oceans. In this short presentation I plan to achieve two objectives. First, I want to discuss the factors responsible for the breakdown of plastics once they are introduced into the marine environment. Then, I want to consider the various technical options, particularly the technologies for biodegradable and photodegradable plastics that are available, to address the problem of plastics in the marine environment.

TYPES OF PLASTICS

Shown below in table 1 are the major classes of plastics commonly used in fishing gear application. As you know, fishing gear, accidentally lost or intentionally discarded, remain an important component of persistent marine debris. There are hundreds of different types of plastics and plastic compositions, but of this only about four or five types are commonly used in fishing gear. The table also includes the specific gravity of the plastic and as you see some, as indicated, are denser than seawater and will sink rather than float at sea. Out of these plastics it is the nylons and polyethylenes (and also some polypropelynes) that are used most in the construction of fishing gear. This is not surprising as these plastics have the unique combination of properties that make them best suited for the purpose. For instance, they have very good strength, good elasticity, and have low perceptibility in the water column and contribute to the high efficiency and catchability of the fishing gear.

With all these strengths, plastics as a class of material have a significant drawback from an environmental standpoint in that they biodegrade at an extremely slow rate compared to other organic materials. All organic materials, including plastics, do biodegrade, but they biodegrade at such a slow rate that they are of little practical consequence. This bioinertness of plastics is both a drawback and also an asset because the biggest shortcoming of the natural fiber fishing gear that we had a long time ago was that they were readily biodegradable! They weakened as they biodegraded over time and therefore could be used for only a limited duration. However, in cases of loss or abandonment of the natural fiber gear, the environmental consequences were limited as the gear biodegraded readily without posing significant ghost fishing, entanglement, or other hazards.

Table 1 **Types of Plastics Used in Fishing Gear Applications.**

Type	Density (g/cm3)*	Buoyancy	Gear type
Polyethylene	0.96	float	Trawls
Polypropylene	0.90	float	Trawls
Nylon 6 or 66	1.14	sink	Trawl sections, gill nets
Saran fiber	1.70	sink	Seine nets

** A nominal density is given. Each class of polymers display a range of densities.*

Figure 1 (not shown) is representative of the consequences of poor biodegradability of synthetic fishing gear. It shows skeletons of marine mammals entangled in a submerged section of netting, probably nylon gillnet. What are the factors that govern the breakdown of plastics in the ocean environment, or for that matter, in any environment? The primary factor is the solar actinic radiation, or the part of the solar spectrum that spans from about 290 nm to about 315 nm. This ultraviolet radiation, called UV-B radiation, readily photodegrades all plastics commonly used in fishing gear. However, the effectiveness of this factor depends on whether an efficient light-stabilizer is compounded into the plastic. Understandably, manufacturers routinely incorporate efficient light-stabilizers into most plastic products, certainly including fishing gear, in an effort to obtain long service lifetimes. Therefore, in practice, the solar UV radiation does not have that much effect in breaking down most plastic compositions exposed to sunlight. In addition to sunlight, the slow oxidation of the plastic, where oxygen in the air oxidizes the plastics slowly and facilitates the breakdown, can be a contributing factor. This process too is very slow and with some plastics can be comparable to the rate of biodegradation. Hydrolysis (or chemical breakdown by water) is available with certain and very special types of plastics. But these types of plastics are not used in the fishing industry. The conclusion here is that there are no effective reliable mechanisms to breakdown a well photstabilized plastic product in a reasonable time scale when exposed to the marine environment.

This leads to perhaps the most popular question posed to scientists working in this area—"How long will the plastics last at sea?" Typically, scientists respond to this question somewhat vaguely. The lifetime of a plastic material in the marine environment is quite variable and depends upon the intensity of the different factors contributing to the breakdown available at that location of interest. It depends, for instance, on the temperature of the water column, on the amount of solar UV-B insolation, the biotic potential of the environment, and more importantly on how one defines the "lifetime" of plastic at sea. The term can have different meanings. Does it mean how long does the material persist in a geometry (such as webbing) strong enough to cause entanglement? In

which case you have a certain time period within which the strength of the extensibility of the plastic is decreased and an animal caught in the plastic netting can free itself without any problem. Alternatively does it mean in a stricter environmental sense that total mineralization or total conversion of the plastic to carbon dioxide and water? The latter process will take hundreds of years because most plastics mineralize at extremely slow rates.

RECENT STUDIES

Research over the last decade has clearly established one important factor conclusively. Plastic exposed floating at sea at a given location tends to break down at a much slower rate compared to the same plastic material exposed outdoors on land at the same location. This is reported to be generally true for most plastics, except perhaps for Styrofoam. In the case of Styrofoam, the material does break down into smaller particles faster at sea than on land, perhaps because of the unusual expanded bead structure of the material. This experiment has been carried out in several locations with various types of plastic products including troll webbing, rope used in fishing, six-pack rings, and Styrofoam packaging.

There are two reasons that can explain this finding. The first is that plastics in contact with seawater undergo extensive fouling. Sunlight is often not able to reach the plastic surface partially covered with foulants, unlike with the sample on land. This shielding effect of foulants on floating plastics can reduce the rate of light-induced breakdown. But more importantly, the differences in the temperature of the material exposed floating in seawater and in air on land may also explain the difference in rates of breakdown. The temperature of a piece of plastic exposed to sunlight on land rises up because of the absorption of infrared light, in a process called "heat buildup". The temperature of the plastic can rise by as much as 20° centigrade higher than that of the ambient air. But when the same plastic is exposed in seawater, the plastic is maintained at the relatively lower temperature of seawater. As the rate of degradation reactions has a positive temperature coefficient, the samples exposed in water degrade at a slower late.

This was recently illustrated in an experiment of weathering plastics in the desert environment where two sets of polyethylene film samples were used. One was exposed in air and the other placed in an UV-transparent box that was air-conditioned and kept at 25° centigrade. The tensile extensibility is a particularly sensitive indicator of photodegradation for film samples and was used to monitor the degradation process over a period of 10 months. While the experiment is still ongoing, the data collected to date illustrates the dramatic effect of temperature on the degradation process. The sample exposed in air disintegrated within a few months while the sample maintained at lower temperatures maintained its integrity and had significant residual extensibility even after 10 months of exposure.

Latex rubber balloons are an important category of product in the marine environment. Promotional releases of balloons that descend into the sea pose a serious ingestion and/or entanglement hazard to marine animals. Based on the fairly rapid disintegration of balloons on exposure to sunlight in air, the expectation is that balloons do not pose a particularly significant problem. In an experiment we carried out in North Carolina we observed that balloons exposed floating in seawater deteriorated much slower than those exposed in air, and even after 12 months of exposure still retained their elasticity.

What technological control options are available to mitigate the problem, if any? I want to briefly discuss four different options here. We have photodegradable plastics and we have a category called biodegradable plastics, which is somewhat of a misnomer in that all plastics are invariably biodegradable. These refer to particular types of organic polymers that biodegrade at a much faster rate than regular plastics. Then we have on-board plastic waste management that can be practiced on fishing vessels as well as on naval vessels. Then finally you have education, because willful discharge of plastics in the ocean is really a behavioral problem and there are no technical options that will completely eliminate that.

PHOTODEGRADABLE PLASTICS

There are certain types of products with which photodegradable plastics work very well. I do not want to get into a chemical discussion of the structure and function of these materials because of the lack of time. However the structure of polyethylene, for instance, can be changed chemically during manufacture so that it absorbs UV-B radiation from sunlight and breaks down into a very brittle material in a fairly short period of time. As polyethylene is the most used commodity plastic, this is a very useful technology. A common product, such as a six-pack yoke, when discarded outdoors may last a fairly long period of time. If the same item were made of this modified, enhanced photodegradable polyethylene, it would deteriorate in sunlight in a faster time frame, minimizing the chances of entanglement hazards. This type of technology is also useful in litter reduction to improve aesthetic appeal of beach or even urban areas.

An important consideration, therefore, is if this technology will perform adequately under marine exposure conditions as well as it does under land exposure. A test procedure employing a floating rig in the Biscayne Bay in Miami, FL was used in an effort to answer this question (the experiment was subsequently repeated in Seattle, WA). Essentially, a set of plastic samples of interest, for instance sections of trawl webbing, were attached to the PVC pipes that made up the rig and were exposed to sunlight while the samples were floating in sea water. The mechanical properties of these materials were monitored weekly over a period of time. This exposure procedure is now an ASDM standard protocol [ASTM D54 37]. We studied two of the commercially available photodegradable polyethylenes and found that the rate of degradation of the samples accelerated considerably even when the samples were exposed floating in seawater. The advantage in terms of

preventing entanglement from at least the polyethylene products in marine environment will be significantly reduced by the use of this technology. We also found, as expected, the rate of deterioration was slower than that of the samples exposed in seawater, compared to those that were exposed in air.

For instance, an unstabilized polyethylene film material, such as a section of a thick plastic sheet, exposed outdoors in Miami, would gradually loose its tensile strength over a period of several months. Typically, the point of embrittlement (the level of degradation where the material has virtually no strength and breaks down into little small pieces on handling) was reached in about three to three-and-a-half months. The period is short because the material has no light-stabilizer in it. But if you were to expose the same sample floating in seawater at the same location, after three to four months no significant decrease in the strength can be found. The test results on tensile strength will be about the same as the unexposed samples. In repeating the same experiment with photodegradable materials we found that the samples exposed in both air and seawater photodegraded and lost strength much faster compared to the regular unstabilized polyethylene material. The point of embrittlement for the samples exposed in water was reached in four to five months of exposure. Samples exposed on land embrittled in several weeks under these exposure conditions. However it is important to recognize that while convincing studies of this nature have been carried out on samples of different plastics, no data is available for plastic fishing gear made out of photodegradable materials.

With fishing gear using this type of technology an important question is the nature of trade off between catchability of the gear and its degradability in the ocean. This issue has not been addressed in the literature. In the early-'90s we carried out some studies on the fouling of fishing gear in both Biscayne Bay and the Seattle, Washington area. We do not have the time to examine all the findings in detail, but an important possibility emerged from that study. The study included measurement of the density of fouled trawl web segments at different durations of floating exposure. Based on the data, we were able to surmise that a floating piece of fishing gear in the ocean would initially increase in density because of copious fouling. The density would be high enough for the material to be negatively buoyant. This is hardly surprising because of the high levels of fouling obtained at the locations where the tests were carried out. Upon submerging it to a level in the water column that is determined by the density, the algal fraction of the foulant colony is likely to die because of the lack of sunlight. The density could change again and become low enough for the sample to float again. This was postulated based on density data for samples exposed floating and submerged in seawater. Recent experimental observations by Murray Gregory are consistent with this notion. In relying on solar exposure to bring about faster degradation of derelict gear at sea, the possibility of foulant-induced sinking and subsequent, possibly intermittent, disruption of the exposure needs to be taken into account.

With controlled lifetime fishing gear that employed photodegradable technology, it would of course be crucial to keep it shielded from light when not in use. The technology allows one to build an approximate timer into the gear that would allow it to be exposed to some predetermined level of exposure to sunlight before enhanced degradation sets in. Typically the transitions in strength of the gear, once the enhanced degradation has commenced, would be fairly rapid. At least in theory, it is possible to set this timer for controlled lifetime at a pre-selected duration of use longer than the anticipated period of use for the gear. This would not work for all gear, it would only work for floating gear, floating plastics, and for gear that is expected to last for a certain fixed period of time (not for gear that is continuously repaired and reused).

In these discussions we have assumed embrittlement to be an adequate end point in the degradation process. From the point of view of minimizing entanglement of marine mammals and perhaps ghost fishing, it is certainly a very pertinent end point. At embrittlement we have essentially converted the plastic six-pack ring, or a piece of netting, from a hazard into a collection of relatively small pieces. But have we removed the plastic material from the marine environment? In a recent experiment we exposed an enhanced photodegradable polyethylene sheet (the same material used in photodegradable six-pack rings) in Florida. The tensile strength was measured every few weeks to monitor the degradation of the sample. In addition, the molecular weight of the same samples used for tensile testing was measured using gel permeation chromatography (GPC). The goal was to find if the dramatic reduction in the strength of the photodegradable plastics was accompanied by a correspondingly large reduction in the molecular weight. At embrittlement, the molecule weight was 11,000! (see table 1) The material still remained a polymer. It is well established in the literature that a molecule rate of 11,000 polyethylene is not biodegraded in any practical time scale. There is no mechanism for biodegradation of that long of a molecule in the marine environment. In defining degradation in terms of embrittlement we may be helping the marine mammal population. The powdery residue, however, remains persistent in the sea environment as debris perhaps affecting the filter feeders. Some evidence of accumulation of small plastic pieces in the ocean environment has appeared in the literature.

A related issue is that of careless handling of virgin resin beads during transport and processing. Plastic resin beads are widely distributed in the world's oceans and are ingested by marine birds. This is an example of a type of plastic pollution for which there is no technological solution. What is needed here is better shipboard management and an increased general awareness of the fragility of the ocean ecology by all users of the sea. If one stops to think of it, except for the small amount of plastics incinerated, every little bit of plastic manufactured in the world for the last 50 years or so, still remains in the environment somewhere. It's either in the landfill or it's somewhere in the ocean because there is no effective mechanism to readily break it down.

PLASTICS AND THEIR IMPACTS IN
THE MARINE ENVIRONMENT

BIODEGRADABLE PLASTICS

While most plastics biodegrade far too slowly to be practically significant, a few have chemical structures that allow rapid biodegradation. These are relatively expensive specialty plastics, rarely used in common applications. Some of the more promising polymers in this category are polylactic acid and poly (hydroxy butyrate valerate) copolymers. In biodegradation, microbial enzyme action converts a plastic material first into small organic molecules and invariably into carbon dioxide and water. This is the ultimate fate of natural materials such as plant and animal debris in the marine environment. The enhanced biodegradable polymers are generally more expensive than the common polymers such as polyethylene and nylon used in fishing gear. Also the effectiveness of the biodegradable plastics as materials of design for fishing gear has not been well studied. Materials for gear application require specific properties. Good elongation is important in gill net applications and good abrasion resistance as well as fast sinking rates are desirable in troll or bottom type gear. Nylons remain the most popular choice for construction of fishing gear because this class of plastics exhibits nearly all of these key properties (except perhaps for sinking speed where polyesters are superior).

CONCLUSION

While we continue to gain an increasingly better understanding of the fate of plastics in the marine environment, there are no ready-to-apply technical solutions to the problem of marine plastic pollution. Degradable plastics technology may eventually mature into a class of controlled lifetime fishing gear. But much developmental work needs to be undertaken to make this a reality. Other practical options include incentives to encourage the return of waste gear to the shore where collection facilities hold the gear for subsequent recycling. The reduction of shipboard plastics material is also a valuable contribution in this regard. The previous speaker had very elegantly described the Naval efforts in this regard. It is important to continue our efforts in education aimed at increasing the environmental awareness of users of the ocean.

Land-based plastic debris is a significant source of the plastic waste found in the oceans. The photodegradable plastics technology, already used in some products such as six-pack rings, has a valuable role in reducing beach plastic debris. Biodegradable plastics may also be appropriate for some of the products often found in beach debris.

ACKNOWLEDGMENTS

I want to acknowledge the help of Jim Coe and the Entanglement Research Program of the National Marine Fisheries Service. For several years the program supported some of my work. I also would like to thank the Department of the Navy, the research program at the David Taylor Research Lab, and the U.S. Environmental Protection Agency for supporting my work as well. Finally I appreciate the help by Kathy O'Hara (Center for Marine Conservation) in providing the photographs used in this presentation.

WELCOMING REMARKS

Honorable Daniel K. Akaka, United States Sentor, Hawai'i (via video)

Aloha kakou! Welcome to Hawai'i! I am pleased to greet you and wish you well as you discuss marine debris, a very important topic for the future of ocean life. I would like to recognize Allen Tom, manager of the Hawaiian Islands Humpback Whale National Marine Sanctuary, for his hard work and dedication in putting this international conference together. And I would like to thank Dr. D. James Baker, the Administrator of NOAA, for his continued support of efforts such as this to address marine debris.

My hope is that as you meet in our beautiful islands, your efforts will help international, federal, state, and local agencies and the public at large to serve as good stewards of our valuable ocean resources. I hope you will have an opportunity to understand and experience firsthand how important the sea is to Hawaiians and the native Hawaiian culture, and come to see how we practice malama kai—the care of the sea.

There will be other distinguished speakers talking about legal frameworks, biological and ecological impacts of marine debris, economic costs, and current efforts to remove debris from the ocean. These are all important topics for the conference, and I look forward to the results of the working groups and their advice about what we can do about marine debris.

I want to talk about marine debris from a different perspective. I want to talk about what it means to me as a native Hawaiian. The essence of Hawai'i is captured not by the physical beauty of its islands, but by the beauty of its people and their willingness to welcome others into their society in order to share their culture, environment, and lives. This attitude, often referred to as the "Aloha spirit," originates from the culture and traditions of Hawai'i. It is one of the many attributes that contribute to the uniqueness of the state of Hawai'i.

The motto on Hawai'i's great seal reads, Ua mau kae 'ea 'o ka 'aina 'i ka pono, "the life of the land is perpetuated in righteousness." This statement captures the culture of native Hawaiians. Prior to Western contact, the native Hawaiians lived in an advanced society that was steeped in science. The native Hawaiians honored their 'aina (land), kai (sea), and environment. They developed methods of irrigation, agriculture, aquaculture, navigation, medicine, and fishing where the land and sea were efficiently used without waste or damage. Respect for the environment and for others formed the basis for our culture and tradition.

We can learn a valuable lesson from these traditional practices and values as we work to conserve and protect our precious natural resources for future generations.

My own love for the ocean comes from a lifetime of living in Hawai'i. I learned much from my parents, our large Akaka ohana (family), and kapuna (respected elders) about malama kai. I have sailed to other islands using celestial navigation just as Polynesian explorers did to reach these islands and journey throughout the Pacific.

I enjoy fishing as did my father and family before me. I fished for both reef fish as well as bottom fish, including Ahi and Mahimahi, kumu (my favorite), Weke, 'Ama'ama, 'Aweoweo, Opakapaka, Papio and Ulua. I helped my grandmother gather opihi, shellfish, and the seaweed limu for special meals. My great-grandparents depended on the ocean for life. Like most Hawaiian families, most of our family's nutritional needs were met by the sea.

We were taught not to waste ocean life or take more than we could use. It was not pono (not proper) to catch more fish than you could consume. If we caught more than we needed, we dried, smoked, and shared with others. We did not sell fish to others. A healthy reef system was critical for abundant fish.

In many ways, Native Hawaiians and Polynesians practiced what is now called sustainable fishing and "limited access." In traditional Polynesian systems, access to reef areas and fishing grounds was granted by the ranking chief. The fishing grounds were not open to everyone. A poacher's entire village was held financially responsible for any infraction.

Today fishery management has come full circle back to the old ways. Commercial fishing is moving rapidly to various forms of limited access. I hear that lobstermen in Maine are using their long traditions in each cove to design localized fishing areas that they manage with the state.

Native Hawaiians also had effective and resourceful fisheries, long before Western contact. One difference was that the gear was made of natural substances and was degradable by biology and wave action. Hawaiians utilized leaf sweeps made of coconut leaf fronds woven with leafy vines. We did leaf sweeps in the lagoons for hukilau feasts and celebrations. Any lost gear did not kill seals, turtles or birds. It was only with the advent of monofilament line and nets that fishing gear became more deadly in the long run.

Clearly, today's marine debris is not a part of the natural order of the ocean, lagoons, and reefs of our islands. I am talking specifically about the nondegradable, petroleum-based plastics and toxins that we find even 200 miles from shore—beyond the U.S. Exclusive Economic Zone. Abandoned or lost fishing nets and lines foul the reefs and entangle seals, turtles, and birds.

This is of critical importance to Hawai'i—the only state in the Union that is completely surrounded by ocean. We are the most ocean-dependent state in the United States; our economic well-being and security depend upon the sea. In 1999, Hawai'i generated $14 billion from travel and tourism because of the ocean, our coral reefs and beaches, and our renowned Aloha spirit. This figure is forecast to grow to $28.7 billion in just ten years. So issues discussed and solutions proposed at this conference are of great economic importance to our islands.

I am very encouraged by efforts to clean up debris in the Northwestern Hawaiian Islands, and I applaud the hard work of the National Marine Fisheries Service, the U.S. Navy, and the U.S. Coast Guard for their reef cleanup effort. I understand that several tons of gear still remain in the Northwestern Hawaiian Islands! The care and stewardship of the Northwestern Hawaiian Islands is extremely important as we embark on the series of conferences organized under President Clinton's directive to protect the islands.

I know that many of you are returning from the U.S. Coral Reef Task Force in American Samoa. I am sure that you have seen many of the same ocean issues that we face in Hawai'i. I am pleased to tell you that the Conservation and Reinvestment (CARA) legislation that I'm working on in the Senate Energy Committee will bring much needed funds to coral reefs. It will bring funds to coastal management and to marine sanctuaries, and to fisheries research and enforcement. I am gratified that our efforts have resulted in a strong coastal conservation component in this groundbreaking conservation legislation.

In the three decades since the founding of NOAA and enactment of the Coastal Zone Management Act and the International Decade of Ocean Exploration, we have made good progress towards conserving ocean resources. Most coastal states have extended their jurisdictions to 200 miles offshore to manage resources better. We now know the intimate relationship between the ocean and the atmosphere. We acknowledge the importance of nearshore and coastal areas to the health of the oceans. And we have extended our abilities to monitor and explore nearshore deepwater ocean environments with technologies that did not exist twenty years ago!

As an advocate for the oceans, I support marine technology and exploration. In many ways, the sea, in all its mystery and power, remains the last frontier. Settlers tamed the American West and adventurers have conquered Mt. Everest and the poles of the earth. Man has walked on the moon and is gearing up to live in space. Yet we have so much more to learn about the sea. Our hope and our task is to ensure that our precious ocean resources continue to enrich, sustain, and nurture our lives and the lives of our children and grandchildren in the new century.

Thank you.

"PILIKIA"

Dayton "Lee" Alverson, Chairman of the Board,
Natural Resources Consultants, Washington

INTRODUCTION

Well, the title of my section actually implies that I'm going to talk about derelict gear and fishermen. I'm going to talk a little bit about fishermen, but we have a section tomorrow dealing with the issue and I really don't want to preempt or pull key issues out of that section. So I'm going to cast a lot of my talk in reflections.

HISTORY OF MARINE DEBRIS CONFERENCES

This was done somewhat yesterday and I think it's important to realize some of the history of this process. As it was mentioned, we gathered here in 1984 for the first major marine debris conference that was held on a global scale. Another smaller group gathered in Kona in 1987, which was organized by the fishing industries of the North Pacific and dealt with the same issue. As I remember, we were in Honolulu back in 1989. Then there was a session in the '90s in Miami, and now we're back in Honolulu for the beginning of this century.

In addition to those meetings, there was an international task force on persistent marine debris. Each of these conferences had an output of technical papers building a sort of library of information related to marine debris. It's rather interesting when I go back to the rosters to see who was in attendance; I notice Kitty Simonds, Jim Coe, Richard Shimura, Chuck Fowler, and yours truly were there a lot of the times. There is something rather attractive or compelling about the marine debris conference in Hawai'i. Marine debris drifts down from the North Pacific and, as I understand, from the Northwest Pacific and about every 2.3 years it gets across the ocean. The way I figured, about every 4.2 years, we gather up enough energy to have another marine debris conference and attract a lot of people.

Now there's one thing I was very pleased with yesterday, but I'll start off with a few problem areas. I saw an awful lot of repetition in terms of figures, comments, and recommendations that were embodied in an earlier meeting in 1984. In fact, there's one picture, if you remember, that has some kind of six-pack disc with a fish through it. I don't know who has the rights to that picture, but I've seen it so many times, he or she must be getting rich on royalties. I think we need a new picture of a fish caught in some different way; we need something new.

But there was a new element yesterday and that was the gathering of students. I think this is very important if the process is to go forward. We need to bring the younger people in to be a part of this process, they can commit their fresh minds and new ideas to an issue that a number of us have been working on for the better part of two decades. In fact, I'm convinced that if there's a good student at the University of Hawai'i or maybe up at the

University of Alaska, Oregon State, or University of Washington, a good master's thesis can be made from this material; it could be put together in a book. If you look at the history, we're talking about some 4,000 pages of documented reports, technical reports, and descriptions of marine debris problems. The history of these sessions include: (a) sources of marine debris; (b) types of marine debris; (c) composition of marine debris; (d) quantities of debris; (e) fate of marine debris in space; (f) fate of the various plastic materials in time and in relation to environmental factors; (g) enforcement; and (h) the legal history of marine debris. Put it together and it would be a very convincing story.

Somehow we haven't gotten the message out as well as we should, nor have we elevated it to a level of national concern. I picked up a new book that came out, and as matter fact, it was on my desk the day before I came to the conference; it's called Fishing Grounds. It's a story of the North Pacific and the concerns of probably 100 different scientists of what we need to do and what is the nature of the problems. I don't see a single mention of the word marine debris in the book. And when I look through a number of documents that dealt basically with ocean problems, I find we're pretty far down on the pecking order. Again, I don't know why, because if it is really as bad as we perceive in terms of impacts, and I stress impacts, on marine organisms, and the environment; something needs to be done. Perhaps we need to more carefully focus our questions on problem areas. I came to a marine debris conference, I'd say seventeen years ago, when Kitty was involved with this first conference and she was telling me we've got a problem with your damn North Pacific trawl gear nets ending up here and dropping on our coral, it's causing a lot of problems. Well, we have seventeen years under our belts, and I thought to myself, the problem is probably gone, but alas I get on the telephone to Kitty and she says we've got "pilikia"—a big problem. And it remains. The question is, why are we continuing to look at it? I suppose we shouldn't really be surprised. Think about it; to define a problem is frequently easier than implementing a solution. Additionally, we don't pay them a great deal for writing prescriptions, but the cost of good medicine is fairly high.

In the standing, from documents of the various conferences on marine debris that have preceded this meeting, including the meeting of the task force, I come up with twenty-six recommendations that relate to the needs of research and actions. I sift them down and ask, are they really different? A number are really just repeats of the earlier conference, phrased in somewhat different ways, and I come up with ten fundamental recommendations that tell us what to do. I still think they're pretty good. Some of the more important include:

Education
The education of the public; education of our children; education of those who go to sea and are users; education of those who research the issue and education of those who are harvesters in the sea; this has to be continued. In the sense of stewardship, those who are using the nets and the webbing and the plastics must recognize that these items are finding a way into the world's oceans and are generating a problem. I put that high on my continued list of needed actions.

Identify Loss of Commercial Fishing Gear
The developable means of implementing a process of identifying lost commercial fishing gear. We appear to be making progress on that line. There have been a number of ways people have begun to mark gear, set gear, and take care of the way they handle the gear that has led to improvement.

Recovery of Lost Commercial Fishing Gear
Examine means to reduce the losses of fishing gear, including recovery of lost gear. Obviously, that must be one of the conclusions of this meeting.

Recycle Used and Lost Fishing Gear
Investigate, promote, and enhance activities relating to recycling of used and lost fishing gear. We're going to hear more about this matter. The process has started in several areas and some people are doing this.

Report Economic Losses
Study and report on economic losses to users of ocean space resulting from marine debris. We heard something about that yesterday. We still don't have any great quantification of that in terms of loss. I think there's enough evidence that there is a big problem and I'm not concerned about any detailed quantitative assessment of what the losses are. One thing I am concerned about is the many recommendations I see that deal with understanding the economic consequences to ships, safety at sea, the environment, etc. But I've never seen a recommendation that says, should we quantify the economic impact? Chuck Fowler has done some work on this in terms of the community of animals that are impacted by marine debris. We only have a fragment of an idea of what's going on in this particular area.

Develop a Safe Process for Onboard Disposal of Marine Debris
This is not an easy job as we heard the other day. We need to give this issue careful attention and develop a standard definition for biodegradable. These are fundamental issues that came up, other than specific research processes. The question is, where are we going from here?

Encourage Related Industry to Become Involved
Because of the global characteristics of marine debris and the magnitude of user groups that contribute to the problem, the fishing groups participating in this conference should focus their efforts to encourage other industry contributors to work towards solving the marine debris problem and become involved in seeking solutions.

Encourage Local Programs
The fishing industry should encourage local programs to further the education of fishermen, port authorities, resource managers, other seafarers, and the general public regarding the scope, magnitude, and consequences of growing debris problems.

Encourage Posting of Notices
Fishing vessels/operators in the North Pacific should be encouraged to post, in plain view, notices to officers and crew that the discharge of plastics in the ocean is contrary to the international laws that were expected to come into force in December 1998.

Establish an Effective Shoreside Refuse Disposal System
Participants in this congress should encourage their organizations to cooperate with dock authorities and other government agencies to establish an effective shoreside refuse disposal system.

I don't know how many of these recommendations have been implemented. Although some have been partly implemented, I don't know how well the industry has met its pledge. I'm going to repeat the industry's pledge because this, incidentally, came out of the 1987 group and it shows a rather broad understanding of the nature of the problems faced by the fishing industry. It was called "Principles and Resolutions" and it says:

> Representatives of the fishing industry from Canada, the Republic of China, Japan, the Republic of Korea, and the United States represented at the North Pacific Rim Conference recognize that synthetic marine debris of various origins, including lost and discarded fishing gear, constitute a growing threat to marine life as well as safety at sea, realizing that the maintenance, preservation, and productivity of the ocean environment is in the interest of the world fishing industry and the society as a whole. They further recognize that the fishing industry should make every effort to prevent the deterioration of the ocean's environment by promoting education programs and initiating procedures which will lead to a reduction of marine debris; in particular, plastic materials that are being discarded in the world's oceans. Further realizing the reduction of such

> debris will benefit fishermen throughout the world as well as other users of the ocean environment and noting that the programs on marine debris are distinct and separate from those associated with the direct catch made during fishing trips. The fishing industry should commit to the realization as follows:
>
> Every effort should be made to insure that plastic debris is not discarded at sea and loss of fishing gear should be avoided where feasible or possible. The goal should be to achieve, by incineration of non-toxic combustible materials when feasible, retention of synthetic materials for short site recycling or disposable and disposal of development onboard procedures for the handling of persistent plastic. (Almost all these we heard talked about yesterday.)
>
> Maximum efforts should be made to reduce the quality of synthetics onboard by minimum use of plastic packing material, the use of washing of dishware, and other eatable utensils.

Remember the Admiral yesterday, "Special attention should be given to promote the development of affordable technology and operating procedures, which will lead to the reduction in the loss of fishing gear and which will enhance the recovery of fishing gear."

The questions that will confront this August group are, is there anything new to say that will send a message at the end of this conference? Is it perhaps time to clearly identify the source of debris generating negative impacts on the ocean environment and find legal or other means to resolve the problems?

In this respect, I hope you will take careful time to articulate your concerns, write them in detail, and narrow the scope of our recommendations. We can solve a number of significant problems if we identify them and focus on solutions. We can't take a shotgun approach and say we're going to do everything. But we can say there's a problem in Hawai'i and this is what the character of the problem is, state the scope of impacts and what we intend to do to solve them. We must identify from where the material comes and how we intend to initiate national or international activity that minimizes current problems.

I'm just about finished here and I wanted to talk a little bit about how you take care of the details because it reminds me of a story about two Hawaiians, a kane and wahine. They were out on a fishing boat and they were pretty far south of here, down towards Tahiti somewhere when they got caught in a big storm. They were married and they got lost at sea. This is not a Gilligan's Island story. They ended up on this small island that had plenty of coconuts, taro, breadfruit, and some pig; they could survive. But of course their goal

was to get off the island. Day after day they kept looking and searching for ships on the horizon that never showed up. Thirty years later, they're both sixty, and they're still on the island. The wahine is walking on the beach and finds a bottle, she stoops down, picks it up, and cleans it off; it's a beautiful vase. She notices it has a screw top lid. She screws it off and out comes this gigantic genie. The genie looks down at them and says, "I've been in this vase for 10,000 years and I'm going to honor you each with one wish. But be careful that you articulate your wish properly." The genie turned to the young lady and says, "What's your wish?" She says, "I want two first class tickets to Hawai'i, and I want an airport to be on this little island, and a 747 sitting over there to pick me up and I want a reservation for three full weeks at the Halekulani." Suddenly, there was an airport with a 747 waiting, she and her husband were ready to go to Hawai'i. Then the genie looked at her husband and said, "Well, what's your wish?" He got a big smile, thinking I am going back to Hawai'i and will have a second honeymoon with my wife, he said, "I'd like my wife to be thirty years younger than me." In a second he was 90 years old. So be careful about how you make your recommendations.

It may be difficult to relate my attempted humor at this conference to the mandate, but it is my hope that any new recommendations will address the problem of resolution. In this regard, we're not going to return the world's ocean to a pristine state. On the other hand, it would seem that there are some specific marine debris problems, in specific regions, that are subject to resolution and mitigation. I hope that we spend some effort trying to sort these out and give them priority.

CONCLUSION

In conclusion, through all of these conferences, I've never seen marine debris brought into the equation of mortality. I talked a little bit about it, but at the present time, the ICES scientists are attempting to expand the overall fishing mortality. This is a complicated equation that includes all of the different things that are affecting the fate of animals in the ocean.

It starts with the overall fishing mortality as a: (a) function of what the commercial fisherman catches and lands; (b) function of whatever fishermen catch during recreational activities; and (c) function of what subsistence fisheries take out of the oceans. It also looks at the function of incidental catch, discarding, the effect of the fishing gear on the habitat, and the effects of ghost fishing. Three of these basic items, adding up to the summation of instantaneous fishing mortality, are concerned with marine debris.

We generally discuss marine debris in a very qualitative sense. There's lots of this, there's lots of that, and we know it moves from here to here. But there's not very much in the way of attempts to sit down and ask, what are the populations impacted by marine debris and can we differentiate them from the other factors that impact the equation? I leave you with that to think about.

I only have one comment, Kitty, and I know you listened to the Admiral yesterday. I thought the Admiral gave a very, very nice talk. He brought to our attention a lot of interesting things. But I also know the Admiral wasn't in the same war I was in, because we were not "throwing around environmentally friendly stuff" in WWII.

- Transcribed from a speech given on August 8, 2000.

CURRENT EDUCATION AND PUBLIC OUTREACH EFFORTS TO ADDRESS DERELICT FISHING GEAR

Seba B. Sheavly, Director, Marine Debris Prevention Campaign,
Center for Marine Conservation, Virginia

INTRODUCTION

Good morning. I've been asked to talk to you today about current education and public outreach efforts related to derelict gear and marine debris. We can summarize this very easily—existing efforts are inadequate and in many areas they are now non-existent. Shifting and dwindling appropriations, inadequate monitoring, and ineffective enforcement activities have created an unsteady foundation for establishing long-term mechanisms to reduce the presence and impacts of derelict gear. Based on what other speakers have told us during this conference so far, I think we can say that derelict gear still poses a problem. Well, if derelict gear is still a problem, what do we need to do to handle this issue related to education and public outreach efforts?

MARINE DEBRIS EDUCATION PROGRAMS

First of all, we know that lost and discarded gear in the form of traps or pots, monofilament line, rope, gill nets, longlines, dredges, and trawls are the result of illegal dumping, accidental loss, or system failure. Derelict gear has been documented since the 1930s to impact marine wildlife through entanglement and ingestion, wasting valuable fishery resources. It can destroy fragile coral reef systems and other aquatic habitats. It poses a threat to human health and safety through vessel disablement and diver interactions. With this background information, the question arises—if we are not currently conducting campaigns related to marine debris and derelict gear, were we ever doing programs and campaigns? The answer is yes. From the mid-'80s until the mid-'90s many programs were in place, the effort had momentum. But starting in the mid-'90s the momentum began to decrease due to changes in funding and programming. Now in the new millennium, we are almost at a standstill in dealing with this issue. If we are to revive efforts to handle this problem, we should first study what we have done in the past. From this information we can capitalize on our past successes and hopefully not reinvent the wheels we have already made.

History

Traditional educational and outreach programs have been designed to inform people about the effects of debris and encourage better disposal practices. Other approaches have included modification in the manufacture of gear so that fewer plastic components are used. Alternative port disposal facilities and practices have been developed to handle garbage and damaged gear. Beach cleanup programs have been conducted to promote public awareness and collect data on the types and amounts of debris. Scientific monitoring programs have been conducted to assess the types and sources of marine debris found along beaches.

Finally, in some regions, a "Code of Conduct" has been developed for fisheries activities related to acceptable practices for solid waste disposal and gear retrieval.

If we want to conduct effective programs, what should they look like? What should we be doing? Well, that's a good question. First of all, you have to know who your audiences are. The audience associated with the derelict gear issue is varied and diverse.

Involving the Right People

There are several audiences related to commercial fishing and derelict gear issues. The core of this group consists of fishers ranging from single, subsistence individuals who may or may not own their own boats to crews on large trawlers. Business and industry associated with equipment and boat manufacturing and marketing are also part of this audience as they are responsible for the production and sale of the materials used by fishers. Individuals who are part of the fish processing industry, including marketing, are also part of this group. And last but not least, we also have to work with the government, regulatory agencies, and resource managers—they are all part of this picture. If you have that vision in your mind, then you know who our audience is and why our work has to be so comprehensive.

Types of Activities—Public Education and Outreach

Well, what types of activities should we be doing? Over the past sixteen plus years we have learned that we need to conduct targeted educational programs and campaigns. In combination with legislative and enforcement strategies related to MARPOL compliance and national fisheries management approaches, a variety of supportive methodologies are needed to change behaviors of fishers and how they manage the handling and disposal of fishing gear and other wastes. Well, have we done this? The answer is yes. From 1988 through 1996, the Center for Marine Conservation, under contract with NOAA, conducted a public education program to educate related industries and the general public about the impacts of persistent marine debris, and their roles in its creation, removal, and proper disposal. Funding for this effort was terminated. This public education effort was successful and unfortunately a mechanism to replace it still does not exist today.

The National Sea Grant College Program is a partnership between U.S. universities and NOAA that began in 1966, when Congress passed the National Sea Grant College Program Act. Today, many of the twenty-nine Sea Grant Colleges have outreach or education programs that address marine debris problems. These programs need revitalized support to continue and expand their efforts. Again, we have a ready mechanism and conduit in place and the "fuel" for this effort is low if not dried out.

Education programs conducted by industry concerns have been effective in promoting public awareness of the marine debris issue and have encouraged compliance related solid waste handling of fishing gear. Programs in the U.S., Canada, and Nova Scotia serve as examples of what can be done, but they are few and far between. During the Education and Outreach Work Group we'll go into more detail on some of these past projects. Many of the pieces for solving the derelict gear puzzle are here in this room at this very meeting. We need to come back together, put our puzzle pieces back together, and walk out with a completed puzzle. That's our challenge, we don't need to reinvent the wheel—again. We need to take the wheel we already have and use it.

Conferences

We need to conduct these conferences. We need an exchange forum. We need a place where people come together. The effectiveness of these meetings is measured by the degree to which workgroup recommendations are implemented by national and regional agencies and organizations. Opportunities to share information and research are essential to the global reduction of marine debris and its impacts. Marine debris is one of the most pervasive pollution issues plaguing our ocean and waterways. Only through a global, integrated approach to this pollution problem can it be controlled.

Based on recommendations from previous conferences, our initial assessments were on target. Our problem is in the follow through. It is comforting to know that we were on track sixteen years ago. What has to change is that we need to actively fulfill these goals and objectives.

Incentive Programs

We need to look at creating incentive programs. Quite honestly the connection between environmental practices and economic practices is strong. You may not like to hear that, but it's the truth. The "E" in economy stands for the environment and the "E" in environment stands for economy. You have to hook them together. We need to develop a strategy that will encompass both.

One such program is being conducted in Hawai'i and includes an incentive program for local coastal fishers called the Marine Bounty Program. Floating, discarded fishing nets are known haunts for fish. All fishers know that certain areas are good places to catch fish. These areas also pose a threat for potential vessel disablement and for entanglement by a host of marine wildlife. As part of CMC's Model Communities Program, this pilot project was developed and piloted by the University of Hawai'i Sea Grant Office under the direction of Chris Woolaway. The project was piloted in Kaneohe Bay, on Oahu, where recreational and commercial fishers were awarded points for reporting the location of abandoned nets found while fishing. Points were redeemed for fishing products and other

prizes donated by local retailers. Arrangements were made to have the nets retrieved and disposed of in the local landfill. The program continues with over three tons of recovered nets and gear to date.

Chris has done a wonderful job and has many plans for future programming using the Marine Bounty Program as a model. Currently, there are plans to expand this program to other areas of Oahu and there are many more islands in Hawai'i where this effort is needed. In addition, there is discussion to tie this to a monitoring program being implemented in Hawai'i through the Coastal Zone Management Program and the Department of Land and Natural Resources. It is this type of teamwork that will make this program a success. CMC was fortunate to be able to work with Hawai'i Sea Grant. This program has gone far beyond our hopes and aspirations, and it is just the beginning.

Port and Reception Facilities

We also need to look at working with education and outreach programs for port and reception facilities. Adequate port facilities for garbage and net disposal and recycling are an essential component in managing solid wastes associated with commercial fishing and other maritime activities. The impacts on local communities that service the fishing industry can be profound. The burden for handling the solid waste from fishing activities can be substantial and requires a collaborative approach for the municipality, port authority, fishing community, and associated industries including solid waste management and plastics manufacturing.

Educational programs designed to promote compliance of MARPOL Annex V should be accompanied by practical methods of handling derelict fishing gear ashore combined with increased technologies for onboard incineration and recycling. Any plan to enforce Annex V requires a progressive and practical approach for waste handling. Inadequate, impractical plans will result in ineffective efforts.

Finding Model Programs

Now that we have refreshed our base knowledge on this issue, what do we need to do? One problem is the current deficiency of educational programs and relevant materials, which target the fishing industry, upon which to model new programs. Based on the scale and importance of this issue, relatively few programs are currently being conducted in this arena. We do have some past experiences and success from which to draw, but we need an intensive infusion of energy, funding, and programming to tackle this problem. In reviewing existing educational materials, most were found to be outdated and not relevant to current issues and technologies. We need materials to help connect us to this issue as it is today, not as it was twenty years ago.

Engaging the Proper Stakeholders

To conduct an effective educational campaign, appropriate efforts must be made to engage all the stakeholders related to this issue. The range of stakeholders in the fishing industry runs from owners and operators of large factory trawlers to members of small, subsistence, artesanal fisheries. Different approaches for education and outreach need to be devised for different size industries. You can't just focus on the fishers, they are just as much a part of the solution as they are of the problem.

Program Planning

We also need to make sure that our educational program designs are effective. We need to employ development strategies that will insure that our efforts will be effective and target appropriate audiences. This involves pilot testing, evaluation, program revision and assessment. Often time and limited resources do not allow this. We will not be starting at zero. We do have some success stories upon which to draw. Many of the early program implementers such as Fran Rick and Chuck Fowler are here for this conference. We need to review thoroughly what we have done in the past before we move forward again. If we continue to re-invent the same wheel after every conference, we will never be successful in our quest. Moving forward means you take what works and build using that as your foundation.

Use of Technology

We also need to place some emphasis on the technology sector. The technology sector's interest in developing alternatives to present technology is unclear. Working with industry on pollution prevention efforts at CMC, I know that the general public often does not know of their innovations and improvements. We need to tap into this resource as it is in their best interest to aid in our efforts to reduce the presence of derelict gear in our oceans.

Educate Leaders

And last but by no means least, we need to be sure that our government, regulators, and resource people are properly educated. They can and must be educated on the importance of this issue as well as the marine debris issue overall. We have to use the resources and influence of our agencies and organizations to make sure that they understand the importance of this problem. They are one of the key stakeholders and without them, we will not be successful and the problem will persist.

Efforts to reinstate former educational campaigns and expand existing programming to address the issue of derelict gear must be given priority during this conference. Derelict gear continues to impact the marine environment. Educating derelict fishing gear

"stakeholders" on the impacts of marine debris on the environment is necessary to change their behaviors and develop management strategies that will reduce the introduction of derelict gear into the ocean. Enforcement of international and national legislation to support MARPOL is complicated. Marine debris research and monitoring is expensive and difficult to conduct in the marine environment. Educating the public about marine debris is imperative, if this pollution source is to be controlled.

We need to refocus our attention and efforts on the establishment of cooperative efforts for fishers, fisheries and resource managers, port authorities, maritime enforcement agencies, business, and industry in forging an integrated regional effort to reduce the presence of derelict gear from our waters.

Education and outreach activities are essential components in dealing with these problems. Without these activities and programs, we will not be successful. We know what to do, we know who the stakeholders are that we need to engage in fighting this battle, and we know what the risks are if this battle is not won. We just need to do it.

CONCLUSION

Thank you for you time and attention this morning. But before I go, I need to remind you that September l6th is the 15th Annual International Coastal Cleanup. I want to encourage everyone in attendance at this conference to participate. Each pair of hands in this room should be holding one of two things—either a trash bag or a data card on that Saturday. This is an ongoing, global effort that is a product of earlier efforts to address the marine debris issue. Please get out and do the cleanup, help us continue to attack this problem—you can make a difference. There is not a single body of water on the planet now that is not involved in some way or the other with the debris problem. We can solve this problem. Let's get out and do it.

- Transcribed from a speech given on August 8, 2000.

THE U.S. COAST GUARD SEA PARTNERS CAMPAIGN EDUCATION AND PUBLIC OUTREACH EFFORT TO ADDRESS DERELICT MARINE DEBRIS

Linda J. Reid, USCGR, U.S. Coast Guard Headquarters -
Office of Response, Washington, D.C.

INTRODUCTION

Thank you very much for inviting me to speak today about the U.S. Coast Guard Sea Partners Campaign—the Coast Guard's environmental education and outreach program.

Many of us here today have participated in shoreline cleanups, either through the International Coastal Cleanup or other locally organized events. The unsightly and destructive results of the improper disposal of trash are all too familiar to everyone.

But the problem we are confronting at this conference is more than unsightly litter on an otherwise attractive beach. Derelict fishing gear can sweep across thousands of miles of ocean, an unseen threat to living marine resources.

SEA PARNTERS PROGRAM

We in the U.S. Coast Guard Sea Partners program have worked for over six years to find ways to combat a particular type of marine pollution—marine debris. Under authority of the Marine Plastic Pollution Research and Control Act of 1987, the U.S. legislation which implemented the MARPOL Annex V agreement, we have conducted a nationwide education and outreach program that has reached over two million people in the U.S.

We have formed partnerships with business groups, the boating community, educators, environmental organizations, aquariums, various segments of the public, and with state and local governments. We have enjoyed many successes and still face many challenges. I am pleased to accept your invitation to share our experiences with you, to learn more about the particular problems under scrutiny this week, and to explore ways we may work together to make the world's oceans a safer, richer realm.

The Sea Partners program operates out of Coast Guard Marine Safety Offices in all the major port cities in the country. Each Marine Safety Office has a team of Coast Guard Sea Partners who have undergone specialized training and have the time, inclination, and flexibility to present programs to our target audiences. The teams assess the needs and pollution problems in their unit's area of responsibility and decide how to focus their local program for the best results. They seek out opportunities for presentations or participation in events that provide an opportunity to speak with certain populations.

We also draw upon the talents of the Coast Guard Auxiliary, the civilian volunteer arm of the Coast Guard, particularly to reach recreational boaters, an audience with a big effect on water quality. The value of using Coast Guard Auxiliarists in reaching the recreational

boating audience is their personal knowledge of boating and the people who participate in boating. Most Auxiliarists are boat owners themselves. They know the issues that boaters deal with. They know what kinds of questions they are likely to ask.

DELIVERING THE INFORMATION

Information delivery is always a challenge. Children are an easy audience because they are held captive in their classrooms or day camps. To reach the recreational boating audience we set up information booths at boat shows and invite boat shoppers to look at displays as they walk by. Or Sea Partners may spend a "day on the docks," talking with boaters individually at marinas or boat ramps as they head out for the day. Reaching fishing industry personnel is a tougher challenge because there are fewer such opportunities where fishermen congregate.

In dealing with various types of audiences, we have to assess their current knowledge on the topic. Are they disregarding pollution laws because they are not aware of them? Are they disobeying laws in full knowledge of the consequences but figuring they won't be caught? Or are they genuinely concerned about the environment but find the laws difficult to comply with? If it's the latter, then we must consider how we can work with waterway users to remove some of the obstacles to compliance. In the case of commercial fishing, are better reception facilities needed? Or some kind of incentive for returning nets to shore?

Marina Survey Program

In tackling pollution problems created by recreational boating marinas, some Sea Partners teams have instituted an informal marina survey program which involves evaluating a marina's pollution prevention preparation and making suggestions for improvements. It is not an inspection—there are no law-enforcement consequences. The Coast Guard member or Coast Guard Auxiliarist walks the marina property with a checklist that is subsequently turned over to the owner. Some items are simple, such as tying down or covering trash receptacles so that trash cannot be blown into the water, but if the marina operator just plain hasn't thought of the consequences of the current set-up, he probably hasn't thought of the need for improvements.

In the Sea Partners Campaign we learned that recreational boaters often try to clean up a small fuel spill in the water by squirting some dish detergent on it. Many boaters our people talked to actually thought this was the proper way to clean up the spill, not realizing that: (1) they were causing additional harm to the environment by dispersing the spill into the water column; and (2) it's an illegal practice. When boaters are shown how a sorbent pad kept handy can prevent or quickly clean up a small spill at the fuel pump, they are generally glad to make the small investment to keep some on board. This is just an example of how person-to-person interaction can be effective in solving a problem. The first step

was discovering why the problem existed and then coming up with a solution workable for the user.

For coastal residents, sometimes the effective approach is to show the immediate impact of debris. Some of our Sea Partners have collected debris items from local beaches that they use in public displays and which show people what comes from local careless activity. Some examples reported are: discarded fishing line along the Verrazano Narrows bike path in New York; detached line from lobster pot buoys in Rhode Island Sound; plastic cups with turtle bite marks found on Padre Island, Texas; and a "ghost net" from the waters near Juneau, Alaska. Sea Partners use these displays to make a point about the consequences of such activity—trashy beaches, animal entanglement, injury, and death.

In the recreational boater community, the discarded monofilament line that comes back to foul a prop shows a boater how a careless action can have a direct undesired consequence. Fish that die from entanglement or ingestion of plastic are fish that cannot fill someone's dinner plate. The videos and slide shows we use in the Sea Partners program graphically show such situations.

In children's programs, we have found it's important to leave the students with some positive action they can use to help the cause. For instance, even young children can cut or tear six-pack rings apart to avoid a possible animal entanglement. They can make sure they put all their trash in the appropriate trash receptacle. They can talk with their parents about reusing and recycling household items.

Commercial fishing is, and has been for some time, big business. But business is not so good these days. Our boundless banks are getting fished out. The recent release of "The Perfect Storm" has brought the subject of commercial fishing to common conversation. At first glance, the movie is a pulse-pounder about a meteorological monstrosity, but when you get down to it, it's a bottom-line story of economic survival. Those who don't go out every chance they get, regardless of weather, lose out on their share of an increasingly competitive market. So to have any kind of success in reaching out to these businessmen, it is important to understand their business.

We can take some lessons from the Coast Guard's Commercial Fishing Vessel Safety program. This program has been expanded over the past few years because of an increase in deaths due to the sinking of fishing vessels. One main goal of the program has been to get as many fishermen as possible to participate in a voluntary dockside fishing vessel safety examination. The Coast Guard Auxiliary has helped out with a number of volunteers who have undergone training to become a fishing vessel examiner.

THE U.S. COAST GUARD SEA PARTNERS CAMPAIGN EDUCATION AND PUBLIC OUTREACH EFFORT TO ADDRESS DERELICT MARINE DEBRIS

Much of the success of this program has been due to the dedication of these examiners and the personal approach they bring to the task. The more knowledgeable about the fishing industry these examiners are, the more likely they are to succeed in gaining the ear of the fisherman. Fishermen are unlikely to waste their ashore time listening to someone with little understanding of their problems.

Part of the challenge is convincing fishermen to take the time for a safety inspection. Examiners have an assortment of small giveaway items—signaling mirrors, whistles, zipper lubricant, miniature tool kits—that they use to break the ice, start a conversation, and open a door. After the offer of a "freebie" and an introduction, the examiner then suggests scheduling a free safety inspection or engages the fisherman in a conversation about a specific safety issue. Pointing out a better way to store gear which will increase stability of the vessel, for instance, gets the fisherman's attention because he sees an immediate benefit to his own safety and survival. Examiners also emphasize that these exams are non-punitive—for the benefit of the vessel owner only.

With the derelict fishing gear issue, it is more difficult because the consequences of any individual's actions are not direct but aggregate. If dumping unusable gear over the side is the quick answer to an immediate problem, one obvious counter argument is that short-term economic gain will lead to long-term economic extinction. The economic impact of repairing fouled propellers or damage to other equipment caught in derelict gear is a point that must be made. And if fishermen kill fish before they can catch them by casting off gear they can no longer use, they hasten the day when they will have to tie up their boats for another vocation. In short, they need to become stewards of the resources they rely on for their living. Appealing to polluters to become stewards has been one of the tenets of the Sea Partners Campaign.

In addition to working with the fishermen, we can work to convince the public of the importance of these issues. We have had great success in Sea Partners in getting schools, scouting groups, and many others to join in public education campaigns against marine pollution. The ongoing dolphin-safe tuna debate is an example of public pressure influencing practices in a private industry. Public outrage over seeing animals entangled in plastic six-pack rings led to a design change by the manufacturer, making all currently produced rings photo-degradable.

CONCLUSION

There are many ways in which the success of the Sea Partners program may be of interest to you, and there are certainly many challenges ahead. We are a long way from having all the answers. I look forward to discussing these issues while at the conference this week and learning how we can work together toward our common goals.

A MODEL OF EUROPEAN-WIDE COOPERATION BETWEEN INDUSTRY AND THE ESTABLISHMENT

Gary Dunlin, Gear Technologist, Seafish Authority, United Kingdom

Just a few words about Seafish to help explain how we work and fit in with our fish industry.

• Set up by an act of Parliament.
• Have statutory responsibilities for the whole industry (boat to throat as it were). From the guys that build the boats through the fishers, buyers, processors, transport, storage, and the consumers.

The way we're set up gives us a guaranteed income from the levy on fish sales plus what we generate from other sources—R and D contracts. The set up, paid by industry, also makes us directly accountable to industry. My talk today—FANTARED (redes fantasmas), literally Spanish for phantom nets, a model of European-wide cooperation between industry and the establishment. In this talk I'll be:

• Describing the ghost fishing projects that fit under the Fantared umbrella.
• Outlining the sorts of concerns that they have tried to address.
• Explaining how our UK fishermen's associations reacted to the project.
• Giving you the flavour of what we've discovered so far.

First a brief rundown of the UK Static Gear Fisheries, my speciality and the focus of our efforts in the Fanta family of projects. It's made up of a gill netting sector, almost exclusively bottom set, and a thriving trapping sector. There are a wide range of boats used, but few over ~15 m (50 feet). From this cobble, a typical inshore netter/potter used in the North Sea. This 55-foot netter operates offshore in the western approaches to the English Channel, the Irish Sea, and in the channel itself often targeting prime specimens like this hake. Unfortunately, like many other netting fleets, ours has been caught up with crude imagery and suffered the 'Walls of Death' syndrome. Potting and creeling (or trapping) uses a wide variety of designs and targets a wide range of species from lobsters to Nephrops.

Now let me explain Fanta and why we felt the need to look at ghost fishing phenomena in European waters. Most previous work seemed to be opportunistic; "I know of a lost net, let's dive on it". Areas were chosen for convenient observation rather than, "How can we work out the range of what happens?" We thought that fishermen should be involved in the program because they have the most knowledge of what actually happens. We also started taking the view that we needed to know everything about fishing operations so that we could look at improving performance. We had to know the size and shape of problems and where they existed, so we could begin to sort them out. This is what we've been doing, starting in 1994:

• Fantareds are EU supported.
• Fantatrap is funded by our fisheries ministry, the Ministry of Agriculture Fisheries and Food (MAFF).

Fanta 1 was our first and quite modest project restricted to inshore shallow waters. It was in many ways a feasibility study to pave the way for a bigger more objective study and had partners from the UK, Spain, and Portugal. Fanta 2 is much more ambitious. It aims to identify, quantify, and where necessary, manage the impacts of static gear lost in European waters. As you can see it is quite a big partnership covering a very wide range of fisheries—from arctic to semi-tropical—similar in many ways to the USA. Fanta 2 involves a number of activities in its early stages like:

• NAGs—working through our federations and national organizations.
• Carrying out a review of each partner's "significant" fisheries.
• Conducting comprehensive surveys of fishermen's experiences.
• Teasing out from them and others how and where gear was being lost.
• Surveying those areas and then setting up a program to simulate the loss of gear.
• Then monitoring how the gear evolved by both physical and catch rate profiles.
• Trying to retrieve gear lost.

The aim of all this fieldwork is to:
• Understand what's going on and how it is related to targeted fishing activities.
• Look at the need and potential for change.
• Work out the implications and potential benefits, and then negotiate a way forward with our industry.

I think it's instructive to look at how our industry viewed these projects and why. I'm talking here mainly about our own experiences, but similar reactions were found by our other European partners:

• Fanta 1—Industry opposed.
• Fanta 2—Industry was cooperative.
• Fantatrap—Initiated by industry.

We needed to find out what was going on. Why the difference in attitudes? Our first experience wasn't too successful in terms of industrial relations. We didn't have a free hand in setting the project up. The luck of the draw was that we had some strong (a euphemism) personalities in local fishermen committees, often the only ones who turned up. The project was a feasibility study and was picked on for not being commercially realistic! It

involved conservationists as partners, which raised hackles. And there was an undercurrent—hard to define—of vulnerability/paranoia.

By the time we started the next project, the situation was quite different. The results from Fanta 1 were reassuring. The new project focused on commercial metiers and practices with an assurance of commercial realism as far as possible. The NAG system empowered the industry side, and they had the right to disagree with our findings via a minority report. Finally, there is a mood amongst fishers that they want to know, warts and all, what they are doing.

Our final project in the Fanta suite was actually initiated by the largest shellfish trapping association in the UK. This is a progressive association that keeps at least half an eye on market trends. They knew they could lobby for funding and they trusted us to do the work effectively on their behalf. Being commissioned by a fishers' association to do a worthwhile job is the sort of situation we want to find ourselves in more often.

Returning to the work in hand, here's a reminder of our first stages. These first four areas of inquiry allowed us to identify the main factors which cause loss and the levels of loss that are occurring and then to test our national fisheries against these factors in order to decide which should be investigated further. There are ten factors, but of these, three predominate in European waters. Conflicts between static and towed gear sectors are by far the biggest cause of loss—and this loss is defined as "permanent" loss. If it's towed away, you don't know where it is. If your ends—your buoys are lost to weather [sic]. The other main causes are water depth and fleet length, which tend to go together and reinforce one another. Certain slope fisheries have very long fleets running down the slope and are only marked at one end. What is interesting here is that these factors can be used to score any fishery for its predisposition toward gear loss.

Our experimental sites in Europe, actual and hoped for, give us a good spread of target species and ground conditions. In those areas we've tried various rapid survey options for ground where significant losses are reported, trying to reconcile fishers' accounts with conditions on the ground. These are traces here from the Celtic Sea. What are they? We've surveyed wrecks in poor conditions and good, but we've had no real success in identifying nets except in ideal conditions like headline high and clean fine/soft ground. Not often met as working harder ground is a way of avoiding trawlers. The marks earlier were cables/warps. This and the next slide are Norwegian images at slack water of nets on clean ground. You can get images, but at a cost! Having failed with remote surveying, we've used devices like this to try to recover gear from ground where high levels of loss have been reported. It's used like this—towed behind a vessel at about one nautical mile

per hour. And we've set out arrays of short fleets to track the net's evolution over time. What you see here are three replicate sets of fleets that are retrieved sequentially over a two-year period. We've also set nets on wrecks. Most of these are fairly shallow and we've used divers for early observations, deployment verification, and monitoring. What were our results from retrieval operations? Retrievals typically produce objects like this—a lot of rope, but not much netting. Under photec conditions we get a lot of this—typical on wrecks. And this was the fate of an experimental net set in the North Sea delivered ashore after four weeks! And in more detail, badly tangled up and incapable of catching anything. That's about as far as we've gotten.

Now let's step back a minute and compare what's being said in Europe with the reality of what we're finding. The sound bite images are these:

- A focus on nets (usually drift nets) and no traps.
- Lost gear fishing forever.
- Inshore grounds carpeted with nets smothering marine life.
- Lost gear constantly moving. All these things conjuring up an image of legions of undead gill nets fishing forever.
- Indiscriminate/heavy take of cetaceans, phocids, bird species, and shellfish.
- And finally the much less fashionable issue of impact on commercial species.

What we're finding in Europe is that impacts:

- Are very site specific and very depth dependent.
- Have little or no impact on non-fish species.
- Have some significant impacts on commercial species.

In as much as we can generalize about the outcomes of net loss, there seem to be three main types of outcome: inshore, set on open ground; inshore, set on or near wrecks and reefs; and those set in the deeper waters or down oceanic slopes.

In the first of these, in depths of up to ~100 fm, there are four influences that lead to a very common outcome: bio-fouling, wave action, currents, and towed gear conflict. Between them they ensure that fishing area and catch rates diminish rapidly and nets are either cleaned up or deactivated. For the special case of wrecks and reefs in inshore areas the outcome can be a little different: netting may be held open for often long periods; biofouling occurs rapidly, especially in shallow waters; and catch rates generally fall rapidly although some fishing potential may remain. The contrast to this seems to be in deeper water with a threshold of ~300 m. Out of the photic zone and with minimal water movement there seems to be the

potential for prolonged ghost fishing. This is borne out by the evidence from Norway and Canada. Retrieval exercises show nets fishing strongly after ~10 years immersion. If there are problems for us, the solutions fall into three categories: technical fixes, effort limitation, and effort management.

The first of these seems attractive at first sight, but is of limited applicability to nets. Fishermen are not confident with gear if strength is uncertain or happy with high maintenance costs. Also among the "technical fixes" category are ways of improving gear retrieval by using acoustic markers. Two obvious, but immensely unpopular, answers to the industry and always the cause of conflict are:

- Zoning—an attractive alternative, widely applied for a variety of reasons, with real potential to reduce gear loss. It has the advantage of being more readily accepted if consensus is reached on the implementation of zoning, usually at a local level.
- Allowing trawlers into a defined area after netters have been operating. This guarantees that the ground is cleaned up.

So what's next?

- There will be a continuation of fieldwork. We will be looking at mitigation measures worldwide. Conferences like this are a huge aid to these processes, drawing together expertise from all disciplines.
- Cost and benefit analyses of any mitigating measures.
- Organizing an international fishers' workshop. Building consensus and perception of fairness is very important in Europe and enables fast tracking of new approaches.
- Entering into negotiations with fishers and managers.
- Investigating what constitutes "good" practice. As in every profession there are good and bad practitioners.
- We hope to develop a Code of Good Practice. Let's take all that's good and develop it.
- Disseminate as widely as possible through reporting and publicity.
- The European inshore static gear sector has a relatively low ghost fishing impact.
- Losses in deep water are a cause for concern and need addressing.
- Effort limitation is essential for sustainability.
- Effort management holds most the potential for mitigating ghost fishing at this point.

- Transcribed from a speech given August 8, 2000.

ESTABLISHING PARTNERSHIPS TO MITIGATE THE IMPACTS OF DERELICT FISHING GEAR ON THE NORTHWESTERN HAWAIIAN ISLANDS

George "Bud" Antonelis, Chief, Protected Species Investigation,
National Marine Fisheries Service, Honolulu Laboratory, Hawai'i

The title of my talk is "Establishing Partnerships to Mitigate the Impacts of Derelict Fishing Gear on the Northwestern Hawaiian Islands." I know this seems a little anticlimactic since everyone has begun their working groups, but I think that this will help give some perspective as to where we are now and how our ongoing partnership has helped facilitate a renewed interest in the marine debris problem in the Pacific Ocean. I hope that we can use this as an example in the development of future partnerships. During the talk, I'll provide a brief background and then discuss partnerships, program goals and objectives, use of innovative techniques to address issues, significant achievements, the beneficiaries of our projects, and future plans.

By way of background—over the last eighteen years we have observed no abatement in the monk seal entanglement rates in the Northwestern Hawaiian Islands. During the mid-1990s, we started receiving intermittent reports of monk seal entanglement in marine debris attached to coral reefs. This sparked our interest and we conducted a few preliminary surveys that revealed information that was quite surprising.

We now understand that not only was this problem manifesting itself through our observations of entangled seals that were coming ashore, but also by the documentation of seals in the water that were entangled in debris attached to coral reefs. The more we surveyed coral reefs, the more debris we found.

We immediately solicited support from other agencies to help solve this huge problem. As an aside, I'd like to point out that we were dealing with a very large area that was being impacted. Our focus was on the six major breeding sites of the endangered Hawaiian monk seal: French Frigate Shoals, Laysan and Lisianski Islands, Pearl and Hermes Reef, and Midway and Kure Atolls.

This slide illustrates the number of the seals we have observed entangled in marine debris since 1982 and, as I stated earlier, there was no abatement in the entanglement rate. During 1999, we observed the highest number (n = 25) of seals entangled in marine debris ever recorded within a single field season. This slide illustrates the fact that the entanglement rate at each of these sites varies and that the differences probably reflect local variation in currents and other factors related to their location. Seals from French Frigate Shoals and Laysan and Lisianski Islands have the highest entanglement rates, while moderate rates of entanglement have been observed at Pearl and Hermes Reef and Midway and Kure Atolls.

Based on this information we began to solicit the help of other government and non-government entities. We also had photographs, such as this dramatic slide showing a NOAA diver disentangling a seal, which really instilled a lot of concern. Within a few months we were able to gather a rather impressive list of collaborators. One of the primary reasons for such a positive response is that marine debris was impacting not only the endangered monk seals, but also our precious coral reefs here in Hawai'i. Program goals have been formulated to conserve and protect the Northwestern Hawaiian Islands coral reef ecosystems with an emphasis on Hawaiian monk seals. The objectives have been designed to: optimize debris removal in high impact areas where we know monk seals frequently occur; assess the distribution, abundance, and type of debris found; and monitor accumulation rates. Mary Donohue (NMFS, Honolulu Laboratory) talked about these topics during the first day of presentations.

The techniques used for this work have been innovative and we have established an unprecedented collaboration with fourteen other agencies.

We have conducted the first quantitative assessment of derelict fishing gear on coral reefs. This work was pioneered by Ray Boland (JIMAR, Honolulu Laboratory) and later refined by Mary Donohue. Our hope is that this effort will serve as a model for similar programs in other oceans.

The main issue that this project addressed was the conspicuous and continuous threat to the Northwestern Hawaiian Islands by marine debris. It has been impacting endangered and threatened species, and it continues to destroy our wildlife. But we also know that this project was just an initial step toward a much larger need for mitigation. That's why we're all here today, to try and solve this problem.

A significant achievement of this partnership has been the removal of 77,000 pounds of derelict fishing gear. The multi-agency marine debris cleanup effort has been an ongoing program to restore the coral reefs in the Northwestern Hawaiian Islands. Although the effort has been rather small compared to the immensity of the problem, we have been making progress. We've also enhanced the survival of many protected species associated with the coral reef ecosystem, and last year we received the Silver Hammer Award from Vice President Al Gore for our conservation efforts. You can see from this slide that many people have been part of this effort. Key individuals in getting this project moving were Terry Rice from the Coast Guard, Chris Woolaway from Sea Grant, and John Henderson from the National Marine Fisheries Service.

ESTABLISHING PARTNERSHIPS TO MITIGATE
THE IMPACTS OF DERELICT FISHING GEAR ON
THE NORTHWESTERN HAWAIIAN ISLANDS

In this case, all stakeholders have benefited from our efforts to conserve one of the oldest and most diverse ecosystems in the world. Our efforts have contributed to the restoration of essential fish habitat and critical habitat for endangered and threatened species. We've also promoted stewardship ethics in the Northwestern Hawaiian Islands and we hope to continue this work with our partners in the future.

Future plans essential for the success of the program include increased international participation. We also plan to revisit several selected sites to monitor accumulation rates of debris and expand our debris reference collection in determining the sources of the debris. Also the exchange of information resulting from this conference will help us refine our techniques and methodology for future studies.

Finally, I list in this slide the key elements in putting together our partnership. The most important item was that we had a clear and present need. We also required physical assistance to begin the process of marine debris collection and disposal. Our initial success in obtaining several key partners helped attract other agencies to the alliance because it was a situation in which all stakeholders benefited, and everyone realized that this was the right thing to do.

There have been a couple of analogies mentioned at this conference and I like to think in those kinds of terms. We have been cautioned not to reinvent the wheel. I think at this stage we haven't really reinvented the wheel, we just put the wheel back on track. I'm extremely impressed with the new technology and the multidisciplinary approaches that can be used to solve the problem of marine debris, especially derelict fishing gear. With our wheel on track, we can make significant progress in mitigating the problem of marine debris in our precious coral reef ecosystem and the Pacific Ocean. Mahalo.

• Transcribed from a speech given on August 8, 2000.

GETTING THE MOST OUT OF OUR EFFORTS

Daniel J. Basta, Director, National Marine Sanctuary Program,
National Ocean Service, National Oceanic and Atmospheric Administration

INTRODUCTION

Thank you. It's always kind of strange when a person says, "Here's the person that's going to lead the charge," and you go over the hill, turn around, and you're by yourself. A lot of people in this room I'm sure have had that experience.

Allen asked me to spend some time to try to focus and motivate us by putting into perspective why we're here. I have to say that I'm extraordinarily impressed with the range of individuals that have come to this conference. It says something about the importance of marine debris. But we all have been to many, many conferences in our careers and we often go away with, "Well I met a lot of good people." I guess that's what we get from conferences, but we all seek to have more purposeful outcomes from the commitment of our time to what it is we're trying to do.

I would not want to calculate the expense that's sitting here in this room right now for everybody that's here and for how long they're going to be here. But it's a significant investment that is being made in this topic.

So the question is how can we organize ourselves so that we can make the most out of our efforts? That when we walk away from here on Friday we have taken this topic and the things we're trying to do to another level. That's what the next two days are about.

I was particularly struck by Lee's comments earlier about the 1987 meeting and other meetings that I've been to. Are there new issues? Maybe a few. Are there new strategies? Maybe a few. But don't we already know what to do? Probably! And haven't we known that for some time? The question then is: Why haven't solutions been implemented? Is another report going to add much to a pile of reports on the shelf of marine debris? Or are we maybe at a juncture here that provides an opportunity that may be a bit unprecedented for taking this topic forward? Based upon what Dr. Baker said and what I can offer in terms of changing times, I think we are at a crossroad of partnership and community building. What we haven't figured out very well is how to build these integrated fabrics to tie us together as bigger communities.

I would offer to you that this rather modest marine debris conference has an opportunity to build a bigger "marine fabric" than just on the topic of marine debris. All of you are

marine debris experts; if that's what you do every day, if it's one of the tasks you do, one of the jobs you perform. So, what happened? Why are we still behind the power curve?

So there are a couple of things that I want to stress to you. First is that in order to build bigger community partnerships, we also have to change how we work together and interact to build those partnerships. Part of that, whether we like it or not, is something called a little bit of structure and organization. The next two days, starting when I leave this podium, is putting you into working groups that are designed to do that. It's not anything terribly new, but the challenge to you is to try and step up and stick with the process. The process is trying to do two very simple things. It's trying to focus you collectively as a community on those things in a series of topic areas that are first and foremost of importance to you. Secondly it's then trying to get you to add some of the information content to actually set the conditions for understanding the costs, benefits, and impacts for implementing strategies and solutions. So there's a process that you're going to go through.

There are some rules of the road that you have to follow. Whether it's to be nice to one another or agree that every idea is a good idea because there are no bad ideas. You have to follow the rules of your panel chairs and facilitators as they try to move you to the next level; you must move with them. Ultimately they are going to ask you to take ownership by actually sitting down and writing some things that I believe would be a far more content-driven outcome from a gathering like this than is typically the case.

Now that does a couple of things for the community and for the issue. Number one, it begins to put into the process at the right time, and I think timing is everything. I'm always amazed to realize that sometimes it's not good work, not hard work, but timing. Having done all the work and being ready to jump through the window of opportunity when it opens. So we need to document what comes out of the marine debris conference that is far-reaching, that has practical elements to it, and is understandable by the process and supported by the community.

The other thing that I think works to the advantage is that this work will be put up on the web. The objective is to attempt to use this issue to establish a more virtual community around this topic in the Pacific Basin. If we are going to move forward in this 21st Century we must all understand that partnerships are the key, working together is the key, joint programs are the key, but how do we do that? I think part of what you're about today is part of the experiment on how to do that and to prove to yourselves that this actually does

work, and then to make an effort to move this into the virtual community. If you do these things, then it's not just marine debris, it's all the issues that are in common in the Pacific Basin. You have the mechanism, you have the focal point, and you have the means to communicate and transfer that knowledge. But you've got to start somewhere in picking up, as we say, the corner of the rug.

Marine debris is an easily understood topic to the world. At a very general level everybody understands what it is about. It's a common resource topic that is not complex. So it's a perfect one, I would argue, to begin to build a partnership and demonstrate leadership in pushing a community to where it needs to go. Dr. Baker was correct. There is a window of opportunity, but if you don't embrace it and go after it aggressively at this point in time, you may be here ten years from now having a marine debris conference that we obviously talked about in 1987 and have been wrestling with for about twenty-five years. So in trying to lead the charge, I don't have a bugler, but my recommendation to you to is to stick with the process, make the effort to work in these working groups, push your facilitators, push your working group chairs, be sure the issues get out, then use the process to get to those priorities and, finally, take the ownership to write things down.

There is a logic to this. Truly, it's not just make-believe, I think you have a great opportunity. So with that, Allen, I think that's the only charging I can do. So I'm going to give it back to you. Good luck everyone and I'm going to be doing my little bit to help in the next four days.

• Transcribed from a speech given on August 8, 2000.

VIEWPOINT OF THE ADMINISTRATION

D. James Baker, Under Secretary, U.S. Department of Commerce, Washington, D.C.

Thanks Allen for the opportunity to be here. I just came back from the Coral Reef Task Force meeting, but I was also doing what we call NOAA in Samoa. We have four of our five line organizations represented there, with measurements of air chemistry, a marine sanctuary, marine fisheries, and the weather service all in that one area. It's obviously a critical spot, being the southern-most location in the United States, to pull all these things together. Of course, the Coral Reef Task Force was an important meeting.

Before I turn to the results of that meeting, let me talk about this conference, which is, as you saw in my letter in the booklet, the first of its kind. Marine debris is one of those problems that you are all aware of, but the public is not. So what you're doing is very critical. Twenty years ago we didn't recognize this was an issue. But today we know that we're going to be overwhelmed if we don't take action. This is typical of many ocean issues today.

We haven't been able to do a lot about solving these problems, but now we have new technologies and lots of interested parties. We have to start doing something now. That's why a conference like this is critical, and why we were able to get the Vice President to send us a letter, which I will now read.

Bob Rock, Marine Debris Communications Committee

Dr. James Baker, then the Under Secretary for Oceans and Atmosphere for the U.S. Department of Commerce's National Oceanic and Atmospheric Administration, delivers words of encouragement from the Presidential Administration.

Dear Jim:

Thank you for supporting the International Marine Conference currently underway. I hope the conference proves to be a successful and productive event. This important gathering brings together private and public sectors from around the world to assess the problem of derelict fishing gear and to recommend solutions. I share your concerns about the need for greater human stewardship about our marine environment. Unfortunately, not a day goes by when marine debris is not washing up on a shoreline entangling marine mammals, smothering around a coral reef, or wrapping around a boat propeller. We have learned perhaps the hard way that our ocean and coastal areas cannot withstand the onslaught for which we have subjected them over the past decades. I do believe that positive strides are being

made to combat this growing concern. Annual beach cleanups, scientific research on currents and biodegradable products, industrial breakthroughs and educational efforts all aid in finding solutions to this problem. In Hawai'i alone, volunteers have removed more than 35 tons of derelict fishing nets from reef and shorelines. But there is so much that can be done. I look forward to working with you in the future to ensure that all options are considered as we race to save our planet's precious marine resources. I look forward to hearing the results of the conference. Please extend my warmest wishes to the participants.

Sincerely,
Al Gore

So you can see that we have vice presidential interest here. Somebody should work up a debate question and see if we can get ocean issues raised in the Presidential candidate debates.

We have just finished our 5th Coral Reef Task Force meeting in America Samoa. The Task Force has gone to each of the areas of the U.S. that has coral reefs. We started in Florida, then Maui, the Virgin Islands, and then we went to Washington, which doesn't actually have any coral reefs, but we were doing budgets. Finally, we went to American Samoa. I think we achieved a lot of enthusiasm and interest there. Of course, one of the big heroes of the meeting was Captain Terry Rice, who is here from the Coast Guard. He played a key role in helping remove the boats that washed up on the reefs during Hurricane Val in 1991. This had been a problem for quite a long time. The task force raised the issue and Captain Rice was instrumental in solving the problem. Also at the meeting were Michael Crosby and Rusty Brainard from NOAA, Dave Jansen from Congress, Roger Rufe from the Center for Marine Conservation, and Dave Hoffman from the NOAA Climate Monitoring and Diagnostic Laboratory.

Let me say a few words about the results of the Coral Reef Task Force. This has been an exciting adventure. We started with eleven federal members from the federal agencies that have something to do with coral reefs ranging from the Department of Commerce/NOAA, Department of Interior to Defense, Coast Guard, Transportation, NASA, NSF, Agriculture and so on. It became clear that we had to also involve the states and territories. So we very quickly, at the first meeting, agreed that we would add representatives of the states and territories that had coral reefs. So all of the U.S. states and territories, all the Pacific Islands, and the Caribbean Islands are represented there in our discussions. That has added a certain liveliness to the activity. In fact, the islands were out in front of everybody else with their "All Islands Initiative." The All

Islands group took us out at the meeting in Maui to one of the rooms at the sanctuary and said, "Please listen. We've got a good plan here and we want you to listen to what we're doing." I think you can see from the accomplishments that we have followed that advice.

The Task Force has made real progress; we have a plan. We've made progress in mapping, monitoring, and conserving U.S. coral reefs. We have significant new funding this year, and we've developed some very nice partnerships. Unfortunately, Congress did not continue that money in the budget for next year. I'll say a little more about that in a minute.

But we do know that coral reefs are important to our economy. When you look at the total impact of coral reefs on fisheries and tourism here in Hawai'i our numbers show that half a square mile of a coral reef preserve will bring in something like $9 million each year to the economy. We see this in all our island states. We saw it very clearly in American Samoa that coral reefs are a critical part of the island culture. So we're not just protecting a beautiful area or trying to have a sustainable commercial fishery, but we are preserving the sustainability of communities. I think this is essential for the long-term.

This past year we developed the first U.S. action plan for the conservation of coral reefs; this was a major new step. It's a blueprint for how we would operate in the future. It lays out a series of priority actions that we need to take and the first comprehensive action that we put together for coral reefs in the U.S. It dovetails very nicely with the International Coral Reefs Initiative, which was already in place there.

At our meeting in American Samoa we looked at a number of items related to that action plan. We have provided about $2 million to states, territories, and commonwealths to support local and regional efforts. We've launched a massive effort for mapping with the point of view that if you don't map what you have, you're also not going to know where you should go to conserve; you're also not going to know what the trends are. We're using all the different techniques: on-site techniques; surface-based techniques; aircraft and satellites to map where the coral reefs are. We're determining what the geography is, what the geology is, and what the biological diversity is. We have some wonderful maps. If you want to see any of these you just have to go on the web page: coralreef.gov without the www. We're trying very hard to get all of the information onto the web page; your comments are welcome.

Another important achievement was the removal of the nine grounded ships that were damaging coral reefs in American Samoa. You can't see them now; that's because the Coast Guard, NOAA, and Interior found a way to remove what was remaining of those ships and to use the oil pollution act as a way to get some of the funding. The harbor looks wonderful now. It's an important accomplishment for the Task Force. As you know, you can't always point to real accomplishments by government tasks forces.

We also have used the Task Force to raise the issue of anchoring in protected habitat areas. Not just coral reefs, but all kinds of protected habitats. You know that the International Maritime Organization is not easy to move in terms of putting new regulations in, but they felt very strongly that establishing no anchoring areas by large ships in coral reefs and other fragile habitats was a sensible thing to do. This would be a way of protecting, for example, the coral reefs in the Flower Gardens Marine Sanctuary, U.S.

The Task Force has also completed the first ever inventory of U.S. coral reefs marine protected areas. We are looking at ways to improve the effectiveness of those marine protected areas. Right now the action plan calls for at least 20% of the coral reef area to be set aside by 2010 to be used as replenishment zones. This would rebuild the coral reefs with what we call no-take ecological reserves. And, of course, we're working hard on the specific definition of no-take to make sure that we can satisfy some local subsistence needs. It's very clear that you have to have some protected areas in the reefs and this is one thing we are working on.

We have also identified a need from the Pacific islands for a Sea Grant program. We are working closely with them as they start the development process. The Sea Grant program has been very important in the continental U.S. as we look at ways to merge and link research and applications in the oceans area. We're hoping we can develop such programs out in the Pacific islands.

The All Island Coral Reef Initiative includes Hawai'i, American Samoa, Guam, Puerto Rico, U.S. Virgin Islands, and the Commonwealth of the Northern Mariana Islands. We were able to get about $1.3 million out to the islands to implement all of these coral reef conservation measures; that was a good start. With the enthusiasm and success so far, we were able to get the President to put together a request of $26 million for coral reefs: $16 million in Commerce and $10 million in Interior. This is a big increase from the year 2000. The $10 million in Interior seems to be moving along pretty well, but the $16 million in Commerce is not there at the moment. We are urging Congress to look carefully at this as they go into conference on these bills. This is something we need if we're going to make sure that ten years from now we're not looking back on any damaged reefs.

We took a number of other actions. We agreed to assist the White House Council on Environmental Quality in developing new guidance under the National Environmental Policy Act, NEPA, to make sure that the actions that federal agencies take do not degrade coral reefs. NEPA is a powerful framework for us to work in.

That pretty much covers what we've done. We expect to have an oversight policy in place somewhere later this year, no later than November. The oversight policy takes the ideas of

the Presidential Executive Order and turns them into a transparent process. That means that agencies say what they're going to do. If there is a petition from somebody saying we don't think that's really going to work, the agency responds. There are timelines and deadlines built into the system and everything is open so it's clear how the task force works. We have codified the way we operate because it has been so successful up to now.

That concludes my discussion of the Coral Reef Task Force. Thank you for the opportunity to speak today.

I'd be happy to take questions from the press, but we're also looking for questions from anyone else. I'll also have an opportunity to talk with anyone else after this discussion here.

I urge you to go to American Samoa and have a look at the reefs, the culture. It's a beautiful part of the world, but you all know that.

QUESTION AND ANSWER PERIOD

(Question regarding roads) I think most of those causeways have been removed. This is something Captain Rice can explain further. We went through a very, very careful process of removing the corals before the big cranes came in and then re-cemented them back in place. Right now there is a very extensive effort going in to finish this work that was started by Dave Kennedy and his group at NOAA.

(Question regarding policy) Well it certainly is our intention to do that. I think we recognize that whenever we put in these kinds of regulations, you have to have some money. That was the reason for the fairly expansive presidential budget request this year. We will continue to do that as we go forward because you can't just put down rules without having some budget support. One of the reasons for this marine debris conference was to get some thoughts about incorporating the ideas of removing marine debris into this idea of marine protected areas. We want feedback on the recommendations of this conference for the marine protected area concept.

(Question) Well there are two questions there. One is that the cooperative process works very well. We're all big believers in trying to work cooperatively and trying to find imaginative ways in trying to do things. At the same time, you can't move too far away from the way the funds were originally set up. So one of the things that we agreed that we would do was to set up a small group that would look at the broader implications of what we had done in American Samoa. We wanted to see if we could apply some of the same funding and some of the same ideas that we accomplished there.

(Question) There's a very important bill that is currently moving in both House and Senate. It passed in the House and we have a version in the Senate. This is the Conservation and Reinvestment Act, or CARA, which uses royalties from oil and gas revenues to fund land acquisition and coastal zone protection. It's a very important act. I think we can come very close to getting agreement between the administration and the Congress of how things can be managed under that. It's just a question of trying to get it through in a shortened congressional session. As you look at things that you want to accomplish, the CARA bill as we call it, is going to be very important. I believe it's either going to happen this session or next session because there is very broad support.

(Question) Okay, two questions. The first question is the political question about the transition of institutions from one administration to the next. Since the Clinton/Gore Administration established the Coral Reef Task and I have a letter here from the vice president, he is obviously very supportive. He would certainly see things continue. In the case of a republican administration, we know that Republican Candidate George W. Bush's brother, Jeb Bush, is the governor of Florida. Any governor of Florida, particularly this governor, is very engaged in coral reefs. We talked with the head of the Florida Department of Natural Resources as a member of the task force and he said, "Yes, the governor is very committed." So I don't think you could get any closer than having the brother of a presidential candidate. But that's for the issues we have and I think that's pretty good. So I say, yes, there's a very good probability that regardless of which administration wins in November you will see strong support for this. We've been pointing out the importance of the issues, the need to codify the actions of the task force, the cooperative work that we do, and the way agencies have been able to accomplish things. We hope that the new administration would say, "Yes, that's a good thing. I think we should continue it." I think we have a very good opportunity because these are issues that really transcend politics at this point.

(Question) It's always a good question, but let me just say that all of us in this room have been pushing ocean issues for a long time. I think these issues have not always gotten the attention they deserve. I certainly see that as I work on the NOAA budget, and others see it in other parts of agencies. But we were able to convince the President, the First Lady, and the Vice President to come out to Monterey in 1998 to hold the first-ever National Ocean Conference. And as a part of the National Ocean Conference, we got a commitment from the Office of Management and Budget to make real progress in about fifteen different areas that ranged all the way from ocean exploration, oil spills, marine transportation, and Coast Guard issues, to national security, and marine protected areas. I think that shows a real commitment. Since then, the President has made his commitment about marine protected areas, and he created the Coral Reef Task Force. There's a whole set of things

happening that have not happened since the time of Lyndon Johnson who was also very engaged in ocean issues. I think this is not just a question of where we are in the timing of administration. You could be cynical and say, "Hey, the administration has reached the end of an eight year term and they're looking for legacy issues so they picked something." But I think it is mostly the fact that the trends are all driving these issues to be critical. That's the fact—the public is feeling these things, that society and business feel strongly about this. Our fisheries issues get more and more important as we see the stress on fisheries and the need to try to have sustainable fisheries. I think the politics are driven by the underlying trends that are there. This administration has responded and I think you'll see exactly the same thing in a Republican administration. So I think there is a real opportunity which builds on the same recognition that we had to have that National Ocean Conference to pull all the stakeholders together. This conference here is just one more piece of that.

(Question) The question was what are other countries doing about marine debris? I don't know the answer to that, but there are a lot of people here who do. Either in the issue papers or in the discussions you are going to hear a lot about that topic I know.

(Question) Well the most important thing is for members of Congress to hear from constituents that subjects are critical. Over the past twenty years or so and into the beginning of the Clinton administration, the focus was generally on what could you cut in order to make sure your spending equaled your income. But we are on a different playing ground now; we have a budget surplus. Some of that surplus we can use to reduce the debt, but some of that surplus can go to other programs. In this new framework there is an opportunity to talk to your member of Congress and say, "this is a topic that is important to me and I think you should consider it when you look at the budget process." Discussions and letters directly from constituents to members are very effective in the U.S. government process. That's something you should all be doing and I know you have been doing it because I can see the impact on Capitol Hill. The other thing is coming together in groups like this and writing resolutions, making sure that you're addressed by the right members of Congress and you've just done that because you've had Senator Inouye and Senator Akaka here. Visiting Washington is also useful. The more awareness that they get from hearing what they care about, the better we will all do.

• Transcribed from a speech given on August 8, 2000.

BRIDGING THE POLICY, SCIENCE, AND MANAGEMENT STREAM

Honorable Neil Abercrombie, Representative, United States Congress, Hawai'i

Thank you very, very much. Mahalo and aloha everyone. Aloha. Thank you for the opportunity for me to be here. I know with some trepidation that I am supposed to kind of keynote this luncheon panel session. I am very pleased to be sharing the platform, at least in its initial stages with the people who will be addressing you, whose cards you can see here, Ms. Lent, Mr. Rufe, and Mr. Julian. I think that what they have to share with you will be very, very important.

Now I expect that many of you, even the young people that are here today, have been addressed by elected officials and politicians before, and politicians generally start off by saying how happy they are to be some place. And I don't want to break that tradition. I want to say how happy I am, but the difference is that I mean it quite sincerely because this does give me an opportunity. And as you know about politicians, an opportunity to speak is something that they treasure.

It does give me an opportunity to acquaint some of you, especially the young people, with what we are actually doing in the United States Congress.

There is sometimes a disconnection between the academic and scientific community for those who are particularly interested in the environmental aspects. Whether it's of ocean science, marine biology, or any of the speculative activity that might be associated with the ocean, up to and including commercial activity in fisheries.

Sometimes a disconnection exists between that and the political sphere. What I am about to do today in the few minutes that I have to speak with you is indicate to you very, very clearly, I hope, that such a gap exists that shouldn't and that I can help close that gap if it exists today. I want to do it.

Now, having come from an academic background myself, perhaps I don't necessarily have a prejudice in that direction. But I certainly have some experience and some comprehension as to what is necessary in order to make certain that whatever risks there might be, or seem to be, get healed or stitched together as quickly as possible. The oceans cannot afford to have that kind of gap much longer.

I am a member of the Resources Committee, but not all of you may be familiar with that particular phrasing. It used to be called the Committee on the Interior. It is the same thing, because much of the work we do in the Resources Committee in the Congress of the

United States has to do with land issues, water issues, anything having to with what is generally thought to be involved with the Interior Department of the United States.

I have served on park committees, ocean committees, insular affairs committees. Many of the young people here today, of course, are from our Pacific and island neighbors to the west of us. As a result, those who have served on the committee for some time have developed some expertise, perspective, and depth of knowledge with respect to the subject matter with which they're required to do legislation. This is not so much an argument against term limits as it is an argument for keeping people in Congress who are judged to be competent and useful to their districts.

Now, on the particular instance that I am speaking of here in my work with the Resources Committee, I am just going to cite very quickly as an example, "coral reefs."

We now have a bill in the House of Representatives that we are dealing with in the Resources Committee with respect to the protection, preservation, and the maintenance of coral reefs. We are trying to do this in the context of trying to figure out what global warming means and what long-term and even short-term trends might be in terms of climate and how that would affect the ocean. We are trying to deal with it in the commercial context through the Department of Commerce with regard to fisheries and the proper management and mission of the fisheries that may exist, especially in the Pacific areas where coral reefs are located.

We have a more particular responsibility in the Hawaiian Islands with respect to those coral reefs that we have some nominal jurisdiction over. We deal with those aspects of the Department of the Interior through the Fish and Wildlife Service that have regard for and responsibilities and obligations to deal with the ocean environment. What I want to get across to the young folks, some of whom have already spoken to me in the brief moments that we had a chance to meet one another here today, is what they can do to effectuate some kind of immediate response. They can take some immediate responsibility and urge those who now have "charge of these issues," if you will, to make certain that we will act in such a way as to leave something for them to be able to protect, preserve, and utilize in the proper way.

I want to say in that context, it is somewhat frustrating to me as a member of the National Legislature United States Congress and a member of a very hardworking committee of very knowledgeable people, to see disputes go on between the Department of Commerce and the Department of Interior. I can tell you that the legislative intent that we have, whether it's with regard to coral reefs or marine debris, as such, has to do with the ocean environment concerned. People are going to insist upon a parochial and narrow vision of what it is that they are responsible for or who is best able to do it. They don't take into account the cooperative

endeavor I and most of my Republican or Democrat colleagues believe is necessary to accomplish these overarching goals with respect to the ocean environment and, even more particularly, towards inner space.

We seem to have a predilection in the United States, in particular today, towards dealing with questions regarding outer space. There is a certain romance to it, there is a certain exploratory quality that is enumerated over and over again, "a look to the star" kind of approach to outer space which is seen as visionary, which gets broad support from people who are willing to commit many resources. And we do not take into account that the oceans, which take sufficient account in my estimation, constitute better than three-quarters of our planet. The oceans constitute, for the most part, inner space, which is yet to be explored, let alone exploited, in a manner that can, in any way, be associated with the kinds of knowledge, commitment, and focus that we have in outer space.

Therefore it is even more imperative that those that have the governmental responsibilities and obligations of law to try to effectuate activity in and on the oceans with respect to all the items that I have outlined. It is even more important that they work in a more cooperative way with us. It's sometimes disappointing to me to see announcements in the newspaper about proposed objectives in various departments which have not really been shared with the Congress or that Congress has seen as some sort of an obstacle. We have not yet fully taken into account that the role of the player may not be played by the U.S. Military and/or the Coast Guard. When decisions are made on an international basis we need to see to it that they, in fact, will be supported and enforced. We've got to make some basic decisions about that.

On land we are making those kinds of decisions for better or for worse. I'm not saying that every decision gets made with the use of coercion as in body or international forces of one kind or the other. I am on the Armed Services Committee as well and I can tell you that these are problems not easily resolved in a post cold war world.

We now have a situation with the United States Military and International Forces under the United Nations in which they not only have a war fighting capacity, but they have to have a peace-keeping and peace-making capacity as well. I foresee a time in the very near future and, in fact, I believe in the immediate future, where we have to make decisions about international enforcement of international regulations, laws, and other protocols that might be developed. Enforcement will be required, if not the U.S. Navy and Coast Guard, by international forces or navies and coast guards throughout the world cooperating with one another. There need to be a clear understanding as to what will constitute enforcement, and what the penalties will be for disobeying the rules and international rules and regulations, not just of commerce, but of interaction on and under the sea.

Now, that is something we have to come to grips with and to try to ignore it seems to me if we do so our peril is certainly the ocean's peril. So, I believe and I want to emphasize to you that I think we need, to have if you will, a kind of intellectual memorandum of understanding with one another.

We have to make a commitment to one another and with one another that we will not only act in a theoretical way or an academic way with regard to the oceans and the ocean environment and with that which takes place in and on the ocean. We need to carry through with effective institutional mechanisms of enforcement of those decisions that we have made to see to it that we have all lived up to what we need to do. In many instances it is going to mean that institutions such as the Commerce Department and the Interior Department are going to have to sit down with one another and decide how best to implement the legislative intent that I am talking about. If we don't do that, and if we are not able to do that, we are going to end up doing two things. First of all, we will violate what I consider to be a fundamental legislative intent, which is that legislators should write laws respecting the intent of policy. The mission and the goals of the legislation should be embodied in the law.

The rules, regulations, and management act should not be included in the law because no law can be written that takes fully into account all the circumstances that will have to be met, most certainly, the changing circumstances that take place as a law is implemented. Just take the question of commercial fisheries utilizing use of the oceans on the one hand, the Department of Commerce that I mentioned, and then take the idea of preserving the resources of which may involve coral reefs. Again, I'll use that as an example because it's right in front of us that maybe the Interior Department has and then watch them fight with one another. Then you end up then with the Legislature saying, "Okay, if you folks can't come to some memorandum, some basis of understanding as to how this business will be conducted, what kind of environmental situation exists, what kind of science needs to be applied, what kind of commercial and/or recreational or other environmental aspects will come as a result and what other implications there are, then we'll have to do it in legislation itself." That's not a good idea.

I don't think that is the way we should approach it. It is impractical and it doesn't work very well. Now, if it doesn't, then the Legislature is going to have to require that and we want to try and avoid that if we can in my estimation. So I am hoping that this key problem between policy and management, and this is something you young folks have got to understand, takes more than having good ideas and having good intentions. You have to have your policies very clearly in mind based on the best science and the best understanding of where you want to go. But then you have to manage it. After that, that is almost the easy part, you have to figure how, in fact, you are, in the practical every day world, going to manage it and how you can get people to pay attention to what your real problems are.

Coastal scientists and policy makers, who as far as I am concerned don't interact sufficiently, whether it's on the coast or out on the ocean itself, to ensure that decisions and policies are adequately based in science or are making some progress. It's not enough and the scientist culture, as I have indicated, is different from the policymaker's culture. In the end, if there is a vacuum of recommendations based upon people being able to come to conclusions as to how best to manage the resources, the policy makers, people like myself, are going to make that decision. We don't want to make that decision in a vacuum, but if that happens, that is what we will do. And so we want to move on a broad basis.

Now one of the things that is taken up in Hawai'i, and I'm sure a lot of you have paid attention, is longline fishing problems and dealing with the second area that I want to bring up. If we fail to make the kind of management decisions that I'm talking about, based on policy of mutual understanding of the difficulties involved, what you end up doing is focusing on single issues. When you focus on single issues you miss the context within which multiple problems or multiple level problems have to be solved. I don't even want to use the word problems, let's use the word challenges—multi-level challenges have to be answered. It does no good to have a judge or a legislator because, I tell you right now, I'm the judge when it comes to the oceans in the Pacific sitting on that committee, or Representative Faleomavaega from American Samoa, or Representative Underwood, or any of us from the Pacific area that are on the Resources Committee. I don't want to be the judge, that is not my function. But by default I end up being that. Or if by default, we end up in court where there is Judge Ezra or anybody else, doesn't make any difference. It tends then to be single-issue politics. Single-issue politics. The ocean is politics. If you think you're going to avoid politics when it comes to science, when it comes to the ocean environment, not only are you dreaming, but you're doing a disservice to that what you say and presumably all of us here in this conference are dedicated to.

The question is whether it's going to be good politics or bad politics. That's what the question is. When you are unable to resolve your challenges and you end up in a court making decisions, that is an expression of failure in my judgment rather than a reasonable or rational way to resolve the issues. Because a legal conclusion is not necessarily a resolution of the issues or the circumstances around which the issues were contended. So in some respects I'm giving you a little bit of a sermon today and an admonition. It's not because I'm accusing anyone in here, quite the opposite. I'm pleading with you to utilize all the expertise that is in this room. Certainly, the collective judgment of the people in this room and the commitment of the young people that are here from all across the Pacific area, the dedications they are expressing by virtue of being here today, is far more than I am individually able to produce or certainly able to contend with.

I make no case to you that I'm in a better position as a member of Congress to be able to give a clear expression to those solutions to the problems or the challenges that I have outlined. But I can tell you this, the fact is that there are elections and after this November, 435 people will represent almost 300 million people in the United States of America, tens of millions more across the Pacific, our brothers and sisters, our island friends across the Pacific and all the way to the Rim and, in fact, our extension to the planet when we talk about fisheries and the various ocean environments. Those 435 of us, when we evolve into our committees, have to make those decisions and are going to make those decisions.

In conclusion, what is required is that we have to put the best possible people, the best informed people, we can into those positions to make those decisions and you have to reach out to those of us who must make these legislative decisions with the information that you possess. The worst thing that can happen to me, the worst thing that can happen to these young people who are expecting the adults in the room to act on their behalf as we go into the 21st century, is to be contemptuous of the political process or to say that the political process is something you would rather divorce yourself from, or something that would require the kind of attention from that you find irritating or debilitating. Or somehow an expression of activity which you have to add to all the other endeavors that you are responsible for, it can wear you out if nothing else. But the failure to do it then leaves people like myself in the position of almost having to almost fend for ourselves to try to figure out what we are going to do, where we are going to go, how best we should do it.

I'm not adverse to or in any way not used to the idea of many different points being made all at the same time, some of which are contradictory, some of which are paradoxical. I find that, parenthetically, more often than not. I don't find so often that the issues are necessarily always one of confrontation and contradiction. More often, and I would take the longline fishing example again and good environmental controls, they're paradoxical. They should not be seen as being in opposition. When you get into court, because court by definition is a paradoxical situation in which there is one side and there is another side and, instead of running parallel tracts, they crash into one another.

Our goal should be those of us who care about everything associated with the ocean environment from debris on through to the other things I have touched upon. Our goal should be to stay away from that, to work with one another, to be committed to one another and to do the kind of thing that I'll talk about just very briefly—what we did when I was in the Hawai'i State Senate and how we conducted business there.

We had two rules—no one left when we sat down to get an issue resolved, no one left, and no one punched anyone. Now I see some smiles on people's faces because I notice you

were looking around the room, some of you, to see what person you would like to punch. Now maybe you haven't done it yet, but you've thought about it. Now no one leaves and no one punches another. Now on the surface that sounds funny, but the point behind it is that you must make a commitment—in other words to say we're going to resolve these issues, we're committed to it, we're not leaving until we get it done, we're going to respect each other, and we're going to give the other person the benefit of the doubt with respect to their position. And if we commit ourselves to the ocean, to the betterment of the planet, the betterment of everything associated with those things we care about most deeply where the ocean is concerned, then we can do this.

As a practical matter, I want to leave something with the young people as to how we might do this and as to how we can accomplish it. The Western Pacific Fishery Management Council, along with other people associated with issues like longline waters, has been able to testify directly to us from Washington through tele-conferencing.

So what I want to leave you with, having given you my theoretical sermon, is a practical way not to sin anymore. Then, we absolutely have to try to make use of teleconferencing.

I would like to be able to, and I hope you folks will consider the idea, perhaps by resolution form or if you're associated with some of the institutions that I have mentioned, take up some challenge to push for budget consideration for having teleconferencing in the Pacific so that we can bring in some of the people from Palau to Arrota to Guam in order to speak directly to us in real time. With teleconferencing we can do that.

I, for example, have not been able to get to some of the islands in the Pacific, other then Guam, even though I have that responsibility being on the Resources Committee. I have not been able to work out the logistics between my responsibilities to the Armed Services Committee, Hawai'i, the mainland, and so on when we were actually able to physically travel to the Pacific.

I've been unable to do it, but with teleconferencing in real time we can communicate with one another directly. So I hope that you will take up that issue. Teleconferencing might enable us to meet one another, to speak with one another, to get to know one another a little better than we've been able to intellectually and physically up to this point. So with all those admonitions I thank you once again for this opportunity to be here with you. I hope I've had something to share with you that you'll find a practical value in this conference. I want to indicate to you on behalf of Representative Don Young, the Chairman of the House Resources Committee and the Senior Democrat on the Committee, the Honorable George Miller of California, that they and all the members of the Resources Committee—regardless of their political persuasion—are committed to seeing to it that you have a success with this subject matter that's before you in these days here in Honolulu. We are committed to working with you to see to it that we can all be proud of the work we do with the ocean, environment, and all of the issues that affect the health and welfare of our planet. Thank you very much and aloha.

• Transcribed from a speech given on August 9, 2000.

MARINE DEBRIS:
BRIDGING POLICY, SCIENCE, AND MANAGEMENT

Rebecca Lent, Regional Administrator, Southwest Region,
National Marine Fisheries Service, Long Beach, California

INTRODUCTION

It is an honor for me to represent the National Marine Fisheries Service (NMFS) and our Assistant Administrator, Penny Dalton, at the International Marine Debris Conference. Penny and I are grateful to the organizers for including us on the program and we want to congratulate you on an excellent conference.

In my presentation, I wish to provide a brief overview of NMFS program in marine debris. As noted in the excellent presentations and discussions of this conference, marine debris from both land and maritime origins pose a serious threat to ecosystem health in the Northwestern Hawaiian Islands (NWHI). NMFS is addressing marine debris through a comprehensive, collaborative program involving a number of partner agencies. NMFS efforts focus on assessment and monitoring, marine debris removal, impact assessment, and outreach programs.

ASSESSMENT AND MONITORING

Annual monitoring and removal of derelict fishing gear from the beaches of the NWHI has been conducted since the early-1980s during beach censuses for Hawaiian monk seals at French Frigate Shoals, Laysan and Lisianski Islands, and Pearl and Hermes and Kure Atolls. In 1996, annual surveys of derelict fishing gear and other marine debris on the surrounding coral reefs, via diving and reconnaissance activities, were initiated by the NMFS Honolulu Laboratory. In FY2000, reef reconnaissance surveys were conducted at Pearl and Hermes, Kingman, and Palmyra Atolls, and Lisianski, Jarvis, Howland, and Baker Islands. The surveys are conducted in partnership with the U.S. Coast Guard, U.S. Fish and Wildlife Service, State of Hawai'i, local governments, and many non-governmental organizations (NGOs). These surveys collect data on the type of debris, size, distribution, and density. Once the surveys are completed, the debris is removed.

These surveys have documented that the most common type of fishing debris is trawl netting. The critical importance of addressing marine debris was emphasized by the finding that density of debris was highest in some of the nursery grounds for the critically endangered Hawaiian monk seal. Derelict fishing gear appears to be a greater threat to ecosystems in the NWHI than in other areas surveyed.

Additional surveys are planned in FY2001, as funding allows, and will be conducted at Pearl and Hermes and Kure Atolls. In addition, previously surveyed sites at French Frigate Shoals and Lisianski Island will be re-surveyed in order to monitor debris accumulation rates, including that of derelict fishing gear.

MARINE DEBRIS REMOVAL

Under this program, marine debris removal has been substantial. Some 35 metric tons of derelict fishing gear have been removed in the course of the program. Numerous agencies participated in the cleanup effort, including the U.S. Coast Guard and Navy, U.S. Fish and Wildlife Service, University of Hawai'i Sea Grant program, Hawai'i Coastal Zone Management Program, City, County and State partners, and several private groups and NGOs. The accomplishments of this partnering venture earned a National Performance Review Silver Hammer Award. Removal efforts will continue through the end of 2000 as well as in 2001, again focusing on a multi-agency, cooperative approach.

Once the debris is removed, efforts are made to identify the sources of derelict fishing gear based on the type of gear collected. The NMFS Honolulu Lab is initiating efforts to create a catalog that will assist researchers in identifying derelict fishing gear. Such efforts will be critical in advancing initiatives to address fishing gear debris through international efforts.

IMPACT ASSESSMENT AND OUTREACH

In measuring the density and type of marine debris around various islands and atolls, researchers have been able to assess the actual and potential impacts of marine debris on coral reef ecosystems. For example, Hawaiian monk seals were observed entangled in fishing nets an average of fifteen times per year in the early-1980s. Impacts on coral reefs as well as threatened and endangered turtles are also assessed through this program. Outreach will include educating the fishing and maritime industries about the problems of derelict fishing gear and the potential to minimize future damage through gear modifications and/or identification. These outreach efforts will, of necessity, be international, with collaborative efforts with other Pacific Rim countries.

OUTLOOK

The marine debris program of the NMFS Honolulu Lab has demonstrated the need for a collaborative approach in addressing this serious problem. Not only is collaboration among local, federal, and private partners necessary in identifying, measuring, and removing marine debris, but international efforts will be essential in making a long-term difference. As noted in presentations by representatives of the U.S. State Department, measures designed to reduce marine debris from derelict fishing gear should be incorporated into the conventions of international fishery management organizations. As in domestic fisheries, gear identification as well as avoiding measures which would lead to derby fishing can contribute to reductions 0in lost or discarded fishing gear.

Again, I thank the conference organizers for providing this opportunity to address you today, and I compliment you for an excellent conference.

- Transcribed from a speech given on August 9, 2000.

BRIDGING THE POLICY, SCIENCE, AND MANAGEMENT STREAM

Roger Rufe, President, Center for Marine Conservation, Washington, D.C.

Good afternoon. I'm Roger Rufe, president of the Center for Marine Conservation. It is a real privilege for me to be here with all of you, and to talk about something that is near and dear to my heart—how to work effectively with others, or as I refer to it at CMC, being "shipmates."

We're calling it "bridge building" here, but it amounts to the same thing—working together for a common goal, a goal no one agency, discipline, or constituency can reach on its own. Understanding and trusting each other enough to share information and resources that enable others to do their jobs effectively, and having one's own efforts enhanced through the efforts and achievements of others. In short, teamwork.

I came to CMC last November after thirty-four years in the U.S. Coast Guard. Those of you who have served on ships understand the deep and significant implications of the word "shipmates," and the importance of all "hands" working together, sometimes literally, for your survival.

We're here at this conference—and I know some of you have been here since the beginning, sixteen years ago—working for the survival of ocean ecosystems and the wildlife that depends on clean, healthy ocean waters.

I believe—indeed it's been demonstrated over the years—that marine debris is an area in which great strides can be made through "bridge building" and teamwork.

The Center for Marine Conservation has long operated on a core belief that building bridges among various constituencies is absolutely critical to any conservation success. And science is the foundation that supports all these bridges among conservation advocates, policy makers, users of natural resources, and citizens alike.

These tenets have fueled our efforts over the years to hammer out, with the assistance of partners too numerous to name, policies, legislation, and regulations that made good conservation and economic sense.

Commitment to teamwork and inclusivity now drives our efforts to protect special places in the ocean from adverse human impacts. We know that a marine sanctuary that is not supported by a majority of citizens, user groups, local and state, as well as the federal government will be a sanctuary in name only, and does little to safeguard the wildlife and ecosystems within it. And without continuing scientific research into the effects of human activities and management measures we have no way of knowing whether such a sanctuary or protected area is accomplishing its purpose. These same principals have always shaped our approach to marine debris.

When we began looking at marine debris and its effect on ocean wildlife in 1985, we learned about the prevalence of plastic resin pellets on beaches. By that time we had established a relationship with the Society of the Plastics Industry (SPI) that we took advantage of to address the pellet problem. As many of you know, large quantities of plastic resin pellets were being found in dead seabirds around the world, because the pellets were the same size, shape, and color of fish eggs.

Our colleague at SPI had no idea of the extent of the problem until CMC took him to a Texas beach and showed him. Since then, plastics manufacturers, with encouragement and assistance from SPI, improved their pellet transport and containment practices to greatly reduce the number of pellets escaping into the environment. They are educating their employees about the changes and why they are so important.

But CMC's efforts on marine debris are not limited to working with just one industry. We have built bridges elsewhere that dramatically changed national policy.

The massive, annual outpouring of citizen action known as the International Coastal Cleanup, now in its fifteenth year, has tremendous potential for effecting change. We harnessed that potential as early as 1987, when cleanup volunteers throughout the Gulf of Mexico signed petitions urging the U.S. Senate to finally ratify the MARPOL Treaty's Annex V, which addressed solid waste—the very items they were collecting from the beach each September. In that instance, the cleanup data, which showed the extent of the problem, combined with an informed and concerned citizenry helped turn the "wheel" of national government. And the environment has benefited. Since the implementation of MARPOL Annex V in 1989—made possible through U.S. ratification—the amount of sea-borne debris collected at the International Coastal Cleanup has shown a marked quantifiable decrease.

NOAA's Marine Debris Information Office is another successful example of bridge building and load sharing. NOAA received funding in 1988 to develop and distribute educational materials about marine debris to all interested parties—the general public, educators, fishermen, ship captains, and marina operators. CMC had the capacity—and where we didn't have it we could quickly create it, perhaps more quickly than could a government agency—to implement the program. Until federal priorities changed and the funding was taken away from NOAA in 1996, CMC was the conduit and information source on the topic, and we responded to tens of thousands of requests.

If all of what I have said so far is true—if the success of partnerships is so well documented, and if marine debris is so well suited to partnerships, then why, in the sixteen years since you all first met to discuss the problem, are we still meeting to discuss the problem?

First we must recognize that this effort requires dedication for the long haul. The problem wasn't created overnight and won't be solved quickly. Also, we don't use partnerships enough.

I don't know if it's human nature, but it certainly seems to be institutional nature that, once we gain a certain level of understanding of or expertise on an issue, we turn inward, honing our particular skills, approach, and perspective. Once we've found our niche, we refine and repeat it to the point where we forget to look out and beyond our expertise to see what others are doing and to ask how our efforts can benefit from others' involvement. Conservation advocates are as guilty as policy makers and scientific experts.

Part of the problem is that, while we all share the same goal of reducing marine debris, our approaches are different and sometimes appear to be exclusionary. Scientists want to promote and advance scientific research and prefer some level of certainty before taking an action. Environmentalists, on the other hand, working within the reality of dwindling and endangered resources, advocate action before it's too late and policy makers must weigh the effectiveness of whatever decisions they make against competing interests and players, and often in mind of an uncertain budget process.

What generally results from these conflicts of approach and priority is a spiral of increasing mistrust and misinformed opinions of the other groups' motives and expertise. We have myths about each other that we simply have to overcome if we are to build meaningful, successful partnerships. Here are a few:

- Researchers have no grasp of the real conservation issues. They are interested in pure science and have no desire to play a role in advocating for stronger ocean conservation or policy.
- Environmental groups are only interested in advocacy and fund-raising on high-profile ocean conservation issues. They are not interested in research and they are radical in their approach to conservation.
- Government agencies and government regulations are burdensome and an obstacle to real progress on conservation.
- Government agencies are ineffective. They are not doing enough to conserve ocean resources.
- Industry is interested only in the bottom line and cannot contribute to effective solutions.
- Citizens are fickle and will lose interest in difficult conservation issues. They do not have the time, education, or inclination to participate effectively in ocean conservation.

I don't believe any of that and I hope you don't either, but there are those that do. We must move beyond these myths if we are to see real progress in eliminating marine debris. We no longer have the luxury of choosing whether we will work cooperatively together. We simply must.

Government funding for applied and basic research has and will likely continue to decrease. Government funding for marine conservation is limited, often restricted, and

not always a priority for Congress, as you folks from NOAA and NMFS know all too well. And ocean environmental issues are and will continue to become more complicated. But the good news is that there are ways we can facilitate partnerships and bridge building.

First, the best public policy comes when the affected industry is fully and openly engaged in the policy making process. Second, scientists and environmental groups must improve their understanding of the affected industries, state and local policy-making, and federal regulatory and appropriation processes, and engage more effectively in them. Only by doing so will they affect conservation policy and secure increased funding for conservation. Third, scientists and environmentalists must work with policy makers and industry to create policies and regulations grounded in sound science. Fourth, scientists and environmental groups, together, must develop sound, convincing scientific arguments. They must advocate for stronger marine resource and ecosystem conservation and they must do a better job of educating the public about marine debris and other conservation issues.

Fortunately, we do have great examples of partnerships that work. One effort that you'll hear more about tomorrow was the removal of tons and tons of derelict fishing net and other gear from the Northwestern Hawaiian Islands. This effort took place in November of 1998 and involved fourteen organizations working cooperatively—from NOAA and NMFS to the City and County of Honolulu, from the University of Hawai'i to Browning Ferris, from CMC to the Hawai'i Wildlife Fund.

From the start, NMFS had bigger objectives than simply cleaning the reefs. They wanted to bring other federal and even state agencies into the field of debris cleanup. They wanted to develop expertise and they wanted to establish sites for a study of debris accumulation and its impacts.

To make a long story short, in this first expedition about twenty divers worked from two vessels—one Coast Guard and one NOAA vessel. They gathered floating gear and cut away gear that was entangled on reefs and rocks and brought it back to the Coast Guard cutter Kukui where gear experts and other scientists sorted and catalogued it, and made rough assessments as to the origins. In six days divers collected more than six tons of net and gear.

This demonstration of teamwork was recognized by Vice President Gore with a National Performance Review Silver Hammer Award for Reinventing Government.

Then in November 1999 the effort was repeated, this time at Lisianski Island, Pearl and Hermes Reef, and Midway Island. The "net" result, so to speak? In thirty days 25 tons were collected.

The nets, or samples of each, from both trips are still being analyzed to determine which fisheries and where in the vast Pacific Ocean these nets are coming from. Once some conclusions can be drawn, CMC will work with the government and the fisheries involved in finding ways to prevent the nets from becoming debris—either through fishermens' education programs, new technology, or other ideas that I hope will emerge from this conference.

CMC is proud to have been a part of these projects. We look forward to continuing them with NOAA, NMFS, and the other partners on future expeditions.

Inspired by these successes, this past May CMC staff and the tribal government of St. Paul, in Alaska's Pribilof Islands, conducted a three-day cleanup of derelict net. Together we removed about three tons of net and other gear from the rocky shores of St. Paul, where many species of seabirds nest every year and where northern fur seals—particularly vulnerable to entanglement in fishing gear—gather to breed each spring. Again, meticulous records were kept on what was collected and the information has been sent to NMFS for analysis.

NMFS plans to conduct another Hawai'i net retrieval expedition this fall, going to new sites. From the data they've amassed, CMC and the Western Pacific Fishery Management Council are planning to compile a net reference catalog. Future goals include expanding the project internationally to include other gear experts and developing a web site specifically for information on this project and its findings.

I'll close by supporting Dan Basta's exhortation to you yesterday. Let's use this conference to redouble our efforts, renew and strengthen partnerships, and in very specific ways, begin to lay out an action plan. This conference should not only rekindle enthusiasm by celebrating past successes, but by recognizing that we must focus on those areas where we can have an impact, and it must be a focus for the long haul.

Thank you.

BRIDGING THE POLICY, SCIENCE, AND MANAGEMENT STREAM

Michael Julian, Chairman, Marine Environmental Protection Committee, International Maritime Organization, Australia and Executive Manager, International Relations, Australian Maritime Safety Authority, Australia

INTRODUCTION

First, may I take this opportunity to express my appreciation to the conference organizers and, in particular, Mr. Allen Tom and the Hawaiian Islands Humpback Whale National Marine Sanctuary for inviting me to this conference and for making my participation possible.

Observations

My observations over the past two-and-a-half days, listening to the various presentations and talking to conference delegates, are:

1) There is an impressive amount of work being undertaken with regard to marine debris and derelict fishing gear, in particular.
2) Those involved come from three quite separate streams of people as identified in the title for this panel discussion.
   - We have a large group of policy people. This group is well represented both at the federal and state level.
   - We have quite a sizeable science group, in which I include those sharing environmental concerns.
   - But where are the representatives of the fishing industry to represent the fishery management stream?

Early on Monday morning I went through the list of conference participants to see how many represented the fishing industry. Out of approximately two hundred conference delegates I counted eight or so individuals, most representing fishery councils, which means they probably fit more into the policy group. This left two or three who could be seen as truly representing fishing industry management.

I appreciate the economic reasons to bring fishing industry personnel to a conference such as this. We have heard the argument that fishers cannot afford to "waste time" retrieving derelict fishing gear. Equally it would appear they could not give up valuable fishing time to join us in conferences like this.

However, as major stakeholders in this issue, a means has to be found to closely consult with fishing industry management. They must be involved in reaching solutions; otherwise no solutions will be achieved. Perhaps a separate forum can be established where the outcomes of this conference—the action plan—can be discussed, and the views of the fishing industry obtained regarding the practicality and economic impact of the conference recommendations.

A related exercise could be to compile a list of all stakeholders to ensure that in any future conferences of this nature that we do have full representation. This may well have already been done and we may have full representation apart from the fishing industry community, but more practitioners would help. We also need greater involvement from governments of all Pacific Rim countries and to involve them in future conferences on this topic.

OWNERSHIP

In coming back to address the issue of bridging the various streams, a key issue that has already been identified, but needs emphasising, is "ownership." Who has "ownership" of the problem of marine debris, particularly derelict fishing gear the subject of this conference? The simple answer: all of us at this conference should have ownership.

Government Organizations

The more complex issue to be resolved is which governmental organizations should have ownership? This is a problem both at the national and international level. There is probably no single agency suited to undertake the overall task, therefore there needs to be a clearly identified alliance of the two or three key agencies, with one agency clearly identified and tasked with the responsibility of having coordination.

The agencies should be those with responsibility for fisheries management at the federal or national government level, those with marine environmental responsibilities (NOAA and the EPA in the U.S.). The third group should be the agency responsible for administering the MARPOL 73/78 Annex V regulations (the USCG in the U.S.).

At the international level it is probably organizations like FAO, UNEP and IMO which must work together to bridge the gaps. However, before embarking on establishing such an alliance at the international level, the issue of marine debris has to be clearly demonstrated to these UN organizations as being a significant problem.

Currently, I can say it is not even an issue at the IMO's Marine Environment Protection Committee simply because member governments have not submitted papers informing the committee that it is a problem. But from what I have seen and heard here at this conference, it is a significant global problem with very little being done to minimize the environmental as well as economic impact of it. Similarly, FAO and UNEP have probably not been made aware either.

We should also include international non-government organizations such as the International Union for the Conservation of Nature, Marine Stewardship Council and the World Wide Fund for Nature (WWF).

Other groups that need to be involved, but at the regional level, come under the umbrella of regional fisheries management organizations (RFMOs) responsible for managing high seas and or shared fish stocks. There are several of these and as an example include the Commission for Conservation of Antarctic Marine Living Resources (CCALMR), Indian Ocean Tuna Commission (IOTC) and the Commission for the Conservation of Southern Bluefin Tuna (CCSBT).

It is a challenge to broaden the scope of the various fish management or resource agreements to include management of ecological issues including marine debris and loss of fishing gear. It is up to governments as well as the fishing industry represented in these groups to achieve this.

A broader agreement, the UN Fish Stocks Agreement, which is currently awaiting ratification, will provide a broader framework from which regional fisheries management organizations operate.

The FAO Code of Conduct for responsible fishing, together with the FAO International Plan of Action to prevent, deter, and eliminate illegal, unreported, and unregulated fishing (IUUF), are key instruments which could be used in the future to better manage the problem of derelict fishing gear. In the future IUUF will be particularly relevant to the flag state and port state roles and responsibilities envisaged by FAO.

With the potential of introducing port state control on foreign fishing vessels, port state vessel inspections will be able to be made to identify fishing gear usage and comparisons made with gear supplied and remaining. If there is any shortfall that cannot be explained, the vessel and master could be held accountable. Providing legislation is in place, they could also be subject to penalties.

With three groups having or sharing ownership, the problem will still exist unless there is a political drive or directive to fix the problem.

It would appear that we need an "Exxon Valdez" equivalent in marine debris and derelict fishing gear terms to motivate our politicians and the general public. I am not sure what would constitute an equivalent incident other than much greater live television footage of marine mammals entangled in derelict fishing gear and the large quantities of fishing debris washed up on the world's beaches on a regular basis.

The coordination issue is one identified in the Prevention and Legal Issue Working Group of this conference—particularly the coordination of information exchange—and it is likely this group will recommend the creation of a marine debris web site. This would be a depositary for a wide range of information, research data, ideas, possible solutions, and links to other relevant sites. This would be a particularly valuable tool in bridging the policy, science, and management streams, and in building partnerships.

As we are honoured to have on our panel the President and Chief Executive Officer of the Centre for Marine Conservation, I would like to invite him to consider the feasibility of his organization hosting such a web site. It would be beneficial for an NGO to be involved in this way and the CMC has clearly demonstrated its commitment to solving the issue of marine debris. Therefore it would be an excellent choice to host such a marine debris web site.

Youth Organizations

Another means of bridging the gaps is to utilize environmental programs designed for our younger generation, particularly bearing in mind the challenging questions they asked us on Monday at the opening session. Recently, in Australia, a group of dedicated private sector groups launched AUSMEPA, which stands for Australian Marine Environment Protection Association. AUSMEPA is modelled on the Hellenic Marine Environment Protection Association's HELMEPA, which has been in operation for some eighteen years. Funded by Greek ship owners, it has a key objective of providing education and training in both maritime safety and marine environment protection. AUSMEPA is more attuned to HELMEPA Junior, which is designed to involve school children in education programs which focus on the importance of preserving the marine environment. Seeing the representatives of several Pacific islands schools at this conference serves to illustrate the importance of educating our younger generation in the significance of environmental preservation and sustainability.

Fishing Industry Organizations

Yet another means of bridging the gap is the need for greater collaborative arrangements between the range of organizations involved in the fishing industry. Using a comparative example in recent years is the shipping industry, which has a significant problem trying to rid the world of sub-standard shipping, has been the need to engage in the debate related interests such as insurers, cargo owners, charterers, and ship brokers.

We could do something similar in our efforts to rid the oceans of derelict fishing gear. By opening dialogue with the equivalent groups in the fishing industry they will have a better understanding of the concerns and hopefully join with us in seeking solutions. Insurers may be able to devise a scheme, which will help minimize loss of fishing gear. We need to address those groups who purchase fish catch and involve them to use leverage on the fishing companies and or vessels they purchase from. I am not sure if brokers have a role in the fishing industry, but if they do, they too may be in a position to influence retention of fishing nets for proper disposal ashore. Equally important in these discussions are fishing gear equipment manufacturers.

An important issue, which appears to be emerging from some people at this conference, is that IMO should do more with regard to preventing derelict fishing gear from being dumped in the ocean. However, before member governments seek greater IMO involvement in this matter they must first look at their own back yard. Are the governments representing the Pacific Rim fully implementing the Guidelines to Annex V? I would suggest that neither the U.S. nor Australia have fully implemented the guidelines. It would appear that MARPOL 73/78 Annex V, as currently drafted, is adequate but where the problems seem to be arising it is because of lack of implementation and enforcement. Implementation and enforcement of international fishing vessel regulations and agreements is up to individual member government fishing agencies to monitor and ensure compliance.

SUMMARY

- We have a vast number of organizations, from government agencies, NGOs, industry, and the community working for the prevention and removal of derelict fishing gear. Each group, while not working in isolation, could work in a more coordinated way, particularly in the fishing industry. For example, vessel owners, managers, and skippers.

- We need to encourage the governments of Pacific Rim countries to be more involved and also work toward the objectives of this conference.

- We need to find some mechanism for "ownership" of the marine debris and derelict fishing gear problem at both the national and international level.

- Finally we need to exert influence at the main UN organisations, particularly the FAO and other international and regional fisheries management organisations.

Thank you very much for your attention.

- Transcribed from a speech given on August 9, 2000.

TRASHING THE SEA

Jean Michel Cousteau, President, Ocean Futures Society, California

MARINE DEBRIS

According to the Gulf of Mexico Program, October 1991, marine debris is trash in the ocean or any manufactured object accidentally or purposely put into the marine environment such as: cans, bottles, rope, packing materials, bags, sheeting, fishing lines and nets, net fragment, trawl webbing, cargo strapping bands; six-pack rings; and other man-made items.

Marine debris represents the foremost natural resource management problem at the Padre Island National Seashore located a few miles south of Corpus Christi, Texas and includes aesthetics and impacts to marine mammals, birds and reptiles from entanglement and ingestion. Additionally, toxic chemicals and medical waste wash ashore and pose a safety hazard to the visiting public.

MARPOL

In 1987, the U.S. joined thirty-nine other nations in signing the Plastics Act, thus ratifying Annex V of the International Convention for the Prevention of Pollution from Ships. These laws became known as MARPOL. This treaty bans the dumping of certain garbage by vessels at sea. It also limits the dumping of other vessel-generated garbage to specific distances from shore.

According to the U.S. Coast Guard and MARPOL regulations, plastics (food and non-food contaminated) and noxious liquid substances (bulk carriage) are not allowed to be discarded from vessels anywhere at anytime. In other words, there is to be no dumping of these materials anywhere in any ocean waters.

Trash (non-plastic) has no discharge from 0–3 nautical miles (nm) of the shoreline and from 3–12 nm discharge is not permitted unless it is ground to less than one inch. Discharge is permitted from 12-50 nm. Hazardous substance discharge is not allowed unless permitted under Annex II of MARPOL.

The U.S. Coast Guard is a major party responsible for enforcement of such policies as MARPOL. They patrol our waters, as best they can, to ensure no illegal dumping is occurring. Other agencies such as the National Park Service also enforce rules regarding improper disposal of man-made waste left on our beaches by visitors to our national parks.

What all this is dealing with is ocean based sources of marine debris. Land based sources of marine debris can be cleaned using several methods. Corpus Christi Mayor, Lloyd Neal, on July 10, 1997 at a "Meeting with the Mayor" mentioned that our drainage system does not work properly because of all the trash and litter that finds its way into the gutters. This garbage winds up in our bay, the gulf, and on our shores because of the problems it (the trash) poses on the drainage system.

There are numerous organizations that do their part to clean our shores and waters. The Padre Island National Seashore has employees who clean the seashore seven days a week. Adopt-A-Beach has a chapter in Corpus Christi that sponsors programs aimed at cleaning our beaches as well. Nueces County and the City of Corpus Christi also have programs aimed at ridding our shores of garbage. Along portions of North Padre Island, workers are out on their bulldozers every morning removing Sargassum and marine debris from large areas of our shores. If anyone has ever seen any coastlines in America and most of the world, they may agree with the authors in saying that our shoreline along the entire Coastal Bend is among the filthiest in all of the country.

These organizations cannot win this war against beach garbage alone. Our beaches and our coastline need everyone to work together, collectively, to make our region beautiful.

Prevention

What can be done to prevent marine debris?

There are many ways in which individuals can help with the vast problem of marine debris. The easiest way is to not add to the problem while visiting the beach. Throw all your litter in the proper disposal areas. Also be sure that when you take your garbage to the street corner for collection, have only those items allowed in landfills in the dumpsters. Dispose of all oil and other hazardous materials in the proper and legal fashion. Recycle all material that is labeled with recycling codes.

These actions seem to be common sense, however, it will take more than individuals taking personal responsibility to achieve these goals. Our community needs volunteers and civic organizations to participate in beach cleanup events. These should occur more often than the twice a year cleanups already in progress.

There are organizations such as Keep Texas Beautiful, Inc, located in Austin, Texas, which organize beach cleanup events. Padre Island National Seashore is also very active in this issue and they presently are working on several studies aimed at identifying the sources of marine debris and what the public perceives as marine debris. Contact the Padre Island National Seashore for more information on this study and how you can help. The Texas Adopt-A-Beach Program, organized through the Texas General Land Office, describes the various problems caused by the presence of plastics and trash in the marine environment and offers programs that are primarily concerned with beach cleanup.

John Rawls, in A Theory of Justice (1971), states that each generation has an obligation to future generations to preserve and protect our natural resources. Rawls argues that no one generation has a stronger claim on any natural resource than another. The problem with this idea lies in the willingness, or lack thereof, of present generations to respect the claims of future generations. Mankind is inherently self-interested (selfish) and lacks respect for other human beings, not to mention the lack of respect many humans have toward other living creatures.

CONCLUSION

If we as a society do not change our behaviors as related to our environment and one another, our children and grandchildren will not have the same simple pleasures we have, such as taking a safe, relaxing stroll along the shore. For further information and for ways you can become involved, contact your local officials (city council member, county commissioner, congressional representative [state or federal] or senator) and encourage them to support bills that will give more funding for enforcement of the laws already on the books. The laws are there, it is our responsibility to make sure they are enforced.

CLOSING REMARKS AND NEXT STEPS: TAKING ACTION AGAINST MARINE DEBRIS

Daniel J. Basta, Director, National Marine Sanctuary Program,
National Ocean Service, National Oceanic and Atmospheric Administration

Now that the conference has ended, I have been asked to address the challenges before us: What we are seeing, how we can get the most out of our efforts so that this is not just another conference that winds up on "the shelf," and about the timing of things to come. I encourage everyone to take the process seriously.

I would say that this conference did better than most in terms of actually presenting useful material, clearly articulating some recommendations, and generating some operational information. Often times, within the structure of large groups, little real progress takes place. Neither agencies nor individuals truly believe in the structure or the process, and one wonders why they even come.

Hawai'i is a long way from the mainland, and perhaps that's why things seemed different here. I saw a real commitment from people to give up their own "devices" and to work through the process, patiently and diligently, in order to cure the difficulties we face. In addition to these observations, I learned several things. I gained a real appreciation of the scale, scope, severity, and nature of the problem of marine debris.

With respect to the challenges that await us, there are certainly challenges with respect to the document itself. The first step is complete. You have worked extraordinarily diligently to hammer out these recommendations, which was done in the heat of contact and pressure. Now you will have to go back and review this work, and add more value to it. The best way to do that is to review it in the quiet of your offices, and think through the details that may have escaped you while you were here working in groups. We will facilitate this with a web site primarily for conference participants. The address is www.los.noaa.ghost/debrisresults. The purpose, really, is to discover and extract the "pearls" of this conference, the philosophy behind these recommendations, and how to make them a reality.

This brings me to the proceedings document which will serve as the "raw material" with which we shall begin to effect the changes that we have discussed. These proceedings are going to be substantial and valuable in terms of the content.

Once the document is published, the real challenge begins: Getting it to the right places and into the hands of the right people. The Ocean Commission, for example, will be established in January 2001. This will be the first U.S. commission on the oceans since the Stratton Commission met in 1969, and the nation will be looking to the commission for guidance in solving problems related to the coasts and oceans. We should be able to hand them the proceedings for concrete recommendations, on the national and international scales, with respect to the problem of marine debris.

Thus, your challenge is to assure that you make an impact in those areas that will be touched by an organization such as the Ocean Commission. This includes taking some responsibility for distributing the document—even hand carrying it to the people who are in a position to make a difference policywise and budgetwise. You can, of course, also refer them to the web site when it is launched for public use.

This web site is going to be more than a place to publish documents. It will be dynamic, and may, for example, allow experts and others around the world to register incidents of marine debris, discuss the issue, and share information to help resolve it.

The ramifications are far reaching, and the good news is that this program is committed to such a web site. This could become a truly effective mechanism, but again, it is up to you: It will go nowhere unless you "market" its effective use.

I also challenge you to make a real commitment to the issue by working with WestPac and the State of Hawai'i on the quarterly newsletter, so that you are not only aware of, but also contributing to, what is happening "on the ground" in terms of the issues. We are also committed to having another conference in two years, which is a reasonable time frame to begin to demonstrate to ourselves that we are making a difference. The extent to which this is going to work, however, essentially depends upon your support.

Nevertheless, I wish to make something clear. Nothing is going to happen very fast or, I should say, it's very unlikely that anything is going to happen fast. When one wishes to effect change, the first thing to do is to get the world into the right "rhythms," if you will, to accept change. This takes an amount of time that is generally out of tune with one's desire for "immediate gratification." In other words, six months from now if you look back, you will be disappointed. Don't make that mistake. Instead, consider that now, you have the opportunity to get involved with like-minded individuals, who, together, have the potential to make the world change its "beat." I would argue that this alone could take several years.

So I ask of you: Be patient, be persistent, and keep the faith. If you do, we should be able to look back five years from now and say, "Look at all the things we have done. Look at how we have changed the contest. Look at the programs that are now in place."

To this end, I'll leave you with a short-term challenge—some "homework," so to speak. When you return to your offices and all of the many things you have to deal with there, things that will absolutely distract you from the goals you have voiced today, set aside one day to forward the action of this conference. On that day, call three people and tell them what a great conference this was. Tell them that there are some new expectations, and that recommendations are forthcoming. Then tell them that you'd like to follow up with them to see what they think. If you find that you can't make the time to do this, then it's possible that you are more committed to other issues than you are to this one.

Believe me, if you do this it will work. In terms of how we in the "ocean community" do business these days, the power of the community is at an all-time high. The system and the institutions want to do the right thing. For the most part, they need to be told what that is. And it is really completely up to us. We can't blame the state, and we can't blame the bureaucrats. We can only blame ourselves if we don't keep the faith and make the commitment to put the answers in front of the people who matter. We can already point to certain successes; this conference is one of them. To me, it was a revelation. We're off to a great start, now it's time to go the distance.

• Transcribed from a speech given August 11, 2000.

THE WAY FORWARD

‘Akau‘ola, Secretary for Fisheries, Kingdom of Tonga

Tulou, tulou, tulou.
Tapu moe Eiki Sea,
Tapu mo Hawai‘i moe ‘otu toputapu ‘oku nau totofa ‘ihe fonua ‘eiki ni,
Tapu moe kau fakafofonga kotoa,
Pea talangata ‘ia te au ‘o fai ki tu‘a mama‘o,
Kae ‘ata ke fai atu ‘ae fakahoha‘a ni.

No one who was privileged to witness the reefs of the Pacific come alive in this hall or who has heard the anguished cries of the inhabitants as they suffered from man’s thoughtless and wanton destruction of the oceans can remain unmoved by their plight. For in the end, their plight is ours. In the creation it was preordained that our destiny would be linked to our oceans until the end of time. All life is dependent on this one great resource which we neglect at our peril.

The story of our reefs and the many sea creatures that live out their lives in surroundings that are already dangerous enough without our deadly contribution is as thought provoking a story as I have experienced in a very long time. It is a hauntingly beautiful tale told with the clarity that only a child could command, so that grown-ups such as us might begin to understand.

So how will we answer this cry from the heart? How will we send our youth home? What comfort can we provide? And what is the message that we in turn might wish them to convey to their peer groups from this great gathering? Will it in return be a message that is uplifting? Will it speak of hope, of determination, of courage? Will it be interwoven with the best that science has to offer? Underwritten by the captains of industry? Safeguarded by those in uniform that protect our shores? Will it be in the language of diplomacy, silver tongued that it might easily cross every frontier? Will it bear the imprint of the great departments of state? Will it be sent forth with the blessings of our legislatures? And will it carry the conviction of those in society that toil long hours only out of concern for the marine life whose well-being we the majority totally disregard?

The fruits of our labors of this passing week give us the courage to confirm that we might make such an honest pledge. That we, with assurance and conviction, confirm to our young ambassadors that the pleas and the warnings so eloquently conveyed to us have been heard and will be acted upon. Let them return home comforted that their mission was discharged with honor and with a warmth and humor all too often lacking when adults turn to address matters of great importance. Let them in turn carry our message and give heart to the youth of the Pacific, the wider international community, and the generations that will follow that their inheritance will not be empty and void, a worthless coin debased of all value by the guardians of today. Let the youth of our generation and the custodians of the future know that we welcome them to our ranks to stand shoulder-to-shoulder facing the great challenge of our times. Let them also know that we are sorry for our neglect.

So where do we start and how might we be able to carry forward the efforts begun some fifteen years ago? It is entirely appropriate that our youth have played such a prominent role in identifying and highlighting the problems and the issues, for real and lasting change will only follow if built on solid foundations of education, training, and awareness at every level of society. We need to build the bridges of collaboration, the foundations of which have already been so well laid out at this meeting, and internationalize the issue of derelict fishing gear within the wider context of marine debris. The great organs of diplomacy within the United Nations institutions and other international and regional bodies must begin to play a fuller role in coordinating and continuing the process. But that is not to say that we abrogate and surrender our responsibilities, for our roles will become more important as the great debate develops to ensure that local commitment and solutions are not lost.

We need to continue the links that were discussed here this week, to reach out and join with others who deal with related issues such as the reefs project, the multinational consultations to establish a tuna fisheries management regime for the Western and Central Pacific to name but two. MHLC, by which the negotiating process has become known, will hopefully be brought to a successful conclusion in this very hall some two weeks from now. We must not allow the equator to be the dividing factor between north and south; nor must the continents divide east for west. We need to be more aware of the institutions of our larger region who have been mandated with issues that are central to the environment, to fisheries, and to the social and economic well-being of our peoples. We need to engage the Pacific Rim countries through mechanisms that have already been established. We need to engage our scientists so as to allow for a better flow of information and to encourage closer cooperation. We need to link the fishing communities and encourage their participation and commitment so that they do not feel that they are the cause of all that has gone wrong. That is particularly true today of the fishing community of Hawai‘i whose pain I, as a fisheries manager, feel and share.

We have addressed these issues. We have agreed to the solutions. We are armed with the plan. What remains is the strength of our personal commitment. How can we take back the vitality and strength of our convictions when the memory of our shared experiences and the inspiration we provided for each other in these rooms become dimmed with the passing of time? The advent of technological progress with e-mail and www.com is part of the answer. Sharing our successes and our problems will do much since the level of knowledge and wisdom represented at this meeting is awesome. Knowing that others are applying

their strengths and resources, focusing on the common issues, and helping out where they can means that we do not fight our battle alone, that we have the resources of our battalions gathered here today on call and on line.

There remains one challenge that needs to be addressed and that is the continuing mechanism in which our efforts must become firmly anchored. Further thought will need to be given as to how our forward progress is being planned and monitored. I know that many good people are wrestling with the challenge and further ideas will emerge.

And so we leave here reinvigorated, happy that we answered the call and pledging our full commitment. We might not have achieved all that we set out to do but we all have done an honest day's work. No one, not even Kitty or Allen, can ask for more.

To the people of the United States of America, from all of us from beyond your shores, we thank you for the resources that were provided to make this event happen. Thank you for the initiative and the inspired leadership. You have shouldered the burden of this meeting, as you have continued to do since the first tentative steps were taken over fifteen years ago. To the institutions that have provided the backup support and to the many hands that have made light work of a gigantic task—thank you.

In the small island kingdom many miles to the south where I come from, our national emblem is the sea eagle. This is somewhat of a curious choice given that the sea eagle or 'Lulutai' is never seen in Tongan waters. The answer lies in the sea faring traditions of our people, the "Vikings of the Sunrise" in the words of a great Maori scholar, Te Rangi Hiroa or Sir Peter Buck, sometime Curator of the Bishop Museum, as he addressed the origins of the Polynesians. Tongans became familiar with this great bird in their rovings throughout the Pacific. They marveled at its strength, at its fishing capacity, its great endurance, and its freedom of the skies. Inspired, they coined one of the great statements that underpin the culture of Polynesia, "Oku kai 'ae manu vaivai meihe fangota 'ae Lulutai." On the wings of the strong will be carried the burdens of the weak.

And so to the great bald eagle of the United States let me say that your obligation to provide sustenance and protection for this small fledgling movement of ours until it too might take wing was foretold by my ancestors and written in the stars.

May the silver chains of friendship bind us and may He that never sleeps keep you until we meet again. 'Ofa atu fau.

GROUP A: PREVENTION AND LEGAL ISSUES

Chairs:	James M. Coe CDR Paula S. Carroll
Panelists:	Margaret Cummisky Anamarija Frankic, Ph.D. Michael Julian Holly R. Koehler CDR John W. Koster Brent S. Stewart, Ph.D.
Facilitators:	Todd Jacobs Jeff Walters, Ph.D.
Rapporteur:	Brent S. Stewart, Ph.D.

A1. Develop an International Plan of Action to regulate discard and loss of derelict fishing gear

A2. Enlist IMO assistance in addressing the derelict fishing gear issue

A3. Encourage participation of regional fisheries organizations in addressing the derelict fishing gear problem

A4. Develop public-private partnerships to assist the implementation of compliance of international agreements and guidelines

PREVENTION AND LEGAL ISSUES: RECOMMENDATION A1.

Title: Develop an International Plan of Action to regulate discard and loss of derelict fishing gear

Concern: Inadequate implementation of provisions for addressing derelict fishing gear in international agreements

Authors: H. Koehler and B. Stewart

I. DESCRIPTION:

All States contributing to, affected by, or otherwise concerned about the impacts of marine pollution by derelict fishing gear on marine life and vessel safety, should motivate and fund FAO to establish a Task Force to accomplish, inter alia, the cooperative development of an IMO/FAO/RFOa International Plan of Action (IPOA) to control and minimize fishing vessel gear loss. This IPOA should be similar to the ongoing joint development by FAO and IMO of an IPOA to address illegal, unreported, and unregulated fishing activities. This IPOA should include, inter alia:

A. A call for IMO Member States, particularly from the Pacific Rim to: (i) conduct national "assessments" of their implementation of MARPOL 73/78 Annex V and the Guidelines for the Implementation of MARPOL 73/78 Annex V, particularly Chapter 3, and report the results to IMO's MEPCb; (ii) identify implementation impediments to the IMO's MEPC; and (iii) recommend solutions to IMO's MEPC to address these impediments (e.g., amend the Guidelines, make some aspects mandatory if necessary, develop a mechanism for monitoring derelict fishing gear, etc.)

B. A call for States to condition issuance of domestic and foreign fishing licenses on demonstrated applicant compliance with relevant aspects of MARPOL 73/78 Annex V and the Guidelines.

C. A call for national governments and regional fisheries management organizations to urge all States that are Parties to MARPOL 73/78 as well as those that have expressed interest in becoming a party to MARPOL 73/78 and especially Annex V and its Guidelines, to be more vigilant in reporting involuntary net losses, in satisfaction of the Annex V Guidelines and appropriate national laws.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

A. States vigorously bring issue to the attention of FAO

B. States identify and facilitate acquisition of necessary funding for FAO to accomplish the identified tasks

III. TYPE(S) OF ACTION:

Administrative, regulatory and economic

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

The action should be implemented in all areas and habitats.

V. WHO IMPLEMENTS ACTION?

A. FAO

B. IMO

C. National Governments

VI. WHAT IS COST OF ACTION (ESTIMATE)?

One time (Start up) Cost - $500,000 to $1,000,000

Annual Operation and Maintenance - Implementation varies by state

VII. WHO FINANCES?

National governments finance the action through voluntary and discretionary contributions (e.g., from fishing license fees).

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

Benefits from implementation are both environmental and economic.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

Marine life and ocean-going vessels are affected by the action.

PREVENTION AND LEGAL ISSUES: RECOMMENDATION A2.

Title: Enlist IMO assistance in addressing the derelict fishing gear issue

Concern: Sub-optimal action by IMO Member States in addressing the derelict fishing gear issue

Authors: H. Koehler and B. Stewart

I. DESCRIPTION:

IMO Member States should: (a) bring to the attention of IMO's Marine Environment Protection Committee (MEPC) the extent of the problems associated with derelict fishing gear and the lack of compliance with MARPOL 73/78 Annex V and the Guidelines for the Implementation of Annex V of MARPOL 73/78 including the reporting provisions of Article 11a and request that MEPC establish an agenda item regarding this provision; and (b) request IMO Member States (i) demonstrate a more proactive approach in addressing marine pollution from fishing vessels by attending international intergovernmental meetings to raise this issue as one of global concern, and (ii) disseminate MARPOL 73/78 Annex V and Guidelines more widely.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

IMO Member States take steps to proactively inform the IMO's MEPC of the seriousness of the derelict fishing gear issue and highlight current mechanisms, particularly provisions of MARPOL 73/78, Annex V, and the Guidelines which are not being complied with. Member states actively seek the appropriate input, information, and advice from the IMO. NGOs consider mechanisms to assist in the process.

III. TYPE(S) OF ACTION:

Administrative, regulatory and reporting

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

The action should be implemented in all areas and habitats.

V. WHO IMPLEMENTS ACTION?

IMO Member States and the fishing industry implement the action.

VI. WHAT IS COST OF ACTION (ESTIMATE)?

One time (Start up) Cost - $50,000 to $100,000
Annual Operation and Maintenance Cost - $10,000 to $50,000

VII. WHO FINANCES?

A. Member governments through voluntary and discretionary contributions (e.g., from fishing license fees)
B. Private-public partnerships
C. NGOs
D. Fishing industry support

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

Benefits include substantive and procedural gains in implementing international legal instruments to address marine pollution by derelict fishing gear.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

Living and physical resources are affected by the action.

PREVENTION AND LEGAL ISSUES: RECOMMENDATION A3.

Title: Encourage participation of regional fisheries organization in addressing the derelict fishing gear problem

Concern: Ineffective use of regional fisheries organizations to address derelict fishing gear issues

Authors: H. Koehler and B. Stewart

I. DESCRIPTION:

Regional and sub-regional fisheries management organizations and arrangements should explicitly incorporate into their mandate and binding conservation measures: (a) a prohibition on discarding fishing gear and related debris, and (b) a requirement to maximize to the greatest practicable extent recovery of any accidentally lost gear.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

A. Motivation of regional and sub-regional organizations to incorporate elements into their charters

B. Sua sponte incorporation of elements by the regional and sub-regional organizations

III. TYPE(S) OF ACTION:

Administrative and regulatory

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

Minimum Spatial Extent: Where the regional and sub-regional fishery organizations operations are housed

Habitat Affected: All habitats

V. WHO IMPLEMENTS ACTION?

Regional and sub-regional fishery organizations implement the action.

VI. WHAT IS COST OF ACTION (ESTIMATE)?

One time (Start up) Cost - $100,000 to $500,000

Annual Operation and Maintenance Cost - $100,000 to $500,000

VII. WHO FINANCES?

Private and public donor institutions along with NGOs finance the action.

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

Benefits include the facilitation of effective implementation of international legal instruments to prevent and mitigate loss and discard of fishing gear.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

Marine life, physical habitat, and vessel safety are affected by the action.

PREVENTION AND LEGAL ISSUES: RECOMMENDATION A4.

Title: Develop public-private partnerships to assist the implementation of compliance of international agreements and guidelines

Concern: Inadequate support for States to implement agreement provisions

Authors: H. Koehler and B. Stewart

I. DESCRIPTION:
Public-private partnerships should be developed with the assistance of various programs, including private and international donor institutions (e.g., the World Bank or the International Monetary Fund) to increase the capabilities of States, particularly developing states, to implement and comply with MARPOL 73/78, Annex V, and the Guidelines.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:
Development of proposals to potential donor institutions. Clarification of identity and capable infrastructure of various private and public institutions that can accept assistance to facilitate objectives. Implementation of strategic plan by selected organizations.

III. TYPE(S) OF ACTION:
Administrative, economic and educational

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?
Minimum Spatial Extent: Offices of donor institutions and public and private implementation facilities
Habitat Affected: All habitats

V. WHO IMPLEMENTS ACTION?
A. Donor institutions
B. Private and public implementation institutions

VI. WHAT IS COST OF ACTION (ESTIMATE)?
One time (Start up) Cost - $100,000 to $500,000
Annual Operation and Maintenance Cost - $100,000 to $500,000

VII. WHO FINANCES?
Private and public donor institutions along with NGOs finance the action.

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?
Benefits include the facilitation of effective implementation of international legal instruments to prevent and mitigate loss and discard of fishing gear.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:
Marine life, physical habitat, and vessel safety are affected by the action.

GROUP B: REDUCING IMPACTS OF GEAR

Chair: H. Arnold Carr

Panelists: Gerald Brothers
Gary Dunlin
Murray R. Gregory, Ph.D.
Jim Ludwig, Ph.D.
James Maragos, Ph.D.

Facilitators: Brad Barr
Hannah Bernard
Steve Olive, Ph.D.

Rapporteurs: Adam Hill
Jeff Kuwabara

B1. Identify, quantify, and reduce the impacts of ghost fishing gear

B2. Conduct research on the movement and effects of derelict fishing gear, and other plastics in ecosystems

B3. Conduct research to estimate mortality rates and their impacts on affected species caused by derelict fishing gear and other marine debris

B4. Assess the interaction of vessels with fishing gear and marine debris

REDUCING IMPACTS OF GEAR: RECOMMENDATION B1.

Title: Identify, quantify, and reduce the impacts of ghost fishing gear Issues: Lack of data and the effects of ghost fishing on commercial and non-commercial species

Concern: Ghost fishing gear can result in fish mortality equal to or greater than that of the commercial harvest

Theme: Assess the magnitude of the problem so as to determine appropriate responses

Authors: G. Brothers and G. Dunlin

I. DESCRIPTION:

There are some documented estimates of fish and non-fish mortality due to ghost fishing gear. Up until now, there has been little systematic work carried out to analyze this impact on commercial fisheries throughout the world. Comprehensive surveys need to be carried out to establish the cause and extent of gear loss in representative waters.

The physical evolution of gear lost under a wide range of conditions needs to be studied in order to assess the potential for these gears to carry on fishing for prolonged periods.

Using these two research tasks, it should be possible to quantify the impact on mortality to target and non-target marine species. The results of these research areas could be widely disseminated to fishermen and governmental agencies. Information acquired should give them the incentive to do all in their power to reduce gear losses.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

A. Carry out ghost fishing cleanup programs to quantify the amount of lost and abandoned fishing gear
B. Develop model to calculate the amount of fish mortality caused by ghost fishing gear
C. Identify source of gear losses
D. Develop awareness campaign, highlighting cost of ghost fishing to fishermen, and thereby provide incentive to reduce losses

E. Establish management plan to reduce ghost fishing
1. Zoning—defining fishing period for active and passive fishing gears
2. Individual quota system
3. Limit amounts of gear
4. Gear tagging program
5. Observer coverage
6. Mandatory tending of gear
7. Mandatory reporting of loss of fishing gear

III. TYPE(S) OF ACTION:
Research, regulatory and educational

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?
Minimum Spatial Extent: It is difficult to restrict studies to particular areas owing to the global nature of the marine debris problem. The action should be tasked into areas where the problem is identified as such.

V. WHO IMPLEMENTS ACTION?
Government agencies, in cooperation with the fishing industry, implement the action.

VI. WHAT IS COST OF ACTION (ESTIMATE)?
The cost is dependent on the location and magnitude of the problem. Off Atlantic Canada, a program was estimated to cost $10 million (Canadian). Off the United Kingdom a program in certain targeted waters cost $900,000.

VII. WHO FINANCES?
Financial responsibility has not been determined.

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?
Giving fishermen and managers the incentive to reduce gear losses will result in both environmental and economic benefits.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:
All marine species are affected by the action.

REDUCING IMPACTS OF GEAR: RECOMMENDATION B2.

Title: Conduct research on the movement and effects of derelict fishing gear, and other plastics in ecosystems

Issues: Persistence; lack of knowledge and data

Concern: Lack of understanding of the breakdown processes: physical, chemical, biological. The lack of knowledge of the ecosystem impact of these products may provide a direct pathway for these substances to be incorporated into the food web at low trophic levels.

Theme: Assess the magnitude of the problem so as to determine appropriate responses

Authors: A. Carr and M. Gregory

I. DESCRIPTION:
As with all other marine debris made with synthetic materials introduced into the marine environment, the persistence of abandoned and derelict fishing gear is impacting marine ecosystems in an ever-accumulating manner. The accumulation of synthetic materials in the marine environment was first recognized in the late-1950s, but little importance was attached to observations at that time. It was considered a minor nuisance. By the 1980s, the increased use and disposal of persistent plastic materials, as is found in fishing gear, was an acknowledged problem of such magnitude that it generated several international conferences. By the late 1990s, the increased use of plastic materials in fishing activities, as well as elsewhere in society, and the resulting casual disposal in the marine environment brought the problem to a global scale.

The first recognition of the impacts of derelict fishing gear and other marine debris in the environment were visual and aesthetic. They were focused on shorelines. As more derelict fishing gear entered the marine debris stream, attention was drawn to the direct biophysical impacts of entanglement and ingestion.

The magnitude of impacts of derelict fishing gear and other marine debris is only recently becoming appreciated. These include:
A. Alien introductions through attached and associated biota
B. Degradation of larger debris into microplastics and it's assimilation into key parts of the ecosystem (e.g., the sea surface microlayer)
C. Contaminants (e.g., organochlorines and endocrine-active substances)

adhering to microplastics and accumulating in marine organisms (e.g., birds, turtles and fish) upon ingestion - eating plastics may constitute a novel direct pathway into wildlife populations

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

A. Establish the nature of the degradation pathways

B. Determine the extent that degradation products are contaminated by other potentially toxic compounds

C. Devise means to interrupt the pathway of these contaminants into the marine environment (given the pipeline character of marine debris delivery to the marine environment, this will be a long term process - the potential impacts of these types of contaminants are subtle, progressive, accumulative and long term)

III.TYPE(S) OF ACTION:

Research, monitoring, regulatory and educational

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

Minimum Spatial Extent: Global with presently recognized hot spots

Habitat Type Affected: Potentially, all habitats

V. WHO IMPLEMENTS ACTION?

Research institutions supported by government or private funding

VI.WHAT IS COST OF ACTION (ESTIMATE)?

One time (Start up) Cost - $100,000 to $500,000

Annual Operation and Maintenance Cost - $100,000 to $500,000

VII.WHO FINANCES?

The government and/or private funding would finance the action.

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

Maintenance of quality within ecosystems and the reduced possibility of elimination of species, are the benefits from implementation.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

The marine ecosystem would be affected by the action.

REDUCING IMPACTS OF GEAR: RECOMMENDATION B3.

Title: Conduct research to estimate mortality rates and their impacts on affected species caused by derelict fishing gear and other marine debris

Issues: Depletion of target and non-target marine species; effects on single species have larger effects on the ecosystem as a whole; structure and function of ecosystems and their food webs could have adverse effects on economic and social benefits

Concerns: Negative economic impact on fishing industries; long-term effects on resource availability and quality of life

Theme: The extent of mortality on the various species affected by marine debris and the population consequences

Authors: C. Fowler, A. Hill, and N. Hoffman

I. DESCRIPTION:

Studies are needed to provide information on the physical and chemical processes that lead to mortality caused by marine debris.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

Specific methodologies will depend on the question being asked and the species or population of interest and the source of mortality. Not everything can be studied nor can all questions be answered. Species with key roles in their ecosystems and debris that is of suspected concern will determine priorities. Research should include tagging studies, laboratory studies, physiological studies, behavioral studies, population dynamics, and toxicological studies (i.e., endocrine suppression and immune system suppression) to investigate direct effects. Indirect effects would be studied by monitoring to identify long term changes in community composition.

III. TYPE(S) OF ACTION:

Research, monitoring, and assessment

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

Minimum Spatial Extent: It is difficult to restrict studies to particular areas owing to the global nature of the marine debris problem. However, this group identified ecosystems containing commercially valuable species, coral

reef ecosystems containing species of concern, ecosystems of exceptional diversity, ecosystems where large concentrations of debris occur, and benthic systems potentially altered by the settling of microplastic debris.

V. WHO IMPLEMENTS ACTION?

International, federal, state, and local organizations, and various partnerships implement the action.

VI. WHAT IS COST OF ACTION (ESTIMATE)?

One time (Start up) Cost - >$1,000,000
Annual Operation and Maintenance Cost - >$1,000,000

VII. WHO FINANCES?

Initially, the emphasis is on government funding, followed by greater reliance on private lending from trusts and appropriate stakeholders.

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

Benefits from implementation include the production of information that is useful in the education process, which results in both environmental and economic gain. Furthermore, the resulting information can lead to management action.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

Although species of commercial importance are expected to be better conserved, this action does not exclude other species in marine ecosystems, therefore, all marine life is affected.

REDUCING IMPACTS OF GEAR: RECOMMENDATION B4.

Title: Assess the interaction of vessels with fishing gear and marine debris

Issues: Fishing gear, both active and derelict, and other marine debris can become a hazard to navigation and put mariners and rescuers, their vessels, and consequently the marine environment at risk

Concerns: Fouling of vessel propellers, rudders, keels, thrusters, water intakes; drifting while disabled; crew, passengers and rescuer safety; dangers of going overboard to remove gear; risk to environment from disabled vessel; financial burden to vessel operators from lost time and repair; the generation of derelict gear by vessels becoming fouled in active gear

Theme: Assess the severity of the problem to determine appropriate responses

Authors: B. Barr and L. Johnson

I. DESCRIPTION:

Anecdotal reports and preliminary studies suggest that a problem exists with regard to the interactions of vessels with active and derelict fishing gear, and generally with floating debris in navigable waters. This problem may be particularly significant in areas where derelict debris accumulates due to ocean currents, and where fishing effort is high. Problems may involve the fouling of propellers, keels, rudders, thrusters, and water intakes, requiring the often dangerous task of removing entangled gear at sea. Vessels disabled by fouled gear and other debris may collide with other vessels or icebergs while adrift, or ground when near shore, potentially leading to discharges of oil and fuel. These problems can generate considerable cost to vessel operators in terms of repairs and downtime, and potentially costs related to cleanup of oil and fuel spills. Vessels, large and small, may also generate derelict gear when the fouling incidents occur with active fishing gear, causing potential environmental problems from lost gear.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

A. Develop an assessment body, preferably under an existing agency or organization, to address the approach ideas

B. Increase reporting of fouling incidents:

1. Encourage reporting, through directed outreach to commercial vessel operators, fishing captains, and recreational boaters, involving incidents that meet USCG vessel casualty reporting thresholds
2. Encourage reporting of incidents that fall below USCG reporting thresholds to assist in conducting robust statistical analyses of data collected. The U.S. Coast Guard's Field Incident Reporting System (FIRS) might be used as a model or example for such a mechanism
3. Establish a mechanism for collecting and analyzing data reported that is focused on answering the question "Is this a problem?"
4. Investigate possible economic incentives for reporting (examine models such as gear compensation programs administered by National Marine Fisheries Service)

C. Initiate the process of engaging the international community on the marine debris issue and coordinate with the International Maritime Organization through Legal Committee's "Wreck Removal Convention" whose chartered mandate includes drifting material that poses a hazard to navigation or threat to the marine environment - focus of coordination would be on quantifying the extent of the problem worldwide, on public safety, and on the economic impacts of fouling incidents

III.TYPE(S) OF ACTION:

Research, monitoring, economic, educational, and assessment

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

Minimum Spatial Extent: Action should focus on vessels that operate in all U.S. waters, particularly where significant fishing effort and/or areas where debris collects and persists

Habitat Type Affected: Principally surface of water column/pelagic environment, but potentially coral reefs and other sensitive near-shore benthic habitats

V. WHO IMPLEMENTS ACTION?

The U.S. Coast Guard may be the best candidate to conduct assessments for U.S. waters in collaboration with other U.S. Federal agencies with related responsibilities (i.e., NOAA). The U.S. Coast Guard is currently responsible for investigating and monitoring marine vessel casualties of the Unites States and visiting foreign vessels of certain magnitudes.

VI. WHAT IS COST OF ACTION (ESTIMATE)?

For all U.S. waters, assessment may cost:

One time (Start up) Cost - >$1,000,000

Annual Operation and Maintenance Cost - $100,000 to $500,000

For a regional pilot study:

One time (Start up) Cost - $100,000

Annual Operation and Maintenance Cost - $50,000 - $75,000

VII. WHO FINANCES?

This assessment should be funded through Congressional appropriation to the U.S. Department of Transportation/United States Coast Guard.

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL AND ECONOMIC) FROM IMPLEMENTATION?

Benefits from assessment relate to assessing the extent of the problem. There are no direct environmental or economic benefits from assessment. Benefits will accrue from implementation of solutions if they are found to be necessary and appropriate.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

There are no direct environmental or economic benefits from assessment. Benefits will accrue from implementation of solutions if they are found to be necessary and appropriate.

GROUP C: SOURCE IDENTIFICATION

Chair: John R. Henderson

Panelists: Al Burch
Dave Foley
David King
Rick Steiner

Facilitators: Tom Culliton
Timothy Goodspeed

Rapporteurs: John Kelly
Jarad Makaiau

C1. Hire a staff person to identify sources of gear — Gear Expert Coordinator

C2. Establish a Network of Fishing Gear Specialists

C3. Develop GIS of commercial fishing and aquaculture locations and seasons in the North Pacific

C4. Create an international reference (targeted) database and gear reference collection, available by region

C5. Build a constituency for the importance of source identification

C6. Develop a web site for identification of gear fragments

SOURCE IDENTIFICATION: RECOMMENDATION C1.

Title: Hire a staff person to identify sources of gear — Gear Expert Coordinator

Authors: A. Burch, J. Henderschedt, K. Kelly, D. King, and N. Young

I. DESCRIPTION:

Recommendation:
Hire a staff person whose sole responsibility is to establish a network of gear technologists, establish and manage the standard reference collection for the source identification of fishing gear collected during debris removal efforts.

Qualifications:
The qualifications of this individual should be specialist/coordinator.

Responsibilities:
A. Establish a network of individuals familiar with fishing gear construction and use in Pacific fisheries
B. As a priority, coordinate periodic examinations, by gear experts, of intact derelict gear (whole portions of nets or material taken as a result of underwater retrieval)
C. Maintain records and catalog sub-samples, pictures, and descriptions of individual pieces of gear as part of a national, regional, and international standard reference collection and database
D. Investigate gear of unknown origin (gear that could not be identified by the experts) that has been retrieved to ascertain sources and verify source determinations of gear experts. Verification should include contact and discussions with potential source fisheries/industries
E. Provide gear identification information for the web site
NOTE: The intent is that this information will be made available to the public for educational purposes and cannot be used to take enforcement actions against a particular fishery or individual.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:
Secure funding either through federal appropriations or through a private funding source (or combination thereof) for this position. Position should be housed either at NMFS, at an academic institution, or at an organization highly involved in marine debris removal. Position should be filled no later than January 2001.

III. TYPE(S) OF ACTION:
Research, administrative, and assessment

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

Minimum Spatial Extent: The action should first be implemented in areas that have been identified as priority areas for marine debris/derelict fishing gear removal and where historic removal efforts have occurred (e.g., Hawai'i and Alaska)

Urge other nations to establish a similar position and database capability so as to coordinate efforts internationally.

Habitat Type Affected: Coral reef and pelagic ecosystems and other marine ecosystems throughout the Pacific

V. WHO IMPLEMENTS ACTION?

Depending on the funding source this action will be implemented either through the federal government or a private institution. Other nations should be encouraged to develop a similar capacity or provide support for this position.

VI. WHAT IS COST OF ACTION (ESTIMATE)?

One time (Start up) Cost – Less than $10,000
Annual Operation and Maintenance Cost - $100,000 to $500,000
(Cost estimates include salary and budget for travel, management of catalog, and travel for experts)

VII. WHO FINANCES?

A. Federal appropriations
B. Private funding source

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

The immediate benefit would be the development of a more effective and targeted educational program. The goal and objective would be to change behavior, create awareness, and eliminate sources of derelict fishing gear through education and outreach, as well as to provide a clear source of information and a conduit to the fishing community, international experts, and gear manufacturers.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

Industry: Fishing communities, international gear experts, and gear manufacturers
Environment: Marine life and ecosystems

SOURCE IDENTIFICATION: RECOMMENDATION C2.

Title: Establish a Network of Fishing Gear Specialists

Concern: There are currently no means to effectively identify sources of derelict fishing gear

Authors: A. Burch, J. Henderschedt, K. Kelly, D. King, and N. Young

I. DESCRIPTION:

The network of fishing gear experts should be familiar with material usage, fishing gear maintenance and construction. The network should be representative of the various international fisheries operating within the Pacific.

Several individuals may be necessary to cover the various fisheries within a geographic area.

The gear experts would be available to assist in the identification of derelict gear, investigate unknown or difficult to identify sources of derelict gear, and provide source information/material for database development.

The gear expert/coordinator would coordinate the efforts of the fishing gear experts (see previous recommendation).

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

Hire the gear expert coordinator to begin to identify candidates for this network.

Develop contacts through fishery organizations and industry, through direct commercial contacts, to find various gear experts and solicit their input or participation.

The initial search should be directed at the fisheries/nations that may be the likely source of the derelict fishing gear.

Invite gear experts to examine gear that has been removed and provide opportunities for these experts to give their input throughout the process.

III. TYPE(S) OF ACTION:

Research and assessment

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

Minimum Spatial Extent: Hawai'i and Alaska (areas where removal efforts have been conducted) in conjunction with removal efforts; international throughout the Pacific Basin

Habitat Type Affected: Coral reefs

V. WHO IMPLEMENTS ACTION?

The Gear Expert Coordinator (see recommendation C1) implements the action.

VI. WHAT IS COST OF ACTION (ESTIMATE)?

One time (Start up) Cost – Less than $10,000

Annual Operation and Maintenance Cost - Budget included in Rec. C1

VII. WHO FINANCES?

A. Federal appropriations

B. Private funding source

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

The benefit of these experts would be in the development of a broad-base source of individuals to assist in the identification of gear and the creation and maintenance of the reference database.

Other benefits are discussed in the gear expert coordinator recommendation.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

Industry: Fisheries, gear manufacturers, federal agencies, and institutions involved in gear removal

Environment: Coral reef and pelagic ecosystems and marine wildlife

Title: Develop GIS of commercial fishing and aquaculture locations and seasons in the North Pacific

Authors: D. Foley, J. Henderson, and M. Reppy

I. DESCRIPTION:

Create a Geographical Information System (GIS) mapping of fisheries geographic and temporal distribution around the North Pacific Rim, using effort data for each fishery. Include data on distribution and effort of aquaculture.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

Compile existing data on fisheries from nations fishing in the North Pacific. Update data as new information or reports become available. Possible sources of these data include the Food and Agricultural Organization (FAO) of the United Nations or other similar international organizations.

Incorporate the data into GIS format.

III. TYPE(S) OF ACTION:

Research - initial compilation would be library or literature research, subsequent updates would be monitoring

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

Minimum Spatial Extent: Pacific basin, including waters bordering Pacific rim nations

Habitat Type Affected: Highly variable, including pelagic, continental shelf, coral reefs, and inshore waters (aquaculture)

V. WHO IMPLEMENTS ACTION?

The action should not require a full-time position. Compilation should be performed by a fishery biologist with the National Marine Fisheries Service.

VI. WHAT IS COST OF ACTION (ESTIMATE)?
One time (Start up) Cost – $10,000 to $50,000
Annual Operation and Maintenance Cost – Less than $10,000

VII. WHO FINANCES?
NOAA, NMFS

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?
Information is necessary in order to conduct any action implemented as a result of this conference. For example, establishing a database of derelict gear types requires knowledge of where to look and whom to approach to garner information on the types of debris. Any education or outreach organization would need to know where to target their activities. All parties interested in the issue of derelict fishing debris would benefit from this information.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:
No resources are directly affected by the action.

Bob Rock, Marine Debris Communications Committee

This display by the "Trashbusters", a group of students from around the Pacific, demonstrates interest in solving the marine debris problem.

Title: Create an international reference (targeted) database and gear reference collection, available by region

Authors: D. Foley, J. Henderschedt, J. Henderson, M. Reppy, and J. Wang

I. DESCRIPTION:
A database should be created and maintained which describes fishing gear and equipment, and fishing practices. The database should include information on gear types and specifications. A cadre of gear experts, ideally distributed regionally among world fishing countries would provide data.

The data would whenever possible be based upon collections of reference materials, maintained and curated regionally. The database would be maintained in a central location.

The data, which is business confidential within the database, will be password protected in order to protect fisheries that have contributed to the database.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:
A. Identify user groups and obtain their input regarding the types of information required. Potential users include beach cleanup groups, resource managers, fishery agencies, and other interested personnel
B. Establish standardized protocol for data submission formats, for example: digital images, descriptive texts, refined quantification, measurements, etc. Also establish criteria for submission of samples of derelict gear
C. Establish infrastructure for data acquisition, processing, and storage
D. Identify target areas, using fisheries maps for potential sources and input from experts
E. Have coordinator allocate resources to fill in gaps
F. Establish (web-based) infrastructure for distribution
G. Maintain and update regional reference collections and database
H. FAO provide update to the World Congress on fishing gear and methods

III. TYPE(S) OF ACTION:
Monitoring and educational

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

Minimum Spatial Extent: Action could be implemented in any geographic region.
Habitat Type Affected: The action will not directly affect any habitat.

V. WHO IMPLEMENTS ACTION?

The data should be maintained by an international agency, such as the Food and Agricultural Organization (FAO) of the United Nations.

VI. WHAT IS COST OF ACTION (ESTIMATE)?

One time (Start up) Cost – $500,000 to $1,000,000
Annual Operation and Maintenance Cost - $50,000 to $100,000

VII. WHO FINANCES?

Financial support should be provided by the United Nations.

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

The database would allow outreach and education organizations to identify derelict fishing gear, to better direct their outreach efforts to fisheries that are losing or discarding equipment and gear, and to avoid fisheries that do not have problems with derelict gear. Information could also be provided to fishery agencies.

Implementing this action will in the long run help eliminate derelict fishing gear at its source(s), by increasing the efficiency of outreach activities.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

The action does not directly affect living resources. However, the action will indirectly benefit all living resources impacted by derelict fishing gear, by helping reduce the introduction of this material into the marine environment.

Title: Build a constituency for the importance of source identification

Authors: J. Henderson and N. Young

I. DESCRIPTION:

The goal of building a constituency of fishermen, gear experts, and manufacturers is to make these groups aware of the problem of derelict fishing gear, but more importantly, to enlist their support in efforts to identify sources of derelict fishing gear. This is a critical component of any source identification strategy. The trust and support of the fishing community is essential to determining the source of derelict fishing gear.

In addition, it is important to develop a constituency among government agencies, non-governmental organizations, and educators.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

Fishing Industry

A. Compose a list of fisheries, fishermen, fishing vessel owner associations, gear manufacturers, and fishermen associations

B. Conduct workshops or meetings, in cooperation with these groups, in various fishing ports and provide information tailored to the fishing community about derelict fishing gear, removal efforts, and the goals and objectives of source identification efforts. It is important to seek help and cooperation rather than telling the fishery what you want them to do

C. Work with the industry to identify individuals or associations that can provide a leadership role in organizing source identification efforts and outreach to the fishing community

D. Consider publicizing efforts either through industry publications and web sites or through a separate newsletter

E. Establish incentives and other mechanisms to reward and recognize innovative or cooperative efforts

F. Recognize those fisheries that have an outstanding record related to waste handling, reduction, or recycling

Government and NGOs

A. Provide general information related to the threats posed by derelict fishing gear to marine life and the marine environment. Clearly articulate the importance of an effective source identification program to target education

B. Provide government agencies and NGOs with opportunities to partner in removal and source identification efforts

C. Conduct workshops and provide information tailored to government agencies, NGOs, and educators about derelict fishing gear, removal efforts, and the goals and objectives of source identification efforts

D. Work with the industry to identify individuals within the agency, Congress, and NGOs, who can provide a leadership role in securing federal and private funding, organizing removal efforts, source identification efforts and outreach to the general public

E. Publicize these effort through newsletters, web sites, talks and various symposia or workshops

III. TYPE(S) OF ACTION:

Educational and constituency building

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

Minimum Spatial Extent: The action should first be implemented in areas that have been identified as priority areas for marine debris/derelict fishing gear removal and where historic removal efforts have occurred as well as areas that are potential sources of derelict fishing gear (e.g., Hawai'i and Alaska).

It is important that in establishing a constituency, organizers go to the fishing community rather than asking the community to come to them.

V. WHO IMPLEMENTS ACTION?

The action will be implemented through partnerships with the federal government, international organizations, NGOs, and the industry. The federal government should work closely with these partners to provide the information necessary to conduct effective outreach.

VI. WHAT IS COST OF ACTION (ESTIMATE)?

One time (Start up) Cost - $10,000 to $50,000
Annual Operation and Maintenance Cost - $50,000 to $100,000

VII. WHO FINANCES?

Financial responsibility has not been determined.

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

The immediate benefit would be the development of an informed constituency to support marine debris monitoring, removal, and education efforts. The result will enable more effective and targeted educational programs to the various constituencies. The goal and objective would be to change behavior, create awareness, eliminate sources of derelict fishing gear through education and outreach, and secure international support for these efforts.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

Industry: Fishing communities, international gear experts, and gear manufacturers

Government agencies, Congress, international organizations, and environmental organizations

Environment: Marine life and ecosystems

SOURCE IDENTIFICATION: RECOMMENDATION C6.

Title: Develop a web site for identification of gear fragments

I. DESCRIPTION:

Develop and maintain a web site that provides access to gear identification /standard reference collection database. The web site would provide general information on the location of fisheries, photos or keys of gear types by region, standard protocols for gear sampling, definition of terms, contacts for additional information, links to other web sites of organizations associated with gear identification or marine debris removal efforts.

The data, which is business confidential within the database, will be password protected in order to protect fisheries that have contributed to the database.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

The following actions must be completed prior to the development of the web site:

A. Build the database
B. Define terms
C. Develop standardized collection protocols
D. Identify individuals to create and maintain the web site

III. TYPE(S) OF ACTION:

Information source

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

Minimum Spatial Extent: Website would be available worldwide

V. WHO IMPLEMENTS ACTION?

Depending on the funding source this action will be implemented either through the federal government or a private institution. Other nations should be encouraged to develop a similar capacity or provide support for this position.

VI. WHAT IS COST OF ACTION (ESTIMATE)?

One time (Start up) Cost - $10,000 to $50,000
Annual Operation and Maintenance Cost - $10,000 to $50,000

VII. WHO FINANCES?

Funding for this action could be from the federal government or from a private institution. Other nations could also contribute to the funding for this position.

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

The benefits of this web site are international coordination, access to standardize fishing gear information, and a data source for gear identification for removal efforts.

Additional benefits include greater awareness of the marine debris issue and an avenue to foster international cooperation.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

Industry: Fishing communities, international gear experts, and gear manufacturers
Environment: Marine life and ecosystems
Researchers in the academic field

GROUP D: INDUSTRY

Chair: Dayton "Lee" Alverson, Ph.D.

Panelists: Jim Cook
Steven H. Hendrickson
Peter Leipzig
Brent Paine
Robert Zuanich

Facilitators: Steve Olive, Ph.D.
Jeff Walters, Ph.D.

Rapporteurs: Kevin Kelly
Cindy Knapman

D1. Support fishing effort rationalization

D2. Expand port-receiving sites for fishing gear

D3. Expand recycling opportunities and facilities for fishing gear

D4. Expand focus on gear loss reporting and documentation

INDUSTRY: RECOMMENDATION D1.

Title: Support fishing effort rationalization

Issues: Optimization and control of effort

Concern: Extant gear regimes contribute to gear loss

Theme: Promote fishing practices that minimize gear loss

Authors: L. Alverson, M. Eder, and B. Paine

I. DESCRIPTION:

This recommendation addresses the problem of open access fishing, which often encourages overcapitalization of fleets and gear in competition for resources in limited areas and time periods. Frequently these practices can lead to unnecessary loss of fishing gear. Current FAO efforts to rationalize fishing effort on a global scale should be supported by the U.S. government, and Congressional opposition to this management tool should be reviewed.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

A. Inform regional fishery organizations, national and international, of conference position regarding effort rationalization programs, e.g., limited entry, individual quotas, cooperatives, etc. and importance of these programs in the reduction of marine debris

B. Educate NGOs about the value of effort rationalization programs as a tool to reduce marine debris

C. Communicate to the U.S. Congress that the current moratorium on the implementation of effort rationalization systems, such as individual quotas is contrary to the goal of reduction of marine debris and the position taken at the International Marine Debris Conference, 2000.

III. TYPE(S) OF ACTION

Regulatory, educational, and policy

FINAL RECOMMENDATIONS

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?
Minimum Spatial Extent: Regional, global
Habitat Type Affected: Ocean-wide

V. WHO IMPLEMENTS ACTION?
A. Fishery organizations
B. U.S. DOC/NOAA
C. NGOs
D. Regional management bodies
E. International fishery organizations
F. National and international legislative bodies

VI. WHAT IS COST OF ACTION (ESTIMATE)?
One time (Start up) Cost - >$1,000,000
Annual Operation and Maintenance - >$1,000,000

VII. WHO FINANCES?
Government and users finance the action.

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?
The ocean environment and ocean users benefit from the implementation.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:
All living resources are affected by the action.

Title: Expand port-receiving sites for fishing gear

Issues: Logistics are not in place to receive waste and other materials

Concern: Not many port facilities are outfitted in this way—insufficient

Theme: To be able to adequately divert waste and recyclables from being inappropriately dumped at sea and on land according to MARPOL regulations

Authors: A. Burch, L. Chapman, S. Hendrickson, and M. Minton

I. DESCRIPTION:
Despite requirements of MARPOL for nations to provide adequate port disposal facilities, many ports in the Pacific do not provide adequate facilities. Implementation of this recommendation will help make adequate facilities available to dispose of waste including fishing gear.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:
A. Acquire cranes or other equipment to remove gear from boat to dock
B. Acquire holding containers for solid and other waste including liquids and recyclables
C. Develop transportation system from port dock to landfill or other facility
D. Make waste oil holding facility and testing equipment available. Containers should be provided. Collection site — charge per gallon or free
E. Build oily bilge water holding facility, run through water separating systems and storage/holding facilities for other chemicals, paints, solvents, batteries.
F. Develop incentive program to encourage utilization of services and facilities, free dumping, etc.
G. Foster recycling opportunities

III. TYPE(S) OF ACTION:
Administrative, monitoring, economic, assessment, educational, and improved disposal

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

Minimum Spatial Extent: All ports throughout region with efforts focusing on major ports (particularly targeting those home porting net fisheries and then targeting progressively less active ports)

Habitat Type Affected: All associated environments/habitats are affected by reduced waste disposal into the ocean environment and reduced pressure on landfills

V. WHO IMPLEMENTS ACTION?

The action is implemented by all levels of the government along with help from the public sector.

VI. WHAT IS COST OF ACTION (ESTIMATE)?

Per port:

One time (Start up) Cost - $100,000 to $500,000

Annual Operation and Maintenance Cost - $100,000 to $500,000

VII. WHO FINANCES?

Initially, national government finances with gradual transition of costs to local communities and the private sector (port users, etc.). Funding for monitoring/assessment should be continued.

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

The benefits of implementation include the reduction of improper disposal of wastes, including fishing gear, and other associated impacts.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

All resources are affected by the action.

Title: Expand recycling opportunities and facilities for fishing gear

Concern: Logistics are not in place to recycle waste from fishing practices

Authors: L. Chapman, S. Hendrickson, and M. Minton

I. DESCRIPTION:

This recommendation is intended to develop a capacity to recycle fishing vessel wastes including netting, gear, oil, plastics, solvents, batteries, cardboard, metals, etc.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

A. Have appropriate waste handling facilities in place (see industry recommendation D2)

B. Identify recycling facilities and markets and negotiate recycling agreements/contracts

C. In consultation with recycling facilities, develop procedures, protocols and infrastructure to sort, store, and transport materials to recycling facilities

D. Develop an education and outreach program for the fishing community via a community outreach coordinator

III TYPE(S) OF ACTION:

Administrative, monitoring, economic, assessment, and educational

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

Minimum Spatial Extent: All ports throughout region with efforts focusing on major ports (particularly targeting those home porting net fisheries and then targeting progressively less active ports)

Habitat Type Affected: All associated environments/ habitats affected by reduced waste disposal into the ocean environment and reduced pressure on landfills

V. WHO IMPLEMENTS ACTION?
The action is implemented by all levels of the government along with help from the public sector.

VI. WHAT IS COST OF ACTION (ESTIMATE)?
A successful recycling program is dependent on adequate port disposal facilities (see industry recommendation D2). Costs could vary significantly depending on port(s) and location(s).

Per port:
One Time (Start up) Cost – $10,000 to $50,000
Equipment Cost - $10,000 to $50,000
Annual Operation and Maintenance Cost - $50,000 to $100,000

Note: The coordinator could potentially serve several communities depending on proximity

VII.WHO FINANCES?
Initially, national government finances with gradual transition of costs to local communities and the private sector (port users, etc.). Funding for monitoring/assessment should be continued.

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?
The benefits of implementation include the reduction of improper disposal of wastes, including fishing gear, and other associated impacts. There is also an educational benefit associated with raising local understanding and support for recycling and correct waste disposal.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:
All resources are affected by the action.

INDUSTRY: RECOMMENDATION D4.

Title: Expand focus on gear loss reporting and documentation

Concern: Quantification of amount and origin of lost gear

Authors: J. Cook, C. Oliver, and R. Zuanich

I. DESCRIPTION:
This recommendation is intended to establish regional protocols (regulations) at appropriate State, Federal, or other agency levels to require reporting of gear lost that is not immediately retrieved. The protocols would be limited to net gear (trawl web, gill net, etc.) and would require reporting of type, location, amount, etc. Difficulties with other gear types led the group to focus only on net gear.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:
A. Verify current reporting requirements by region and by various jurisdictions (State, Federal, etc.)
B. Propose specific regulatory language (for each agency/jurisdiction) to require that all federally permitted vessels submit a report form to the NMFS Habitat Conservation Division. Either require that any loss be reported, or let Council/Industry refine the exact reporting criteria (limiting the regulations to net gear will make it easier to define the minimum reporting criteria)
C. Reporting could additionally be linked to the IMO web site discussed in other recommendation(s)

III. TYPE(S) OF ACTION:
Monitoring and regulatory

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?
Minimum Spatial Extent: Net/trawl fisheries throughout the North Pacific (U.S. Pacific management council areas)

Habitat Type Affected: Reefs, water column, and substrate (potentially all habitats)

V. WHO IMPLEMENTS ACTION?
A. Regional Councils
B. U.S. DOC/NOAA/NMFS
C. State
D. Other

VI. WHAT IS COST OF ACTION (ESTIMATE)?
One time (Start up) Cost - $500,000 to $1,000,000
Annual Operation and Maintenance Cost - $50,000 to $100,000

VII. WHO FINANCES?
Relevant government agencies fund the action.

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?
A significant benefit will be having a quantifiable record of the amount and origin of current and future net loss.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:
Resources affected by the action include ocean habitats, protected species and fisheries. Fishermen and the general public will also be affected.

GROUP E: MONITORING AND REMOVAL

Chair: Mary Donohue, Ph.D.

Panelists: CDR Russell E. Brainard, Ph.D.
Ilse Kiessling, Ph.D.
Tatsuro Matsuoka
Daniel Torres N.
Nina Young

Facilitators: Tom Culliton
Todd Jacobs

Rapporteurs: LT Lane D. Johnson
Linda Paul

E1. Establish broad based funding to address derelict fishing gear monitoring and removal via a task force comprised of all interested stakeholders

E2. Establish standardized survey and removal protocols for derelict fishing gear

E3. Establish a high level intergovernmental and stakeholder Pacific Rim Marine Debris Commission to address the issue of derelict fishing gear, and other marine debris

E4. Investigate and establish appropriate financial incentives for recovery, return, and recycling of derelict gear

E5. Continue current derelict fishing gear retrieval, monitoring, and identification analysis efforts at the local, national, and international levels, including the Northwestern Hawaiian Islands

FINAL RECOMMENDATIONS

MONITORING AND REMOVAL: RECOMMENDATION E1.

Title: Establish broad based funding to address derelict fishing gear monitoring and removal via a task force comprised of all interested stakeholders

Issues: Derelict fishing gear is currently damaging and degrading coral reefs and other coastal ecosystems and threatening living marine resources, including threatened, endangered, and other protected species. However, no dedicated broad-based funding, including federal U.S appropriation, currently exists to conduct marine debris monitoring and removal.

Concern: Entanglement of living resources in derelict fishing gear; ingestion of derelict fishing gear by wildlife; scouring of coral, live rock, and other substrate by derelict fishing gear; potential transport and introduction of exotic species to novel environments; hazards to navigation. Enhanced information on the nature and quantity of derelict fishing gear is needed to detect marine debris trends and mitigate associated damage.

Theme: Secure permanent funding sources to execute derelict fishing gear removal and monitoring until such time debris no longer poses an ecological and economic threat.

Authors: T. Culliton, M. Donohue, T. Egeland, R. Miyashiro, and N. Young

I. DESCRIPTION:

Establish a task force comprised of individuals from government agencies, the fishing industry, environmental groups, corporations, gear manufacturers, and insurance companies whose task is to identify funding sources, both public and private, which can be used in marine debris monitoring and removal efforts. The goal of this effort is to secure permanent funding sources to promote the assessment, monitoring, and removal of marine debris.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

A. Establish the task force
B. Develop educational information that highlights the importance of marine debris monitoring and removal efforts

Private Funding Sources

A. Research and identify possible private (national and international) funding sources
B. Identify potential corporate sponsors
C. Develop a merchandizing and marketing strategy using key species (e.g., monk seal plush toys)
D. Examine sources of funding identified through economic incentive programs

Federal Funding Sources

A. Identify key leaders in Congress that will support Congressional appropriations for marine debris monitoring and removal efforts
B. Work with these leaders to ensure that line items for marine debris monitoring and removal are provided for in the federal budget
C. Work with the agencies that may contribute to these efforts (e.g., U.S. NMFS, U.S. NOAA, U.S. DOD, and USCG) to ensure that monitoring and removal efforts are advanced in their budget requests
D. Provide educational materials, testimony, and fact sheets to the Congressional appropriations committees to highlight the importance of this issue

III. TYPE(S) OF ACTION:

Economic and regulatory

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

A. U.S. Congress (Washington, D.C.)
B. Private Sector

V. WHO IMPLEMENTS ACTION?

Task Force members implement the action.

VI. WHAT IS COST OF ACTION (ESTIMATE)?

One time (Start-up) Cost - $50,000 to $100,000
Annual Operation and Maintenance Cost - $50,000 to $75,000

VII. WHO FINANCES?

A. Each task force member absorbs the cost of participation in the task force
B. Some seed money provided by each institution may be needed in the initial phase for research and publications
C. Task force will seek funding to sustain its efforts
D. Additional funding may be needed if the task force decides to hire a coordinator

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

The benefit from implementation is the prevention of environmental and economic damage through enhanced monitoring and removal of derelict fishing gear from the marine environment.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

A. Protected marine species, marine life, essential fish habitat, living coral substrate, and marine coastal and pelagic ecosystems
B. Recreational beaches
C. All coastal resources

Title: Establish standardized survey and removal protocols for derelict fishing gear

Issues: Absence of comparable data sets detailing the survey and removal of derelict fishing gear prevents efficient understanding and remediation of the problem

Concern: Inability to assess trends and impacts of derelict gear on a global scale. Inability to meaningfully compare data between regions and existing efforts. Inappropriate removal and monitoring efforts could potentially do more harm than good.

Theme: Determine global status and trends in derelict fishing gear impacts in order to assist in its remediation

Authors: C. Barr, H. Bernard, A. Frankic, W. Gilmartin, and I. Kiessling

I. DESCRIPTION:

Establish guidelines for standardizing monitoring and removal of derelict fishing gear to facilitate assessment of trends, status, and impacts.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

A. Develop objective-specific and habitat specific guidelines for derelict fishing gear monitoring and removal

Evaluate methods of existing long-term marine debris recovery programs' methods, such as CMC's Marine Debris Monitoring Program and NMFS Marine Debris Recovery Program in the NWHI for adaptation to other regions. Refinement of existing methodology should include the following elements:

1. Survey and removal efforts must consider the protected species and sensitive habitat of the area. Therefore, appropriate resource management agencies must be consulted, and appropriate regulations observed.
2. Where possible, monitoring efforts should endeavor to collaborate with existing monitoring and survey programs.
3. A cost-benefit analysis should be employed during removal efforts to ensure no additional anthropogenic damage is inflicted by removal

efforts (i.e., biologically based evaluation of derelict nets encorporated growth into the reef structure by coral should be undertaken to avoid any additional anthropogenic damage).

4. Survey techniques should strive to be comparable, systematic, and quantifiable and be able to measure the rate of accumulation when possible.
5. Survey design, where appropriate, should endeavor to subsample areas affected to use resources most effectively and minimize disturbance to the environment.
6. Long-term or intensive survey and monitoring efforts should avoid sensitive regions (e.g., seal haul-out sites).

B. Regional criteria for prioritizing and identifying removal sites:
Criteria for identifying and prioritizing debris removal sites will be regionally derived, with consideration given to the present degree of removal efforts' impact on the ecosystem, habitat, species, economy, community engagement, weather, habitat usage patterns of people and/or wildlife, etc.

C. International Database (web-based):
Data collection techniques, when possible, should be comparable regionally and internationally. In order to support this goal, a standard data sheet will be designed as described under section A and peer-reviewed by stakeholders.

We propose the standard data sheet be posted on the world wide web. Ideally, this web site would be interactive, allowing visitors to input data. The host agency will analyze these data annually and disseminate results to all interested stakeholders.

D. Establish a "Hotline" for derelict fishing gear:
Determine agencies within each nation/state that will host a Marine Debris Hotline (telephone and internet) to which mariners/beachgoers can report derelict fishing gear. Generate a response paradigm for recovery (e.g., on beach vs. at-sea).

E. Effectively communicate the full impact of the debris problem, as well as progress on removal and prevention.

Engage all stakeholders in derelict fishing gear monitoring and removal activities (especially developing countries); use existing marine related forums (e.g., international conferences on marine mammals, sea turtles, technology, fishing, and insurance companies) as a mechanism for engaging stakeholders.

Engage advocacy groups in highlighting and promoting funding requirements for derelict fishing gear monitoring and removal.

Encourage industry, NGOs, and governmental organizations to provide links to the aforementioned web site.

III. TYPE(S) OF ACTION:
Monitoring, educational, and assessement

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?
Minimum Spatial Extent: Hot spots - based on the degree of impact (e.g., Arafura Sea, Australia, NWHI and Antarctic Peninsula)
Habitat Type Affected: All oceanic ecosystems

V. WHO IMPLEMENTS ACTION?
All interested stakeholders (e.g., researchers, resource managers, fishers, government and non-governmental representatives) implement the action.

VI. WHAT IS COST OF ACTION (ESTIMATE)?
One time (Start-up) Cost - $500,000 to $1,000,000
Annual Operation and Maintenance Cost - $100,000 to $500,000

VII. WHO FINANCES?
Information not provided

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?
Benefits are environmental, cultural, socio-economic, and global in scale. Standardizing monitoring and removal efforts provides an information base for targeted remediation and may determine if regulations such as MARPOL V are effective.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:
Virtually all levels of marine life, including commercial and protected species, are affected.

MONITORING AND REMOVAL: RECOMMENDATION E3.

Title: Establish a high level intergovernmental and stakeholder Pacific Rim Marine Debris Commission to address the issue of derelict fishing gear, and other marine debris

Concern: Lack of international collaboration on the issue of marine debris

Authors: C. Barr, N. Garon, I. Kiessling, L. Paul, R. Steiner, and D. Torres

I. DESCRIPTION:

The Commission should be comprised of top level regional, national, state, and local resource managers and representatives from other stakeholder groups (non-governmental organizations, industry [i.e., gear manufacturers, fishing organizations], scientific community, etc.) The Commission will provide a forum for interregional cooperation and coordination on all aspects of the debris issue. Its principle task will be to develop an action plan to eliminate sources of marine debris and remove existing debris in the Pacific Ocean by year 2010. General objectives will include:

A. Conduct a comprehensive assessment of debris input sources into the Pacific Ocean and related ecosystems
B. Prioritize problem sources and location of existing debris
C. Establish goals, management objectives, and strategies to reduce priority sources and concentrations of marine debris (develop legislation/regulations on enforcement, etc.)
D. Establish a monitoring program to measure the effectiveness of the action plan
   1. Design sampling protocol
   2. What and how to measure
   3. Reporting format (standardization)
   4. Develop habitat-specific guidelines
   5. Utilize remote sensing
E. Develop and maintain an international data base to serve investigators and other stakeholders and provide for a consistent protocol
F. Establish monitoring and removal network and hotline (trash busters)
G. Regional criteria for prioritizing standard operating procedures
H. Disseminate information to all stakeholders, including policy makers and fishing industries

II. METHODS:

A. The Commission shall meet physically once a year
B. Teleconference three times a year
C. Appoint a Secretariat to be based initially at the East West Center, University of Hawai'i, Honolulu
D. Produce annual report

III. TYPE(S) OF ACTION:

Research, monitoring, economic, educational, administrative, regulatory, assessment, and coordination

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

Minimum Spatial Extent: Pacific basin and associated ecosystems

Habitat Type Affected: All pelagic, benthic, and coastal habitats of the Pacific Ocean

V. WHO IMPLEMENTS ACTION?

National governments via the Commission's umbrella organization

Implementation procedure:

A. International Marine Debris Conference (IMDC) on Derelict Fishing Gear sends a letter with conference recommendations to the U.S. Department of Commerce, Department of Defense, the Department of Interior, the Department of State, the Department of Transportation, the U.S. Coral Reef Task Force and other resource management agencies in the U.S. and other nations represented at the Conference, Governors of U.S. territories, members of Congress, United Nations Environment Program (UNEP), regional resource management organizations by September 1, 2001 (Facilitated by National Marine Fisheries Service Honolulu Laboratory Marine Debris Coordinator)
B. Interim IMDC Committee (made up of interested conference presenters) inquiry with assistance of State Department (Holly R. Koehler) and NOAA (Russell E. Brainard) and other agencies into interest of Asia-Pacific Economic Cooperation (APEC), South Pacific Regional Environment Program (SPREP), and other organizations in serving as an umbrella organization to Commission

C. State Department and NOAA facilitates, does advance work prior to letter being sent from President
D. Letter from U.S. President to Pacific Rim Heads of State at end of October 2000
E. First meeting to be held in Honolulu, Hawai'i at East West Center in March 2001

VI. WHAT IS COST OF ACTION (ESTIMATE)?

One time (Start up) Cost - $300,000
Annual Operation and Maintenance Cost - $750,000 including:
A. Staff: Executive director, fiscal officer, two administrative assistants, four regional coordinators (8 total): $300,000
B. Office and equipment costs: $100,000
C. Annual meeting: $200,000
D. Travel: $150,000

VII. WHO FINANCES?

A. Conservation and Reinvestment Act (CARA), currently pending in U.S. Congress
B. Member country contribution

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

For the first time ever there will be direct and regular dialog and coordinated action throughout the Pacific Basin and a target year of 2010 for eliminating inputs into the Pacific Ocean.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

All Resources are affected.

Title: Investigate and establish appropriate financial incentives for recovery, return, and recycling of derelict gear

Concern: Lack of financial incentives to retrieve derelict gear

Authors: M. Donohue and R. Steiner

I. DESCRIPTION:

Initiate an investigation of financial incentives—bounties, tax breaks, etc. to encourage the retrieval, return, and recycling of derelict gear found at sea or ashore. Establish such incentives as appropriate.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

NOAA resource economists develop a concept paper/analysis of options for providing financial incentives for retrieval and assess the feasibility of such options. For those that indicate a feasibility, establish a pilot program with bounty for retrieval, facilitated by NMFS.

III.TYPE(S) OF ACTION:

Economic, research, and administrative

IV. WHERE SHOULD ACTION BE IMPLEMENTED?

Minimum Spatial Extent: Pacific-wide

Habitat Type Affected: All pelagic, benthic, and coastal habitats of Pacific Ocean

V. WHO IMPLEMENTS ACTION?

NOAA provides assessment of options and feasibility. NMFS provides the pilot project.

VI. WHAT IS COST OF ACTION (ESTIMATE)?

One time (Start up) Cost - $50,000 to $100,000
Annual Operation and Maintenance Cost - $100,000 to $500,000

VII.WHO FINANCES?

A. CARA (and/or)

B. Other Congressional Appropriation

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

Reducing derelict gear in the marine environment is the primary benefit from implementation.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

All resources that are presently affected by derelict gear will be affected by the action.

Jacquelyn Zettles, United States Coast Guard

Students from Pacific Island nations, known as the "Trashbusters", gather in front of sculptures created with marine debris.

MONITORING AND REMOVAL: RECOMMENDATION E5.

Title: Continue current derelict fishing gear retrieval, monitoring, and identification analysis efforts at the local, national, and international levels, including the Northwestern Hawaiian Islands

Issues: Derelict fishing gear is currently damaging and degrading coral reefs and other coastal ecosystems and threatening living marine resources, including threatened, endangered, and other protected species.

Concern: Entanglement of living resources in derelict fishing gear; ingestion of derelict fishing gear by wildlife; scouring of coral, live rock and other substrate by derelict fishing gear; potential transport and introduction of exotic species to novel environments; and hazards to navigation

Theme: Mitigation or prevention of environmental and economic damage by derelict fishing gear removal

Authors: R. Clarke, M. Donohue, T. Egeland, and R. Miyashiro

I. DESCRIPTION:

Institutions that have conducted marine debris monitoring and removal efforts should maintain and expand derelict fishing gear retrieval, monitoring, and identification analysis efforts on beaches and in tidal and subtidal habitats. The continuation and expansion of these existing efforts worldwide are critical for habitat and fisheries enhancement. These efforts should include but not be limited to, the following:

A. Northwestern Hawaiian Islands (NWHI) Multi-Agency Cooperative Marine Debris Cleanup

B. Arafura Sea Beach Cleanup and Survey

C. Center for Marine Conservation International Coastal Cleanup (ICC)

D. National Marine Debris Monitoring Program

E. Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) Environmental Monitoring Program (CEMP) Cape Shirreff, Livingston Island, Antarctica Marine Debris Cleanup Effort

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

A. Undertake public awareness campaigns surrounding these various monitoring and removal projects with the goal of seeking greater participation to expand these efforts
B. Involve more partners in monitoring and removal efforts
C. Allocate funding and seek permanent appropriation to maintain and expand existing efforts
D. Provide reports or updates in newsletters, and public scientific forums to foster greater awareness of these programs
E. Establish, where appropriate, a public relations strategy to complement monitoring and removal efforts with the goal of garnering greater public support and participation

III. TYPE(S) OF ACTION:

Monitoring, research, education, mitigation (removal) of derelict fishing gear, and outreach to the public

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

Minimum Spatial Extent:

A. Northwestern Hawaiian Islands
B. Arafura Sea
C. All coastlines
D. Antarctica

Habitat Type Affected: Nearshore and coastal resources worldwide, including coral reefs, temperate, subtropical, and tropical beaches (urban and remote), and Antarctic and subarctic shorelines

V. WHO IMPLEMENTS ACTION?

A. Multi-Agency Cooperative Task Force including Federal, State and non-governmental partners
B. World Wide Fund for Nature (World Wildlife Fund), Dhimurru Land Management Aboriginal Corporation and Australian Trust for Conservation Volunteers
C. Center for Marine Conservation and partners
D. Instituto Antartico Chileno

VI. WHAT IS COST OF ACTION (ESTIMATE)?

A. $U.S. 1,435,000 per 30 day two ship research cruise
B. $U.S. 10,000 per approximately 9 km of beachfront cleanup
C. $U.S. 200,000 for coordinated volunteer effort
D. $U.S. 6,000 per approximate 3 month season annually

VII. WHO FINANCES?

Presently, as outlined below. Additional permanent funding is critical to sustain these efforts

A. No dedicated budget, all in-kind contributions from multi-agency working group
B. Australian Federal and State governments and in-kind services from various agencies
C. Non-profit organization revenues
D. Instituto Antartico Chileno

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

Prevention of environmental damage through permanent removal of derelict fishing gear from the marine environment

A. Coral reef restoration including, enhancement of U.S. Essential Fish Habitat, protection and restoration of U.S. National Wildlife Refuge beaches, tidal and subtidal habitats and protection of endangered species critical habitat
B. Ensure subsistence resources for indigenous peoples
C. Aesthetic improvement of coastal beaches and enhancement of marine and shoreline habitats
D. Removal of marine debris at Antarctic fur seal (Arctocephalus gazella) rookeries and penguin nesting colonies

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

A. Endangered Hawaiian monk seal (Monachus schauinslandi), threatened and endangered sea turtles, migratory seabirds, living coral substrate
B. Aquatic turtles, indigenous peoples subsistence resources
C. All coastal resources
D. Antarctic fur seal (Arctocephalus gazella) and penguins (Pygoscelidae species)

GROUP F: EDUCATION AND OUTREACH

Chair:	Emily Morgan
Panelists:	Gael Arnold
	Hung Chi-Liao
	MCPO Linda J. Reid
	Seba B. Sheavly
	John Wang
	Christine Woolaway
Facilitators:	Brad Barr
	Timothy Goodspeed
Rapporteurs:	Christina Meller
	Lynn Nakagawa

F1. Reestablish and institutionalize funding for MPPRCA mandate MDIO (CG, EPA, Commerce) in U.S. and similar institutions in other countries

F2. Hire and train peer group representatives to actively deliver derelict fishing gear marine debris message within priority groups (including fishing vessel captains, port captains, enforcement personnel, g ear manufacturers)

F3. Produce training/informational video on MARPOL and gear disposal

F4. Education of public resource managers, administrators, legislators, the fishing industry, and conservation organizations of the true character and impacts of marine debris is important, especially in developing countries. Both the nature of the problem, and mitigation actions taken by governments, NGOs, and the fishing industry, should be noted.

F5. Use source identification to target education

F6. Engage industry in the development of programs to ensure effectiveness

F7. Tailor education programs to regional circumstances and culture; use respected community leaders

EDUCATION AND OUTREACH: RECOMMENDATION F1.

Title: Reestablish and institutionalize funding for MPPRCA mandate MDIO (CG, EPA, Commerce) in U.S. and similar institutions in other countries

Authors: K. Blue, C. Fowler, C. Meller, S. Sheavly, and C. Woolaway

I. DESCRIPTION:

The following U.S. national program is to serve as a model for an international approach to address derelict fishing issues with the intention that the IMO will serve as a clearinghouse.

The U.S. Congress mandated that the Department of Commerce National Oceanic and Atmospheric Administration and the Environmental Protection Agency conduct an education program as part of MARPOL Annex V enacting legislation for the Marine Plastic Pollution Research and Control Act (MPPRCA) of 1987. Funding was appropriated to NOAA to conduct this effort. NOAA contracted with the Center for Marine Conservation from 1989 to 1995 to operate two marine debris information offices. The function of these offices was to establish and maintain a clearinghouse and distribution center for information and materials to educate various stakeholders, including the general public and marine user groups, about the impacts of marine debris and their roles in its creation, removal and proper disposal. Due to the shift of program emphasis, appropriations were cut shutting down the program in 1996.

Currently, the only federal agency supporting marine debris education is the Environmental Protection Agency through its involvement with the International Coastal Cleanup and the National Marine Debris Monitoring Program.

The U.S. Coast Guard (USCG) is responsible for enforcing MARPOL Annex V. The approach utilized by the USCG is one of education and prevention implemented through the Sea Partners program. Funding from the Department of Transportation is needed to support USCG efforts related to this issue.

There is inadequate national support in existence to maintain ongoing educational efforts to address the issue of marine debris—including derelict fishing gear.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

A. Secure long-term national funding through:
   A. U.S. Department of Commerce/NOAA
   B. U.S. Department of Transportation, (USCG)
   C. U.S. EPA
B. Integrate marine debris issues into current legislation at the national and state level
C. Develop an action plan for USCG to put pressure on the IMO to strengthen efforts for enforcement of MARPOL Annex V in the member states
D. Set national implementation for fiscal year 2002
E. Modify CARA appropriations to require state-level marine debris programs
F. Require a port fee of entry for marine pollution education programs similar to insurance programs required on boats entering U.S. ports
G. Partners: Center for Marine Conservation, Coastal State Organizations, NOAA, Sea Grant, CZMP, NMFS, USFWS, USCG, MEP, Sea Partners, EPA, Regional Fisheries Councils, Local and Regional NGOs

Challenges:

1. Fundamentally no one entity has overall authority to manage this issue
2. Intra and interagency conflicts on funding, authority, and implementation
3. Inadequate and inconsistent funding from Congress to address the issue of marine debris

III.TYPE(S) OF ACTION:

Educational, economic, administrative, and assessment

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

Minimum Spatial Extent: Nationwide (U.S.) and all throughout the U.S. Exclusive Economic Zone (EEZ)

Habitat Type Affected: Marine and coastal communities

V. WHO IMPLEMENTS ACTION?

A Presidential Executive Order or Congressional action/appropriation forms a National Working group composed of representative government agencies, conservationists, community members, and industry organizations with experience in addressing marine debris issues related to derelict fishing gear to implement the action.

VI.WHAT IS COST OF ACTION (ESTIMATE)?

One time (Start-up) Cost - $500,000 to $1,000,000
Annual Operation and Maintenance Cost - $500,000 to $1,000,000

VII.WHO FINANCES?

A. Modify CARA appropriations to require state level marine debris programs
B. Require a port fee of entry for marine pollution education programs similar to insurance programs required on boats entering U.S. ports

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

A. Change human behaviors
B. Reduction of presence of derelict gear
C. Reduction of impacts to marine wildlife from derelict gear
D. Improve survival of commercially valuable species
E. Enhance cultural exchanges regionally

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

Marine wildlife, including fish, mammals, and birds, as well as human health and safety, are affected by the action.

EDUCATION & OUTREACH: RECOMMENDATION F2.

Title: Hire and train peer group representatives to actively deliver derelict fishing gear marine debris message within priority groups (including fishing vessel captains, port captains, enforcement personnel, gear manufacturers)

I. DESCRIPTION:

Target Audience: Harbormasters, port authority, wastehaulers, boaters, owners/operators, fishers, boating crew, coastal government

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

A. ID state (national, international) program to house and sponsor the training program

B. Create local forum to address the needs/problems and a local trainer/leader/facilitator will arise — this person then needs to be trained about proper derelict fishing gear issues and disposal in the target community

C. Provide facilitator with educational methods

D. Assist facilitator with program implementation

III. TYPE(S) OF ACTION:

Educational

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

Minimum Spatial Extent: Coastal fishing communities

V. WHO IMPLEMENTS ACTION?

Coastal Zone Management or equivalent international representatives implement the action.

VI. WHAT IS COST OF ACTION (ESTIMATE)?

One time (Start-up) Cost - $10,000 to $50,000

Annual Operation and Maintenance Cost – has not been determined

VII. WHO FINANCES?

A. State/National (i.e., CARA funding); or

B. The fishing industry in state/national program partnership

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

Strong direct outreach and education of user source are the benefits from implementation.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

Affected resources have not been determined.

EDUCATION AND OUTREACH: RECOMMENDATION F3.

Title: Produce training/informational video on MARPOL and gear disposal

Authors: E. Morgan, L. Reid, and C. Yokota

I. DESCRIPTION:

Produce training/informational video on MARPOL and gear disposal that meets the following objectives:

A. Target audience is fishermen
B. Easy to show; relatively inexpensive to reproduce and distribute
C. Includes possibility of translating to reach international audience
D. Tailored to fishermen's culture, using respected or easily identifiable representatives in the video
E. Not overly bureaucratic or technical
F. Complete, accurate, timely
G. Appealing; attention-retaining
H. Makes the emotional connection to why it is important to properly manage fishing gear (i.e., good stewardship, impact on future generations)
I. Features positive examples of compliance, successful models

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

A.Review availability of existing videos for applicability; investigate sources such as U.S. Coast Guard, U.S. Navy, Sea Grant, industry, etc. (e.g., U.S. Coast Guard currently has in stock "A Fisherman's Guide to a Clean Sea," "Guardians of the Sea")
B. Confer with fishermen and fishing trade representatives to review what is currently available, recommend what is usable and what needs to be created
C. Define conceptual video message and script in consultation with fishermen and fishing trade representatives
1. Use existing videos or portions, if possible
2. Keep to 15-20 minutes.
3. Consider creating stock footage that can be overdubbed for use by many countries
4. Consider using kids to make emotional connection to good stewardship
5. Feature fishermen doing "right thing" – as successful model

D. Contract and produce
E. Determine distribution needs and method
F. Assess whether successful in changing fishermen's behavior in MARPOL compliance and decreasing amount of derelict fishing gear in our oceans
G. Revise video if needed

III. TYPE(S) OF ACTION:

Educational

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

Minimum Spatial Extent: All commercial fishermen, focused especially in areas with worst derelict fishing gear problem (per source identification input)

V. WHO IMPLEMENTS ACTION?

The U.S. Coast Guard, along with assistance from other agencies and organizations, implements the action.

VI. WHAT IS COST OF ACTION (ESTIMATE)?

One time (Start-up) Cost - $10,000 to $50,000
Annual Operation and Maintenance Cost – less than $10,000

VII. WHO FINANCES?

Funding for this action has not been determined.

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

Benefits from implementation have not been determined.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

Affected resources have not been determined.

EDUCATION AND OUTREACH: RECOMMENDATION F4.

Title: Education of public resource managers, administrators, legislators, fishing industry, and conservation organizations of the true character and impacts of marine debris is important, especially in developing countries. Both the nature of the problem, and mitigation actions taken by governments, NGOs, and the fishing industry, should be noted.

Authors: K. Blue, C. Fowler, S. Sheavly, and C. Woolaway

I. DESCRIPTION:

Education of derelict fishing gear stakeholders.

There are several audiences related to commercial fishing and derelict gear issues. The core of this group consist of fishers ranging from single, subsistence individuals who may or may not own their own boats to crews on large trawlers. Business and industry associated with equipment and boat manufacturing and marketing are also part of this audience as they are responsible for the production and sales of the materials used by fishers. Individuals who are part of the fish processing industry including marketing are also part of this group including the consuming public. And last but not least, are the governmental regulatory and resource management entities, which are needed to complete the entire scope of this issue.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

A. Empowered Organization: National work group (in recommendation to reestablish and institutionalize funding for MPPRCA mandate…) should empower an entity with broad experience and outreach related to marine debris and derelict gear issues to develop, implement, and maintain a continual educational program.

B. Access past and current educational programs targeting derelict gear stakeholders to develop and implement national program.

C. Following a successful U.S.A. national program, make materials available by adaptation for international agencies and organizations.

D. Funding will be through national support from U.S. EPA, USCG, NOAA combined with industry, corporate and private foundations.

E. The program will start directly following the establishment of the national working group as defined previously.

F. Partners and contributors to the 2000 International Marine Debris Conference are responsible to take recommendations to the next level for action implementation. Activities should be implemented within one year of this conference.

G. Challenges to this process include the degree of cooperation between all agencies, organizations, and stakeholders in this issue; and creating appropriate educational materials for targeted groups particularly taking into consideration specialized needs of stakeholder groups.

III. TYPE(S) OF ACTION:

Educational

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

The action should begin with the U.S. national program then move to international program development after successful models have been developed and implemented in the United States.

V. WHO IMPLEMENTS ACTION?

The action should be implemented by the partners and the contributors of the International Marine Debris Conference, the National work group, and the entities empowered with implementation by the National work group.

VI. WHAT IS COST OF ACTION (ESTIMATE)?

One time (Start-up) Cost - $100,000 to $500,000

Annual Operation and Maintenance Cost – $100,000 to $500,000

Bob Rock, Marine Debris Communications Committee

Pictured left to right, Cindy Knapman and Gael Arnold participate in the Education and Outreach Working Group.

VII. WHO FINANCES?

A. U.S. EPA
B. U.S. Coast Guard
C. NOAA
D. Industry
E. Corporations
F. Private Foundations

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

A. Change human behaviors
B. Reduction of presence of derelict gear
C. Reduction of impacts to marine wildlife from derelict gear
D. Improve survival of commercially valuable species
E. Enhance cultural exchanges regionally

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

Marine wildlife, including fish, mammals, and birds, as well as human health and safety, are affected by the action.

EDUCATION AND OUTREACH: RECOMMENDATION F5.

Title: Use source identification to target education

I. DESCRIPTION:

Development of a website that includes a GIS map of commercial fishing and aquaculture (map to be developed according to recommendation C3 from the Source Identification Working Group) would allow the education component to:

A. Identify the users of the web site
B. Identify 'dirty dozen' list of gear in your community
C. Identify species that are most impacted by derelict fishing gear
D. Identify closest disposal sites and proper methods of disposal plus local/national/international regulations of disposal and efforts/availability of recycling and reuse opportunities

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

Identify University/NGO who will oversee the project and create the web site

III. TYPE(S) OF ACTION:

Educational

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

Minimum Spatial Extent: Identified geographic regions which will be documented using GIS technology

V. WHO IMPLEMENTS ACTION?

The action should be implemented by a University or a NGO (e.g., in the U.S. this entity could be state Sea Grant Programs).

VI. WHAT IS COST OF ACTION (ESTIMATE)?

Cost has not been determined for website development
(For cost of GIS map see Recommendation C3 from the Source Identification working group)

VII. WHO FINANCES?

Financial responsibility for the website has not been determined.

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

The primary benefit from implementation is the information that will be gained which can be used in outreach and training campaigns.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

Affected resources have not been determined.

EDUCATION AND OUTREACH: RECOMMENDATION F6.

Title: Engage industry in the development of programs to ensure effectiveness

Authors: E. Araki, G. Arnold, C. Knapman, M. Minton, L. Nakagawa, and G. Salmonson

I. DESCRIPTION:

Work with fishing industry to develop an educational model that can be translated internationally and tailored to fit culturally to effect a positive behavioral change.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

A. Identify and work with fisheries associations and other stakeholders to develop guidelines and educational materials
B. Utilize existing programs to get the message out, if possible
C. Contact National Fisheries Institute - the Responsible Fisher's Society
D. Partners and contributors to the 2000 International Marine Debris Conference are responsible for taking recommendations to the next level for action and implementation within one year of this conference

III. TYPE(S) OF ACTION:

Educational, economic, administrative, and assessment

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?

Minimum Spatial Extent: Throughout the Pacific

V WHO IMPLEMENTS ACTION?

A. Non-government agencies
B. private sector
C. fishing industry
D. government
E. existing organizations and programs
F. IMO
G. FAO

VI. WHAT IS COST OF ACTION (ESTIMATE)?

One time (Start-up) Cost - $500,000 - $1,000,000 (for U.S. alone)
Annual Operation and Maintenance Cost – cost would be considerably lower to continue the program annually

VII.WHO FINANCES?

A. IMO
B. FAO
C. WorldBank
D. Manufacturers

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?

Educational materials developed with the input of the industry will be more effective resulting in the continued reduction and prevention of fishing gear loss. This will result in reduced environmental and economic impacts associated with derelict fishing gear.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:

All resources are affected by the action (e.g., benthic habitat, species of concerns, marine mammals, sea turtles, sea birds, vessel disablement, commercial species, impacts to tourism, etc.).

EDUCATION AND OUTREACH: RECOMMENDATION F7.

Title: Tailor education programs to regional circumstances and culture; use respected community leaders

I. DESCRIPTION:

When addressing derelict fishing gear issues, there is a need to be more objective. Solutions may vary depending on the local situation.

II. METHODS/STEPS FOR IMPLEMENTING ACTION:

Identify an umbrella organization/entity to house and promulgate information/community training. This organization will be responsible for identifying coastal fishing communities/regions and for providing program development and support.

Umbrella organization will develop at least one internationally recognized logo/symbol/slogan that encompasses derelict fishing gear issue (Remember to incorporate messages into appropriate language for each country).

Each community/region needs to identify the appropriate stakeholders to serve on oversight committee; a local spokesperson (facilitator) that will promote the local education program should be identified. The umbrella organization will ensure that the spokesperson (facilitator) receives adequate training.

Local oversight committee develops a campaign theme that is culturally specific/relevant/significant and determines what is going to pull people into the message.

Umbrella organization will develop educational campaign materials (visual, audio) based upon locally identified needs/themes.

The educational message will be designed to target industry, community and local government—(a three-tiered approach) using multiple educational marketing tools and strategies.

III. TYPE OF ACTION:
Educational

IV. WHERE SHOULD ACTION BE IMPLEMENTED (SPECIFY GENERAL GEOGRAPHIC AREAS)?
Minimum Spatial Extent: Identified fishing communities

V. WHO IMPLEMENTS ACTION:
An umbrella organization (such as marine debris information type of office [MDIO])implements the action.

VI. WHAT IS COST OF ACTION (ESTIMATE)?
One time (Start-up) Cost - $50,000 to $100,000
Annual Operation and Maintenance Cost – not determined

VII. WHO FINANCES?
Financial responsibility has not been determined.

VIII. WHAT ARE THE BENEFITS (ENVIRONMENTAL OR ECONOMIC) FROM IMPLEMENTATION?
The benefits from implementation include the reduction of derelict fishing gear in the sea and on the coast based upon effective community-specific outreach.

IX. IDENTIFY THE RESOURCES (LIVING OR PHYSICAL) AFFECTED BY ACTION:
Affected resources have not been determined.

SURVEY OF SUBMERGED MARINE DEBRIS:
A PERSISTENT AND ONGOING THREAT TO ENDANGERED HAWAIIAN MONK SEALS

Monitoring, Enforcement, And Removal

Raymond C. Boland[1,2]

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Entanglement in marine debris is a threat to the recovery of the critically endangered Hawaiian monk seal (Monachus schauinslandi). From 1996 to 1998, preliminary studies were conducted at French Frigate Shoals and at Pearl and Hermes Reefs in the Northwestern Hawaiian Islands to assess and remove marine debris. Divers towed from small boats conducted 7.5 km long line transect surveys of nine representative geographic stations to depths of 10 m and surveyed a total area of 1.2 km2. Debris was systematically documented using Global Positioning Systems, video and still photography and opportunistically removed. The density of derelict net and debris fragments encountered in a transect ranged from 0 to 23 nets ranging in size from 0.1 m2 to 30.0 m2. The highest encounter rates were on reefs exposed to prevailing wind and seas, and the lower rates on leeward reefs. Divers removed 3548 kg of nets. Derelict nets are known to entangle Hawaiian monk seals, fish, lobsters, coral heads, and cetaceans, but the rate of entanglement is extremely difficult to quantify. Entangled coral comprised approximately 20% of the total weight of the debris removed. The amount of dredged coral not retained by the nets is unknown. These preliminary surveys demonstrate that derelict nets represent a significant threat to Hawaiian monk seals due to entanglement and habitat degradation. Future work will address the rate of debris accumulation, facilitate efficient cleanup efforts of the nearshore reefs of the Northwestern Hawaiian Islands, identify the sources of the debris and initiate international programs to eliminate this pollution.

Chad Yoshinaga, courtesy of NMFS

CHARACTERISTICS OF DERELICT TRAWL NET AT TWO OCEANIC ISLANDS, ONE TROPICAL AND ONE SUBARCTIC

Monitoring, Enforcement, And Removal

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Derelict trawl net is an entanglement hazard to marine life. Lisianski Island (26 N, 174 W), in the Northwestern Hawaiian Islands, is one of the main breeding sites of the endangered Hawaiian monk seal (Monachus schauinslandi). St. Paul Island (57 N, 171 W), in the Pribilof Islands, is the largest breeding site of the depleted northern fur seal (Callorhinus ursinus). Both species suffer entanglement in derelict trawl nets, and trawl netting commonly washes up on the beaches of both islands. Extensive trawl fisheries occur in the Bering Sea and Gulf of Alaska providing a potential source for derelict fishing gear on St. Paul Island. No trawl fisheries occur in the region of the Hawaiian Islands. Here, we compare derelict trawl nets from the beaches of the two islands. Nets were recovered from Lisianski Island from 15–17 October 1999 and St. Paul Island 15–18 May 2000. Nets from the two islands were compared using four different characteristics: color, construction, eye size, and twine diameter. The characteristic of construction consisted of three sub-categories: manufacture of the net, twine twist, and number of strands in the twine. Of the forty nets sampled from St. Paul Island, 5 (12%) were identical to nets sampled at Lisianski Island. An additional twelve nets (30%) shared all but one characteristic. The remaining 23 nets (58%) had two or more characteristics that differed between islands. The comparison of net samples demonstrates that some derelict trawl net from both sites has similar characteristics and possibly similar sources.

DERELICT FISHING GEAR IN THE NORTHWESTERN HAWAIIAN ISLANDS: DIVING SURVEYS AND DEBRIS REMOVAL AT TWO ATOLLS CONFIRMS THREAT TO CORAL REEF ECOSYSTEMS

Monitoring, Enforcement, And Removal

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[3] National Oceanic and Atmospheric Administration Commissioners Corps

Marine debris of a maritime origin, particularly derelict fishing gear, threatens the coral reef ecosystems of the Northwestern Hawaiian Islands (NWHI). Derelict fishing gear entangles and kills endangered Hawaiian monk seals (Monachus shauinslandi), threatened green sea turtles (Chelonia mydas) and other wildlife, as well as damages coral substrate. We describe a multi-agency effort to survey and remove derelict fishing gear from two NWHI atolls in autumn 1999. Distribution, density, type, and epibiont encrustation of derelict fishing gear at Lisianski Island and Pearl and Hermes Reef was documented using snorkel divers towed behind small boats. Debris was recovered using small boats and divers supported by National Oceanic and Atmospheric Administration and United States Coast Guard vessels. A total of 8.4 metric tons of derelict fishing gear was recovered from the atolls' coral reefs and an additional 5.7 metric tons from the atolls' beaches. Coral reef debris density ranged from 1.0 to 62.2 pieces/km2. Trawl netting was the most frequent type of debris encountered (88%). Trawl netting also represented the greatest component of debris recovered by mass (35%), followed by monofilament gillnet (34%), and miscellaneous maritime line (23%). Most debris recovered (72%) had light or no epibiont encrustation, suggesting debris was resistant to fouling organisms or had short oceanic circulation histories. This study demonstrates that, despite widespread ratification of MARPOL Annex V, derelict fishing gear poses a persistent and lethal threat to the coral reef ecosystems of the Hawaiian Islands Archipelago.

NORTHWESTERN HAWAIIAN ISLANDS MARINE DEBRIS RECOVERY EFFORT

Monitoring, Enforcement, And Removal

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The Northwestern Hawaiian Islands include two significant National Wildlife Refuges (NWR) and one Hawai'i State wildlife sanctuary. The islands from Nihoa to Pearl and Hermes Reef comprise the Hawaiian Islands NWR, whereas Midway Atoll is managed as a separate NWR. For the past two and half years the U.S. Fish and Wildlife Service (USFWS) has joined in an effort with a number of other federal, state, and private organizations to remove marine debris from the coral reefs within these refuges as well as the state wildlife sanctuary Kure Atoll. This effort is now moving to a second phase of monitoring marine debris accumulation rates throughout the Northwestern Hawaiian Islands. Additionally, a ten year marine debris removal effort will continue at French Frigate Shoals wherein the USFWS field station collects marine debris from the beaches at Tern Island every two weeks. All of this work has removed over 35 tons of debris that would otherwise cause destruction of the reefs, and ultimate death of many other marine and avian creatures. An estimated 4,000 tons of marine debris still remain in the Northwestern Hawaiian Islands.

KAHUKU BEACH CLEAN UP

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FINDING SOLUTIONS TO MARINE DEBRIS IN THE ARAFURA SEA

Monitoring, Enforcement, And Removal

Ilse Kiessling[1], Rod Kennett[2], and Nanikiya Mununguritj[3]

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The Arafura Sea is an important commercial region with busy shipping routes and lucrative commercial fishing areas. Despite this, much of the region is sparsely populated and coastal areas remain largely untouched by development. Indigenous people own much of the vast coastline and utilize marine resources for food and cultural purposes. A variety of threatened marine species are dependent on a range of internationally recognized habitats in the region. These species, habitats, and people are increasingly suffering the impacts of marine debris. Marine debris in the Arafura Sea region is a cross-border concern both in terms of its impacts and sources: the majority of debris washing ashore in northern Australia is attributed to Southeast Asian fishing operations, while a significant proportion also originates from Australia's prawn (shrimp) trawling fleet. As a consequence, finding solutions to marine debris in the Arafura Sea is both challenging and complex. This poster details three principal aspects to marine debris issues in the Arafura Sea region—cultural considerations, ecological impacts, and regional issues. It introduces a framework of action embracing activities at local, national, regional, and international scales. Actions include research, fieldwork, and policy initiatives, some of which are currently underway. Many initiatives now under development offer opportunities for international collaboration to address marine debris in the Arafura Sea, and links with international activities and agencies are sought.

ABUNDANCE OF PLASTIC DEBRIS AND INGESTION BY ALBATROSS ON KURE ATOLL, NORTHWESTERN HAWAIIAN ISLAND

Monitoring, Enforcement, And Removal

Irene T. Kinan[1] and Kathy L. Cousins[2]
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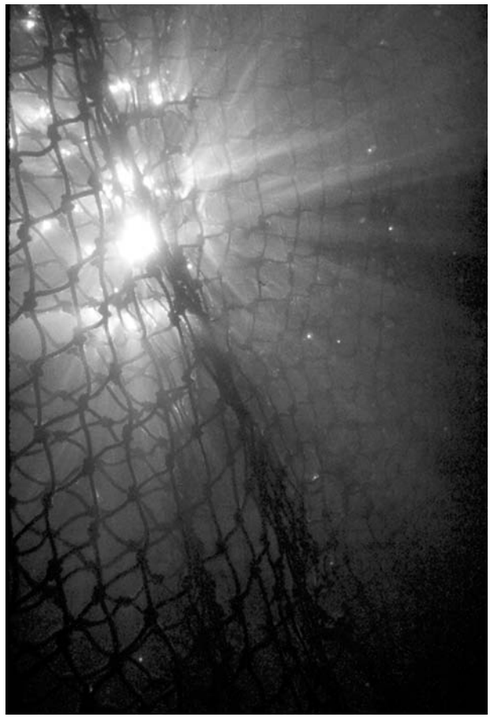
A pilot study to investigate the abundance of disposable cigarette lighters and Cyalume chemical lightsticks with the incidence of ingestion by albatross was conducted at Kure Atoll, Northwestern Hawaiian Islands. A total of 857 cigarette lighters and 200 lightsticks were collected opportunistically between 25 May and 23 July 1999. To examine occurrence of plastics ingested by black-footed albatross (Phoebastria nigripes) and Laysan albatross (P. immutabilis), 43 samples were collected consisting of boluses (regurgitations) and chick carcasses. Plastics occurred in 100% of samples, disposable cigarette lighters occurred in 30% of Laysan albatross samples (n = 26), and no lightsticks were recovered. Items found in Laysan albatross samples included: squid beaks; plastic pieces and chips of various sizes; resin pellets; plastic caps, tubing, bags and toys; disposable cigarette lighters; toothbrushes; fishing floats; Styrofoam; pumice stones; walnuts; and neoprene material. Black-footed albatross boluses (n = 17) consisted mainly of squid beaks and monofilament nylon line. A correlation may exist between availability of plastics in a region and seabirds in the community that ingest plastics. To quantify abundance of items in beach debris at Kure Atoll we recommend continued collection of cigarette lighters and Cyalume lightsticks. In terms of conservation, to investigate negative impacts of ingested plastics on reproductive success of albatross, future bolus collections and necropsies of deceased chicks is necessary.



Ray Boland courtesy of NMFS

FORAGING EFFORT RESPONSES OF NORTHERN FUR SEALS TO ENTANGLEMENT IN DERELICT FISHING GEAR FRAGEMENTS

Monitoring, Enforcement, And Removal

Brent S. Stewart[1,2] and John Bengtson[3]

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Increases in the rate of entanglement of northern fur seals (Callorhinus ursinus) at the Pribilof Islands in the Bering Sea in the 1970s and 1980s correlated with a substantial decline in the fur seal population. To evaluate the effects of small pieces of entangling net on the foraging success of fur seals we compared the foraging patterns of young northern fur seal males that were and were not naturally encumbered with net fragments using small data recorders glued to the seals' dorsal pelage. All seals departed the hauling grounds within five days of tagging. One entangled seal was not seen again. The two others were at sea abut twice as long as the non-entangled seals. All seals dove more often and shallower at night (2330 to 0700 h) than during the day. Entangled and non-entangled seals dove at similar rates ($p > 0.95$). However, the dives of the entangled males were always shallower than those of the non-entangled males. At similar depths, dives of entangled seals were shorter than those of the non-entangled seals. These data suggest that small pieces of entangling net may affect foraging efficiency. But it is unclear whether these differences are great enough to compromise the seals' health and survival. Nonetheless, determining these effects is important for prioritizing research and management responses to concerns about the impacts of derelict fishing gear on these and other marine fauna.

ASSESSING THE RISKS OF REEF-HUNG DERELICT FISHING GEAR ON HAWAIIAN MONK SEALS: MATCHING FORAGING HABITAT WITH DEBRIS DISTRIBUTION IN THE NORTHWESTERN HAWAIIAN ISLANDS

Monitoring, Enforcement, And Removal

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The Hawaiian monk seal (Monachus schauinslandi) is endemic to the Hawaiian Islands. Its metapopulation declined steadily from the 1950s through the early-1990s, but has been relatively stable at around 1,300 to 1,400 since 1993. Poor juvenile survival appears to be the proximate cause of the long-term decline though the ultimate cause is uncertain. One known factor contributing to mortality is entanglement in derelict commercial fishing gear, evidently originating from high seas and remote commercial fisheries. We compared the foraging patterns of monk seals at Pearl and Hermes Reef, using satellite-linked transmitters, with the distribution of derelict fishing gear to assess debris threats to monk seal vitality and to guide management and conservation measures. Monk seals segregated by age and sex while foraging within the atoll at Pearl and Hermes Reef. The key areas used by juveniles were those in the interior eastern end of the atoll, areas of heavy pollution by derelict fishing gear. The removal of such debris may be key to the recovery of this endangered species, particularly in those areas which can be identified as foraging and transit areas for pups and juveniles who are most vulnerable to entanglement. Moreover, more effective prevention and monitoring of loss and dumping of this debris in remote commercial fisheries is key to range-wide conservation and management of monk seals and other biological resources in the Hawaiian Islands marine ecosystem.

GET THE DRIFT AND BAG IT!

Ocean Stewardship, Education, and Outreach

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Experts with the University of Hawai'i Sea Grant college program say about 80% of trash found on Hawai'i beaches comes from land sources. When trash litters Hawai'i beaches, chokes mountain streams, and pollutes coastal waters, it becomes the scourge known as marine debris, a man-made menace that endangers fish and wildlife, smothers coral reefs, and generally wreaks havoc on Hawai'i's fragile ecosystems. Each year, Hawai'i Sea Grant partners with the Hawai'i Coastal Zone Management program to coordinate the cleanup of coastlines, streams, and waterways throughout the islands in its "Get The Drift and Bag It!" program—Hawai'i's contribution to the International Coastal Cleanup effort sponsored by the Center for Marine Conservation. Sea Grant has participated in "Get The Drift and Bag It!" since 1988 and took over its statewide coordination in 1995. Since then, volunteers from the main Hawaiian islands have been collecting cleanup data, which help in the identification of site-specific debris problems, providing essential information as to the scope and locations of marine debris impacting Hawai'i's marine and coastal environment. Last year, 4,279 Hawai'i volunteers walked 153 miles and picked up 216,598 pounds of debris on land and underwater. Offending debris included: cigarette butts, bits of plastic, glass, paper and styrofoam, plastic bags, metal bottle caps, bottles, and soda cans. This year's statewide "Get The Drift and Bag It!" is scheduled for Saturday, September 16.

ABANDONED FISHING GEAR REMOVAL EXERCISES IN HONG KONG'S MARINE PARKS

CHOW Wing-kuen Agriculture, Fisheries and Conservation Department, The Government of the Hong Kong Special Administrative Region,
Marine Parks Division
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The territory of Hong Kong has a rich collection of aquatic animals and plants, such as corals, sea grasses, and dolphins. In order to protect and conserve the marine environment, the Marine Parks Ordinance was enacted in 1995. It provides the legal framework for the designation, control, and management of marine parks and marine reserves. In 1996, three marine parks and one marine reserve were designated in Hong Kong. They comprise scenic coastal areas, seascapes, and important marine habitats. They are Hoi Ha Wan Marine Park, Yan Chau Tong Marine Park, Sha Chau and Lung Kwu Chau Marine Park and Cape D'Aguilar Marine Reserve, covering a total area of 2,160 hectares. Marine parks and reserves are managed for conservation, education, recreation, and scientific studies. In marine parks, visitors are encouraged to appreciate the beauty and diversity of marine life. Diving, snorkeling, swimming, canoeing, sailing, underwater photography, and school

visits are popular activities in marine parks. Destructive fishing activities such as trawling and dynamite fishing are prohibited whereas non-destructive fishing by bona fide fishermen and local villagers is controlled in marine parks through a permit system. To improve the environment of marine parks, the department has organized several abandoned fishing gear removal exercises since 1995 with voluntary divers, students, local villagers and fishermen from a number of organizations. Some of them were carried out on the International Coastal Cleanup Day and the Earth Day. In addition, seminars and code of good fishing practice are given to the fishermen in marine parks with a view to increasing their understanding of the adverse effects of abandoned fishing.

KUKULU KE EA A KANALOA:
RESTORING KAHO'OLAWE

The Kaho'olawe Island Reserve Commission, State of Hawai'i
33 S. King Street, #501
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Kaho'olawe is Hawai'i's eighth island. The 45 square mile island and 90 square miles of surrounding ocean comprise the Kaho'olawe Island Reserve. The Reserve is undergoing a physical and spiritual transformation: no longer a U.S. Navy bombing target and now becoming a refuge for Native Hawaiian cultural, spiritual, and subsistence purposes. In ancient times the island was called Kanaloa for the god of the ocean. It was a place for training navigators and kahuna and served as a point of departure for long ocean voyages. A number of major currents between the islands converge around Kaho'olawe. One interpretation of the name Kaho'olawe is to be carried by currents. There are a number of historical accounts of people surviving shipwrecks between islands and making their way to Kaho'olawe and several dead whales have drifted to its shores over the past few decades. There is a lot of marine debris on the bays and beaches of Kaho'olawe's northern and eastern coasts with the greatest amount at Kanapou Bay. There has been limited public access to the island since the start of World War II. The Navy allowed community beach cleanups in the past, but the practice has been prohibited since 1994. As the Navy completes its bomb cleanup of the island and relinquishes access control, the Kaho'olawe Island Reserve Commission, which manages the Reserve, hopes to assist in regular beach cleanups and surveys.

ELECTRALUME:
THE NEXT GENERATION OF FISHING LIGHTS

Electralume is a new battery-driven lightstick developed to reduce marine pollution. This new lightstick is negatively buoyant and reusable. Made from a durable clear U/V treated polycarbonate, the Electralume is easily attached to monofilament line with a snap attachment and uses standard AA batteries. Electralume easily replaces disposable plastic lightsticks in fishing operations and makes good economic sense. One set of batteries can last for over 30 sets. This means that longline fishermen will not have to change the batteries until they reach dockside.

Peter Lindgren
Lindgren-Pitman, Inc
2615 NE 5th Avenue,
Pompano Beach, FL 33064
(954) 943-4243,
<longline@gate.net>

PACIFIC WHALE FOUNDATION, MAUI, HAWAI'I

Pacific Whale Foundation has a long and proud history of identifying the problem of marine debris in Hawai'i, and being proactive in the search for solutions to cleaning it up. Our organization helped pioneer the 'Get the Drift and Bag It' statewide marine debris clean-up, including Kaunapo Bay on the island of Kaho'olawe. Pacific Whale Foundation identified Kaho'olawe as an important site because, as an uninhabited island, all the debris items collected there are truly marine generated. Our student marine survey addresses the source, quantity, and quality of marine debris found in Maui's beaches, giving kids a chance to participate in the scientific process for the betterment of their world.

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MARINE DEBRIS IN THE NORTH PACIFIC CENTRAL GYRE, 1999 WITH THE FIRST BIOMASS COMPARISON OF NEUSTONIC PLASTIC AND PLANKTON

Other

Charles Moore[1], S. L. Moore[2], M. K. Leecaster[2], and S. B. Weisberg[2]

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Plastics in the ocean persist long after the objects of which they were a part break down. Studies in the North Pacific indicate that both large floating (macro) plastic and smaller (neuston) fragments are increasing, however, no studies exist to assess the potential effects of plastic particles on filter feeding marine organisms. To assess the potential effects of ocean plastics on filter feeding biota, plankton nets sampling the top six inches of ocean surface were towed at eleven randomly selected locations in the North Pacific Central Gyre during August, 1999. The collected samples were separated into plastic and plankton fractions, then weighed and counted to compare the mass and number of plastic particles to plankton. Plankton was sorted by class, and plastic particles by size class and color. While towing for plankton, large floating (macro) debris was collected with an inflatable dinghy. Our survey resulted in the highest mean weight (5,114 g/km2) and abundance (334,271 pieces/km2) of neuston plastic ever calculated for this area. The mass of plastic particles was six times higher than the mass of plankton (841 g/km2), while the total number of planktonic organisms (1,837,342 /km2) was five times the number of plastic pieces. Numbers of particles did not increase in successively smaller size classes, indicating there may be non-selective removal by mucus web-feeding biota, and indeed, salps with poly line and plastic fragments firmly embedded in their tissue were collected. Neuston plastic types in order of abundance were: miscellaneous fragments, thin films, woven poly/monofilament line, styrofoam, and pellets.

Mark Sramek (NOAA), courtesy of NMFS

STUDENT ACTIVITIES

Students from seven different islands in the South Pacific, Hawai'i, and Alaska attended the International Marine Debris Conference to share their concerns about the coastal and marine environment. Coordinated by Patty Miller, Hawai'i science teacher and education committee chair for the Hawaiian Islands Humpback Whale National Marine Sanctuary, the "Trash Busters" were chosen to participate based on their motivation and interest in preserving a clean marine environment. They contributed their perspectives on marine debris issues in Hawai'i, Palau, Rota, American Samoa, Commonwealth of the Northern Mariana Islands, Papua New Guinea, Majuro, Marshall Islands, and St. Paul Island, Alaska.

The student's participation took many forms. The day before the conference, the students cleaned up trash from a site adjacent to Lagoon Drive near the Honolulu Airport. They used the debris, consisting of plastic, rope and netting, to construct a conceptual art piece for display in the conference exhibit room. For their first oral presentation the students premiered a video which they had developed prior to the Conference. The video portrayed student's concerns about the detrimental effects of derelict fishing nets, plastics and rope on the marine environment. After airing the video, each student posed a set of questions to the experts in attendance. Examples of questions asked included:

- "How can we encourage people to protect the environment?"
- "Why aren't manufacturers making biodegradable plastics?"
- "Can't we figure out where the marine debris is coming from?"
- "How do we monitor marine debris dumping?"

Bob Rock, Marine Debris Communications Committee

The "Trashbusters" gather at the International Marine Debris Conference.

STUDENT ACTIVITIES

Bob Rock, Marine Debris Communications Committee

This marine debris sculpture designed by the "Trashbusters", demonstrates an artful way of cleaning up the ocean.

After listening to the experts present their work to the conference participants during the week, the students compiled a list of their own recommendations on how to reduce derelict fishing gear and marine debris. For their final appearance before the audience, the students arrived colorfully dressed as their favorite sea creatures, and reacted as they imagined that the creatures would to chemicals, nets, oil, plastics, and other debris entering their habitat. As creatures of the sea, they described their main functions, and explained how debris affected their lives. Lastly, they shared their views on how to begin to solve this complex issue. Examples of the recommendations given include:

- "Add more trash cans which are convenient for people, and where they will not wash away."
- "Schools should fund programs for beach cleanup, where the students would be given class credit. Also, schools could start an "adopt a beach" program, where they are each responsible for maintaining a certain section."
- "Since many small islands do not have recycling programs in place, attempt to obtain the funds to begin the program. In addition, teach the islanders to recycle and make better choices on which products they decide to use."
- "For reducing problems associated with oil spills, put oil in separate smaller containers to minimize the problem if a puncture does occur."
- "Force the companies who run the oil rigs to pay for the cleanup, as well as the fine for spills."
- "To reduce coral destruction, monitor the vessels that are known to transport toxins and chemicals to reduce illegal dumping."
- "Develop environmentally safe chemicals to use in golf courses and agricultural fields to reduce damage to coral reefs from runoff."
- "Learn how to identify fishing nets which injure marine animals, and require fishing boats to use animal safe fishing gear."
- "Outline public education programs to "reduce, reuse and recycle" and, especially, get the children involved at an early age."

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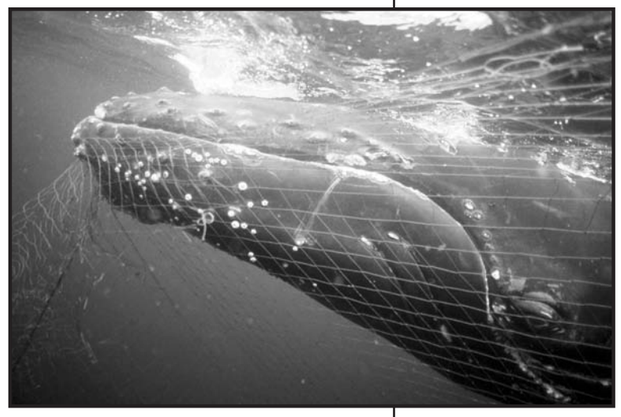

B. & C. Alexander/Seapics.com
Chad Yoshinaga,
courtesy of NMFS

EXHIBITORS

ORGANIZATION/COMPANY
• Center for Marine Conservation
• City and County of Honolulu
• Community Workday Program
• F.I.T. Fishing Tools
• NOAA Hawaiian Island Humpback Whale National Marine Sanctuary
• NOAA Hawaiian Islands Humpback Whale National Marine Sanctuary Advisory Council
• NOAA Public Affairs
• NOAA National Marine Fisheries Service, Southwest Fisheries Science Center – Honolulu Laboratory
• NOAA National Weather Service
• Science and Technology International
• State of Hawaii – Division of Aquatic Resources, Department of Land and Natural Resources and Coastal Zone Management Program
• Trash Busters – Kids Program
• U.S. Coast Guard
• U.S. Environmental Protection Agency, Region 9
• U.S. Fish and Wildlife Service – Pacific Region
• U.S. Navy
• Western Pacific Regional Fishery Management Council

International Marine Debris Conference
On Derelict Fishing Gear and the Ocean Environment
August 6 – 11, 2000

CONFERENCE PROGRAM

SUNDAY, AUGUST 6

2:00-6:00 PM EARLY CONFERENCE REGISTRATION Room 317A

MONDAY, AUGUST 7

7:30 AM CONFERENCE REGISTRATION Room 317A

8:30 CONFERENCE CONVENES Room 313

- Welcome
  Allen Tom, Sanctuary Manager, Hawaiian Island Humpback Whale National Marine Sanctuary, Hawai'i
  Kitty M. Simonds, Executive Director, Western Pacific Regional Fishery Management Council, Hawai'i

- Opening Remarks
  Honorable Jeremy Harris, Mayor, City and County of Honolulu, Hawai'i
  Jim Cook, Chairman, Western Pacific Fishery Management Council, Hawai'i

- Review of Past Marine Debris Workshops
  James M. Coe, Acting Science and Research Director, National Marine Fisheries Service, Alaska Fisheries Science Center, Washington

THE SCOPE OF THE DERELICT FISHING GEAR PROBLEM

- Origins, Types, Distribution and Magnitude of Derelict Fishing Gear
  CDR Rusty E. Brainard, Ph.D., Science Program Coordinator and Oceanographer, National Marine Fisheries Service and NOAA Corps, Hawai'i

DISCUSSION

10:15 BREAK

10:35
- The Ecological Impacts of Derelict Gear
  Charles W. Fowler, Ph.D., Program Leader for the Systemic Management Studies Program, National Marine Fisheries Service, Alaska Fisheries Science Center, National Marine Mammal Laboratory, Washington

- The Economic Costs of Derelict Gear
  Samuel G. Pooley, Ph.D., Chief, Fishery Management and Performance Investigation, National Marine Fisheries Service, Hawai'i

- Navigational Hazards and Public Safety

Bob Rock, Marine Debris Communications Committee

Allen Tom, Manager of the Hawaiian Islands Humpback Whale National Marine Sanctuary, extends aloha to Conference participants.

CONFERENCE PROGRAM

LT Lane D. Johnson, Port Operations, Waterways Management, Marine Response/Prevention, United States Coast Guard, 14th District, Hawai'i

DISCUSSION

12:00 PM LUNCH AND KEYNOTE ADDRESS:

- Society's Role and Obligations as Stewards of the Ocean Environment
  Honorable Daniel K. Inouye, United States Senator, Hawai'i

1:30 • Student Views of the Marine Debris Problem

CURRENT EFFORTS TO ADDRESS DERELICT FISHING GEAR

- International and Domestic Initiatives: Implementation, Enforcement, and Compliance (MARPOL Annex V)
  CDR Paula S. Carroll, Chief, Marine Response Branch, United States Coast Guard, 14th District, Hawai'i

- Removal/Mitigation Efforts
  Mary Donohue, Ph.D., Marine Debris Coordinator, Joint Institute for Marine and Atmospheric Research and National Marine Fisheries Service, Hawai'i

DISCUSSION

3:10 BREAK

3:30 • Monitoring and Data Collection Activities
  W. James Ingraham, Jr., Oceanographer, NOAA/National Marine Fisheries Service, Alaska Fisheries Science Center, Washington
  Charles G. Barr, Program Manager, Center for Marine Conservation, Washington, D.C.

- Technological Advancements
  RDML Larry C. Baucom, United States Navy Director, Environmental Protection, Safety and Occupational Health Division, Office of the Chief of Naval Operations, United States Navy, Virginia
  Anthony L. Andrady, Ph.D., Program Manager and Senior Research Scientist, Research Triangle Institute, North Carolina

DISCUSSION

5:00 ADJOURN

TUESDAY, AUGUST 8

7:30 AM CONFERENCE REGISTRATION Room 317A

CONFERENCE PROGRAM

International Marine Debris Conference
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CONFERENCE PROGRAM

8:00 CALL TO ORDER Room 313

- Welcoming Remarks
  Honorable Daniel K. Akaka, United States Senator, Hawai'i (via video)

CURRENT EFFORTS TO ADDRESS DERELICT FISHING GEAR

- Industry Actions/Considerations
  Dayton "Lee" Alverson, Ph.D., Chairman of the Board, Natural Resources Consultants, Washington

- Education/Outreach
  Seba B. Sheavly, Director, Marine Debris Prevention Program, Center for Marine Conservation, Virginia
  MCPO Linda Reid, Director, Sea Partners Campaign, United States Coast Guard, Washington, D.C.

- Cooperative Partnerships
  Gary Dunlin, Gear Technologist, Seafish Authority, United Kingdom
  CAPT Terry Rice, Chief, Marine Safety Division, United States Coast Guard, 14th District, Hawai'i
  George "Bud" Antonelis, Ph.D., Chief, Protected Species Investigation, National Marine Fisheries Service, Hawai'i

DISCUSSION

- Planning As Ocean Stewards
  Daniel J. Basta, Acting Director, NOAA/National Ocean Services, Marine Sanctuaries Program, Maryland

10:00 BREAK

10:15 WORKING GROUP PANEL PRESENTATIONS

- Group A: Prevention and Legal Issues Rooms 316A and 316B/C
  Chairs:
  James M. Coe, Acting Science and Research Director, National Marine Fisheries Service, Alaska Fisheries Science Center, Washington
  CDR Paula S. Carroll, Chief, Marine Response Branch, United States Coast Guard, 14th District, Hawai'i
  Panelists:
  Margaret Cummisky, Senior Legislative Assistant, Office of Senator Daniel K. Inouye, Washington, D.C.
  Anamarija Frankic, Ph.D., Environmental Consultant, Global Environment Facility, The World Bank, Virginia
  Michael Julian, Chairman, Marine Environment Protection Committee, International Maritime Organization and Executive Manager, International Relations, Australian Maritime Safety Authority, Australia

Holly R. Koehler, Foreign Affairs Officer, Office of Marine Conservation, Bureau of Oceans and International Environmental and Scientific Affairs, United States Department of State, Washington, D.C.
CDR John W. Koster, , United States Coast Guard, 11th District, California
Brent S. Stewart, Ph.D., Senior Research Biologist, Hubbs-Sea World Research Institute, California and Marine Science and Foreign Affairs Officer Diplomacy Fellow, American Association for the Advancement of Science, Office of Marine Conservation, Bureau of Oceans and International Environmental and Scientific Affairs, United States Department of State, Washington, D.C.

- Group B: Reducing Impacts of Gear Rooms 314 and 315
  Chair:
  H. Arnold Carr, Senior Marine Fisheries Biologist, Massachusetts Division of Marine Fisheries, Massachusetts
  Panelists:
  Gerald Brothers, Coordinator-Conservation Technology, Fisheries Management Branch, Department of Fisheries and Oceans, Canada
  Gary Dunlin, Gear Technologist, Seafish Authority, United Kingdom
  Murray R. Gregory, Ph.D., Professor, Department of Geology, The University of Auckland, New Zealand
  Jim Ludwig, Ph.D., Certified Senior Ecologist ESA and President, The Sere Group, Ltd., Canada
  James Maragos, Ph.D., Coral Reef Biologist, U.S. Fish and Wildlife Service, Hawai'i

- Group C: Source Identification Rooms 301 and 312
  Chair:
  John R. Henderson, Fishery Biologist, Marine Mammal Research Program, National Marine Fisheries Service, Hawai'i
  Panelists:
  Al Burch, Executive Director, Alaska Draggers Association, Alaska
  Dave Foley, Coordinator, NOAA Coastwatch/JIMAR, Hawai'i
  David King, Fishing Gear Specialist, National Marine Fisheries Service, Alaska Fisheries Science Center, Washington
  Rick Steiner, Conservation Specialist, University of Alaska Marine Advisory Program, Alaska

12:00 PM LUNCH ON YOUR OWN

1:30 WORKING GROUP DISCUSSION

- Group A: Prevention and Legal Issues Rooms 316A and 316B/C
- Group B: Reducing Impacts of Gear Rooms 314 and 315
- Group C: Source Identification Rooms 301 and 312

5:30 ADJOURN

6:00 GOVERNOR'S RECEPTION One Washington Place

International Marine Debris Conference
On Derelict Fishing Gear and the Ocean Environment
August 6 – 11, 2000

CONFERENCE PROGRAM

- Remarks
  D. James Baker, Ph.D., Under Secretary, United States Department of Commerce, Washington, D.C.
  Honorable Eni F. H. Faleomavaega, Representative, United States Congress, American Samoa
  Timothy Johns, Chairman, Department of Land and Natural Resources, Hawai'i

WEDNESDAY, AUGUST 9

8:30 AM SPECIAL SESSION

- Viewpoint of the Administration
  D. James Baker, Ph.D., Under Secretary, United States Department of Commerce, Washington, D.C.

10:00 WORKING GROUP PANEL PRESENTATIONS AND DISCUSSION

- Group D: Industry Room 315
  Chair:
  Dayton "Lee" Alverson, Ph.D., Chairman of the Board, Natural Resources Consultants, Washington
  Panelists:
  Jim Cook, Chairman, Western Pacific Fishery Management Council, Hawai'i
  Steven H. Hendrickson, General Manager, Recycling Division/Partner, Skagit River Steel and Recycling, Washington
  Peter Leipzig, Executive Director, Fisherman's Marketing Association, California
  Brent Paine, Executive Director, United Catcher Boats, Washington
  Robert Zuanich, Executive Director, Purse Seine Owners Association, Washington

- Group E: Monitoring and Removal Rooms 316A and 316B
  Chair:
  Mary Donohue, Ph.D., Marine Debris Coordinator, Joint Institute for Marine and Atmospheric Research and National Marine Fisheries Service, Hawai'i
  Panelists:
  CDR Rusty E. Brainard, Ph.D., Science Program Coordinator and Oceanographer, National Marine Fisheries Service and NOAA Corps, Hawai'i
  Ilse Kiessling, Ph.D., Natural Resource Policy Manager, World Wide Fund for Nature, Tropical Wetlands of Oceania Program, Australia
  Tatsuro Matsuoka, Professor, Faculty of Fisheries, Kagoshima University, Japan
  Daniel Torres N., Professor, Instituto Antartico Chileno, Chile
  Nina Young, Director, Marine Wildlife Conservation, Center for Marine Conservation, Washington, D.C.

CONFERENCE PROGRAM

- Group F: Education and Outreach Rooms 301, 312 and 314
  Chair:
  Emily Morgan, Director, Citizen Outreach and Monitoring Center for Marine Conservation, Washington, DC,.
  Panelists:
  Gael Arnold, Director, Island Care New Zealand Trust, New Zealand
  Hung-Chi Liao, Director, Kuroshio Ocean Education Foundation, Taiwan
  MCPO Linda J. Reid, Director, Sea Partners Campaign, United States Coast Guard, Washington, D.C.
  Seba B. Sheavly, Director, Marine Debris Prevention Campaign, Center for Marine Conservation, Virginia
  John Wang, Scientific and Conservation Advisor, Kuroshio Ocean Education Foundation, Taiwan
  Christine Woolaway, University of Hawai'i, Sea Grant Extension Service, Hawai'i

12:00 PM LUNCH AND PANEL:

- Bridging the Policy, Science and Management Stream
  Honorable Neil Abercrombie, Representative, United States Congress, Hawai'i
  Rebecca Lent, Ph.D., Southwest Regional Administrator, National Marine Fisheries Service, California
  Roger Rufe, President, Center for Marine Conservation, Washington, D.C.
  Michael Julian, Chairman, Marine Environment Protection Committee, International Maritime Organization and Executive Manager, International Relations, Australian Maritime Safety Authority, Australia

1:30 WORKING GROUP DISCUSSION (continued)

- Group D: Industry Room 315
- Group E: Monitoring and Removal Rooms 316A and 316B
- Group F: Education and Outreach Rooms 301, 312 and 314

4:00-7:00 POSTER AND EXHIBITOR RECEPTION Room 311

THURSDAY, AUGUST 10

8:30 AM CALL TO ORDER Room 313

- Reports on Working Group Recommendations
- Report on Student Recommendations

10:15 BREAK

10:30 • Working Group Discussion

CONFERENCE PROGRAM

International Marine Debris Conference
On Derelict Fishing Gear and the Ocean Environment
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CONFERENCE PROGRAM

12:00 PM LUNCH ON YOUR OWN

1:30 • Recommendation Teams

3:00 BREAK

3:15 • Recommendation Teams (continued)

5:00 ADJOURN

6:30-10:00 LU'AU Bishop Museum

FRIDAY, AUGUST 11

8:30 AM CALL TO ORDER

- Keynote Address
  Jean Michel Cousteau, President, Ocean Futures Society, California

- Poster Unveiling
  Jean Michel Cousteau and **Robert Lyn Nelson**

- Reports on Recommended Actions

DISCUSSION

10:00 AM BREAK

- A Challenge for the Future: Taking Action Against Marine Debris
  Daniel J. Basta, Acting Director, NOAA/National Ocean Services, Marine Sanctuaries Program, Maryland

- Conference Resolution

- Comments from Participants

- Closing Remarks
  'Akau'ola, Secretary, Ministry of Fisheries, Kingdom of Tonga

- Closing Ceremony

1:00 PM CONFERENCE ADJOURNS

CONFERENCE PROGRAM

AFPI	American Flag Pacific Islands
AFSC	Alaska Fisheries Science Center, National Marine Fisheries Service
AMRF	Algalita Marine Research Foundation
APHIS	Animal and Plant Health Inspection Service
APPS	Act to Prevent Pollution from Ships
ASTER	Advanced Spaceborne Thermal Emissions and Reflection Radiometer
AVIRIS	Airborne Visible InfraRed Imaging Spectrometer
C&C	City and County of Honolulu
CARA	Conservation and Reinvestment Act
CBD	Convention on Biological Diversity
CCAMLR	Convention for the Conservation of Antarctic Marine Living Resources of 1980
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CEE	Center for Marine Environmental Education
CIMCO	Convention on the Intergovernmental Maritime Organization
CITES	Council on International Trade and Endangered Species
CMC	Center for Marine Conservation
the Conference	International Marine Debris Conference on Derelict Fishing Gear
CRAMP	Coral Reef Assessment and Monitoring Program
CRE	Coral Reef Ecosystem
CWT	Coded Wire Tag
CZM	Coastal Zone Management Program, Hawai'i
CZMA	Coastal Zone Management Act
DAR	Division of Aquatic Resources, Department of Land and Natural Resources, Hawai'i
DLNR	Department of Land and Natural Resources, Hawai'i
DOC	Department of Commerce
DOD	Department of Defense
DOI	Department of the Interior
DOJ	Department of Justice
DOS	Department of State
DOT	Department of Transportation
EOS	Earth Observing System
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FAD	Fish Aggregation Device
FAO	Food and Agriculture Organization of the United Nations
FDA	United States Food and Drug Administration
FFS	French Frigate Shoals, Northwestern Hawaiian Islands
GIS	Geographic Information Systems
HAPC	Habitat Areas of Particular Concern
HAS	Hawai'i Audubon Society
HCRI	Hawai'i Coral Reef Initiative Research Program
HCZMP	Hawai'i Coastal Zone Management Program
HLA	Hawai'i Longline Association
HOMRC	Hawai'i Ocean and Marine Resources Council
IATTC	Inter-American Tropical Tuna Convention
ICC	International Coastal Cleanup
ICRI	International Coral Reef Initiative
IFQ	Individual Fishing Quotas
IMO	International Maritime Organization
IPOA	International Plan of Action
IOTC	Indian Ocean Tuna Commission
IUCN	International Union for Conservation of Nature and Natural Resources
FIMD	Fate and Impact on Marine Debris
JIMAR	Joint Institute for Marine and Atmospheric Research
KIRC	Kaho'olawe Island Reserve Commission
MARPOL	International Convention for the Prevention of Pollution from Ships
MDIO	Marine Debris Information Office

MEPC	Marine Environmental Protection Committee of IMO
MERP	Marine Entanglement Program
MHI	Main Hawaiian Islands
MHLC	Multi-Lateral High Level Convention
MMC	Marine Mammal Commission
MMPA	Marine Mammal Protection Act
MPA	Marine Protected Area
MPPRCA	Marine Plastics Pollution Research and Control Act
MSFMCA	Magnuson-Stevens Fisheries Conservation and Management Act
MUS	Management Unit Species
NASA	National Aeronautic and Space Administration
NEPA	National Environmental Policy Act
NFI	National Fisheries Institute
NGO	Non-Governmental Organization
nm	nautical miles
NSF	National Science Foundation
NMDMP	National Marine Debris Monitoring Program
NMFS	National Marine Fisheries Service
NMFS-HL	National Marine Fisheries Service - Honolulu Laboratory
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NPDES	National Pollution Discharge Elimination System
NWHI	Northwestern Hawaiian Islands
NWR	National Wildlife Refuge
OEQC	Office of Environmental Quality Control, State of Hawai'i
Pac-Rim	Pacific Rim
PBDC	Pacific Basin Development Council
PFMC	Pacific Regional Fishery Management Council
PFMFC	Pacific States Marine Fisheries Commission
PIAO	Pacific Islands Area Office
PRIA	Pacific Remote Island Areas
PSCO	Port State Control Officer
RCRA	Resource Conservation and Recovery Act
RFO	Regional Fisheries Management Organizations
RFS	Responsible Fisheries Society
ROV	Remotely Operated Vehicles
the Sanctuary	Hawaiian Islands Humpback Whale National Marine Sanctuary
SAC	Sanctuary Advisory Council
SAR	Synthetic Aperture Radar
SEAFDEC	Southeast Asian Fisheries Development Center
SFA	Sustainable Fisheries Act
S-K funds	Saltonstall-Kennedy funds
SPC	Secretariat of the Pacific Community
SPREP	South Pacific Regional Environment Programme
SST	Sea Surface Temperature
HL	Southwest Fisheries Science Center, Honolulu Laboratory
UH	University of Hawai'i
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
USFWS	United States Fish and Wildlife Service
USCG	United States Coast Guard
USCRI	United States Coral Reef Initiative
USPI	United States Pacific Islands
USSD	United States State Department
UV	Ultra Violet
VMS	Vessel Monitoring System
WpacFin	Western Pacific Fisheries Information Network
WPRFMC	Western Pacific Regional Fishery Management Council
WWF	World Wide Fund for Nature

LEGAL INSTRUMENTS FOR THE PREVENTION AND MANAGEMENT OF DISPOSAL AND LOSS OF FISHING GEAR AT SEA

Holly R. Koehler, Office of Marine Conservation, Bureau of Oceans, Environment and Science, U.S. State Department, Washington, D.C.

Brent S. Stewart, Office of Marine Conservation, Bureau of Oceans, Environment and Science, U.S. State Department, Washington, D.C.

and

Hubbs-Sea World Research Institute, 2595 Ingraham Street, San Diego, California

Paula S. Carroll, U.S. Coast Guard, Marine Safety Division, Marine Response Branch, Honolulu, Hawai'i

Terry Rice, U.S. Coast Guard, Marine Safety Division, Honolulu, Hawai'i

1.0. INTRODUCTION

In the early-1980s, concern heightened over the impacts of persistent garbage and debris in the world's oceans on marine flora and fauna and on various human activities. Subsequently, three international conferences and workshops were convened (1984, 1989, 1994) to define the scope and magnitude of the marine debris issue (Shomura and Yoshida, 1984; Shomura and Godfrey, 1990; Coe and Rogers, 1997) and to consider appropriate monitoring, educational, and regulatory responses. A major theme of another international symposium on ocean disposal in 1986 was also the disposal or loss from ships at sea of plastics and other persistent synthetic materials (including fishing nets) and its impacts on marine life (Wolfe, 1987). The consistent outcome of these meetings was the recognition that persistent marine debris, particularly discarded or lost fishing gear, was causing substantial harm to a large variety and number of marine animals when they either ingested or became entangled in it, and posing operational risks to recreational and commercial marine traffic.

In 1984 when the First International Conference on Marine Debris was convened, a number of multilateral and bilateral international agreements or conventions force that regulated disposal into the oceans of some forms of garbage were in. All but one, however, were regional instruments. That one, the London Dumping Convention, arguably regulated only the deliberate disposal at sea of various kinds of garbage that were generated on land. Most of the regional agreements did include provisions to generally prohibit the disposal of persistent plastic and other synthetic materials at-sea. However, these were not bright-line prohibitions. Rather, they contained key exceptions that made the agreements ineffective in regulating disposal or discard of the types of persistent marine debris, fishing gear of various sorts, that are a principle concern for conservation of living marine resources and the focus of the International Marine Debris Conference in Hawai'i in August 2000.

Not until 1988 was there a global agreement in force that addressed discharge of pollution from sources that were other than land-based. This instrument took initial form in 1973 as the International Convention for the Prevention of Pollution from Ships. It was later modified and incorporated into its substantive Protocol in 1978 and then entered into force generally on October 2, 1988. It has become known as MARPOL 73/78 and it consists of twenty Articles, two Protocols, and six Annexes.

Another important recent global agreement, which contains a number of provisions relevant to disposal of various substances by ships at sea, is the United Nations Convention on the Law of the Sea (UNCLOS). Although concluded in 1982 this convention did not enter into force until November 16, 1994.

The London Dumping Convention, MARPOL 73/78, UNCLOS, and the Convention on the Intergovernmental Maritime Consultative Organization (CIMCO, 1948, 9 U.S.T 621, T.I.A.S. 4044) all contain general obligations for the Parties to promote cooperation with regional organizations and to assist developing states in protecting the marine environment. Moreover, two key aspirational principles of the United Nations Conference on the Human Environment (Stockholm Conference of 1972) called on all states to take all possible steps to prevent pollution of the world's oceans and to condition their sovereign rights to exploit resources within their jurisdiction by a responsibility to avoid damage to the resources within the jurisdictions of other states and in areas beyond the limits of national jurisdiction.

Here we briefly: (1) review the provisions of these global international instruments relevant to the prevention and regulation of the discharge, disposal, and accidental discard of fishing gear by ships at sea, (2) highlight some domestic laws which regulate the same in state waters, and (3) raise issues for dialogue on preventing discharge, complying with discharge prohibitions, complying with ship-based and port-based retention and processing, and monitoring the dynamics of derelict fishing gear.

2.0. INTERNATIONAL LEGAL INSTRUMENTS

2.1. MARPOL 73/78

This treaty establishes specific regulations governing the discharge of pollution and wastes from ships at sea. Annex V regulates the disposal of ship-generated "garbage." It provides guidelines regarding whether, where, and how such garbage may be discharged into the ocean. It prohibits the deliberate (but not necessarily unintentional) discharge of all plastics, including synthetic fishing nets, and non-food garbage into the ocean. And it requires Parties to provide garbage receptacles at their ports for the disposal of garbage that is generated by ships while at sea. The provisions in Annex V are optional obligations under MARPOL. States that ratify MARPOL 73/78 are not consensually bound to Annex V's obligations until they also specifically ratify the Annex. As of 30 April 2000, ninety-six countries, accounting for about 94% of the world's merchant fleet tonnage, were Parties to Annex V; most of these are still developing programs to implement the Annex domestically as it is not self-executing in most of those countries. Key to our discussion here and the focus of concern, however, is that the prohibitions of Annex V is read to

primarily apply to merchant fleets with less emphasis given to its application specifically to commercial fishing vessels. Nonetheless, Annex V does prohibit the dumping of plastics and synthetic ropes and fishing gear at sea and also regulates the dumping of other types of ship-generated garbage at sea.

The Annex applies to all vessels registered to Parties and includes a general prohibition of the disposal of 'garbage' in most areas, with some permitted exceptions. Garbage is defined as "all kinds of victual, domestic, and operational waste excluding fresh fish and parts thereof, generated during the normal operation of the ship and liable to be disposed of continuously or periodically except those substances which are defined or listed in other Annexes to the present Convention." The deliberate disposal of plastics is absolutely prohibited; plastics are defined as including "but not limited to synthetic ropes, synthetic fishing nets and plastic garbage bags." Parties to Annex V must ensure that marinas, ports, or terminals provide adequate port reception facilities for garbage whose disposal at sea is prohibited.

There are three exceptions to the disposal requirements of Annex V:

(1) when the disposal of garbage at sea is necessary for securing the safety of the vessel, its crew, or other lives at sea;

(2) the disposal was caused by damage to the ship or its equipment, provided that all reasonable precautions have been taken before or after to prevent or minimize the escape; and

(3) the loss of synthetic fishing nets or synthetic material incidental to their repair was accidental, provided that all reasonable precautions have been taken to prevent such loss.

In 1989 paragraph (c) of Annex V was amended to read "the accidental loss of synthetic fishing nets, provided that all reasonable precautions have been taken to prevent such loss." This change strengthens Annex V by narrowing the application of this exception to just the loss of synthetic fishing nets. Therefore, the loss of net pieces or fragments incidental to net repair, even if accidental and reasonable precautions had been taken, is arguably no longer exempt from the general prohibition of discharge.

The International Maritime Organization (IMO) is the agency responsible for promoting the MARPOL convention. A primary function of the IMO has become the prevention and control of marine pollution from ships. Moreover, the IMO is identified by UNCLOS (Article 211) as the organization that is presumed to authorize the establishment of marine pollution standards. The IMO does have the power to recommend regulations under MARPOL, though it lacks the power to impose those regulations. Imposition of standards is left to the individual states directly or indirectly through regional organizations that are delegated such authority.

Under MARPOL, Parties have a general obligation to capture and prosecute those who violate domestic laws that implement the provisions of the agreement. The monitoring and enforcement provisions of MARPOL 73/78 include two components: one applying to port states and another to flag states. A port state has an affirmative duty and right to monitor and inspect vessels as they enter its jurisdiction. A flag state has a duty and right to investigate an alleged violation by a vessel flying its flag and take necessary enforcement actions against the ship. In addition, as will be discussed in the next section, flag states have a duty under the 1982 Convention on the Law of the Sea (Article 94) to ensure that vessels flying their flag observe and take measures which conform to all the applicable international regulations concerning the prevention, reduction, and control of marine pollution.

For inspections of discharge violations, a party to MARPOL does not need "clear grounds"to proceed. A Party to MARPOL 73/78 may also inspect a vessel to which the convention applies when it enters a port or off-shore terminal under its jurisdiction if another Party has requested an investigation and has provided sufficient evidence that the vessel has discharged harmful substances or effluents in violation of the Regulations. If an inspection by the port state or Party indicates that a vessel has violated the convention, the port state or party must provide the government of the flag state of the vessel with a report and evidence of the alleged violation. The government of the flag state must then investigate the alleged violation. It may request additional or better evidence from the port state or party that alleges the violation and then begin proceedings over the violation in accordance with its laws if the evidence is suitably demonstrative. The government of the flag state must also promptly inform the port state or party that reports the violation and the IMO of any action taken.

Consequently, a state that is a party to MARPOL may generally inspect a foreign vessel as it enters its jurisdiction. If MARPOL violations are found, the party must document them and refer the case to the flag state of the vessel for investigation and enforcement action. The flag state is required to investigate the allegations, take enforcement action (if necessary), and inform the Party reporting the violation of the action taken. Furthermore, Article 4(4) states that the law of Parties regarding violations of the requirements of MARPOL shall specify penalties that are "adequate in severity to discourage violations of the present Convention and shall be equally severe irrespective of where the violations occur." Therefore, a flag state or a port state must not allow for more lenient treatment of vessels flying its flag or apply different penalties based on where the violation occurred.

A Party to MARPOL, which has adopted its own laws and regulations pursuant to the requirements of this convention, may also "cause proceedings to be taken in accordance with its law" when a violation occurs within its jurisdiction or furnish the evidence of the violation to the government of the vessel (Article 4[2(a)(b)]).

Article 11 of the Convention requires all Parties to communicate certain information to the IMO, including the text of laws adopted pursuant to the matters covered by the Convention. This provision not only institutionalizes transparency, but it also allows other Parties to see what enforcement procedures and possible penalties for MARPOL violations exist in other nations. This provision provides an opportunity for Parties to determine if,

in fact, other Parties to MARPOL are specifying penalties that are "adequate in severity to discourage violations of the present Convention and shall be equally severe irrespective of where the violations occur," as required under Article 4(4). However, all Parties do not or have not complied with this provision of MARPOL and there is no regular agenda item to address compliance with Article 11.

Annex V was amended in 1995 to greatly enhance port state powers to enforce MARPOL regulations. Regulation 8 provides that a port state can inspect and prevent from sailing a vessel from when there are "clear grounds for believing that the master or crew are not familiar with essential shipboard procedures relating to the prevention of pollution by garbage." A port state can require that such a vessel remain docked until it has come into compliance with the requirements of Annex V. Also in 1995, the IMO Assembly adopted Resolution A.787(19) "Procedures for Port State Control." This resolution outlines the procedures for port state control of operational requirements related to the safety of ships and prevention of pollution. Moreover, amendments to it in 1999 provide detailed guidelines, recommendations, and definitions for procedural conduct by port states for what actions may be taken, and for how results should be.

The resolution also includes guidelines for when and how more detailed investigations and inspections can be carried out pursuant to the discharge requirements of Annexes I and II, but not Annex V. The guidelines for control of operational requirements address how it may be determined that all of the operational requirements of Annex V have been met. For example, the Port State Control Officer (PSCO) may check certain on-board operational requirements, including garbage requirements under Annex V. However, when exercising the controls "recommended" by the guidelines "the PSCO should not include any operational tests or impose physical demands, which, in the judgement of the master, could jeopardize the safety of the ship, crew, passengers control officers or cargo." Furthermore, the PSCO "should ensure, as far as possible, no interference with normal shipboard operations… nor should the PSCO require demonstration of operational aspects which would unnecessarily delay the ship." Unlike the procedures established for Annex I and II, these guidelines require that the PSCO "exercise professional judgement" to determine if the vessel is operationally fit to sail without being a threat to the ship, persons on board, or an "unreasonable threat of harm to the marine environment." There is no chapter that sets out what the port state action could be based on a PSCO investigation, other than the actions provided for in the Convention (Article 6), like there is for Annex I and II.

The IMO has promulgated guidelines for the implementation of Annex V, but they are generally limited to establishing the conditions under which garbage may be disposed of at sea and to specifically defining garbage. Certain kinds of "cargo residues" are not explicitly excluded from being disposed as garbage, though it is not clear that this may be relevant to fishing gear. The guidelines do caution however, that these items may nonetheless pose harm to the marine environment but may also not be suitable for disposal at port reception facilities that may be equipped to handle general garbage.

2.2. The 1982 United Nations Convention on the Law of the Sea (UNCLOS)
The principal duties of flag states are clearly identified in Article 94 of UNCLOS. Specifically, a state should not register a vessel and allow it to fly its flag unless it can "effectively exercise its jurisdiction and control in administrative, technical, and social matters over ships flying its flag." The duties of a flag state covered by Article 94 include obligations under generally accepted international regulations, procedures, and practices, such as MARPOL.

States that become Parties to UNCLOS accept as an obligatory condition that they must adopt domestic laws and regulations to prevent, control, and reduce marine pollution. Further, the effects of these measures must be in harmony with generally accepted international rules and standards that have been developed through the competent international organization or general diplomatic conference. Therefore, states that are not a Party to MARPOL are still obliged to adopt laws and standards, which give effect to its provisions, under UNCLOS. Furthermore, states must ensure compliance by vessels flying their flag with applicable international rules and standards, developed by a competent international organization or diplomatic conference, and with their laws and regulations adopted pursuant to UNCLOS for the prevention, reduction, and control of marine pollution from ships. Moreover, states should take measures to implement the applicable international rules and regulations and provide for effective enforcement of these rules, regardless of where the violations may occur. These measures particularly include adopting domestic laws and regulations. Thus, obligations under UNCLOS would appear to bring all fishing fleet nations within the disposal prohibition framework of MARPOL Annex V.

UNCLOS also clarified the major difficulty of the MARPOL convention for determining who has authority and jurisdiction to investigate and prosecute pollution violators by codifying the duties and powers of states to protect the flag state. Each state is required to ensure that vessels flying its flag or carrying its registry comply with pertinent international rules and standards. It is the primary response of port and coastal states to detect a ship's violation of these rules and standards and to inform the ship's flag state of the violation, even though it is recognized that flag states may generally be reluctant to prosecute vessels flying their flag. Enhanced port state enforcement abilities as provided by international agreement will undoubtedly promote the effectiveness of such otherwise voluntary compliance by flag states.

In November 1999, the IMO Assembly passed a resolution on the self-assessment of flag-state performance, which includes a self-assessment form. This resolution asserts that flag states have the principal responsibility to have an adequate and effective system in place to exercise jurisdiction and control over vessels entitled to fly their flag and to ensure these vessels adhere to the relevant international rules and regulations. The "Flag State Performance Self-Assessment Form" is intended to establish a uniform set of internal and external criteria which can be voluntarily used by flag states to gauge how well their maritime administrations are functioning and to assess their own performance as flag states. The resolution urges member governments to complete a self-assessment of their capabilities and performance in implementing and complying with the various

instruments to which they are Party. It also encourages member governments to use the self-assessment form when requesting technical assistance from or through IMO. However, submission of a completed form is voluntary and is not a prerequisite for receiving technical assistance. The resolution requests that member governments submit a copy of their self-assessment report so that a database that would assist IMO in establishing its efforts to achieve consistent and effective implementation of IMO instruments.

3.0. DOMESTIC IMPLEMENTATION OF ANNEX V OF MARPOL 73/78

3.1. United States

The U.S. Ocean Dumping Act implements the London Dumping Convention regarding the at-sea disposal of land-generated wastes. The Ocean Dumping Act narrows the exemptions of the London Dumping Convention however to only the discharge of effluents that are incidental to the propulsion or operation of motor-driven equipment or vessels as opposed to matter that is incidental to the "normal operations of vessels."

Regarding the discharge of vessel-source garbage and fishing gear at sea, the U.S. Act to Prevent Pollution from Ships of 1982 (APPS) was specifically enacted to implement the relevant provisions of MARPOL 73/78, including an amendment to include the application of Annex V when it entered into force. The APPS/MPPRCA applies to: (1) a U.S. flagged vessel wherever it is located in the world's oceans, and (2) to all vessels while in the navigable waters or EEZ of the United States. U.S. regulations follow Annex V in that they require the person in charge of a vessel to keep a detailed log of the discharge and disposal of solid waste, including plastics, and to develop a waste management plan. These records must be maintained by the vessel for at least two years and be available for inspection. Vessels must also display pollution prevention placards. Penalties for violations under MPPRCA include civil penalties of $25,000 per day per violation; criminal penalties of $50,000 and five years in prison; and denied access to U.S. ports, terminals, and marinas. In 1998 the U.S. Coast Guard reported 219 violations of the MPPRCA and imposed nearly $500,000 in penalties. Of these 219 cases, 57 were fishing vessels and 90 were recreational vessels.

In 1992, the United States informed the IMO of change in United States enforcement policy regarding ships in U.S. ports suspected of Annex V violations occurring within the U.S. Exclusive Economic Zone (EEZ). As a result of the history of low numbers of flag states responding regarding a reported violation (pursuant to MARPOL 73/78), the United States notified IMO that it "will take direct enforcement action consistent with all international law principles against ships in the United States ports for all suspected Annex V violations that have occurred with the United States 200 mile Exclusive Economic Zone."

3.2. People's Republic of China

The People's Republic of China is a party to MARPOL and Annex V. The requirements of MARPOL and Annex V are implemented by Ministry level regulation and are enforced by the Maritime Safety Administration. Under these regulations, all vessels registered in China and flying a Chinese flag are required to designate a person responsible for the disposal of garbage, have a garbage plant, and maintain garbage disposal records. Both the shipping companies and the vessel's masters are held accountable for adhering to the

requirements of Annex V. Maritime Safety Administration inspectors enforce Annex V regulations on Chinese flagged vessels, but do not inspect foreign flagged vessels for Annex V compliance. In addition, the Maritime Safety Administration implements and enforces Annex V regulations on the high seas, in Chinese coastal waters, and on the Yangtze River. An interagency committee coordinates enforcement on the Yangtze River because several Ministries have jurisdiction over the Yangtze River.

3.3. Republic of Korea

The Republic of Korea is a party to MARPOL and Annex V. To implement the provisions of Annex V, Korea enacted the Marine Pollution Prevention Act in 1994, as the implementing ministerial decree. The law and decree incorporate the suggested language of Annex V, including the language defining the types of garbage covered by the Act. The law includes the following enforcement provisions:

- In instances of insufficient record keeping—a fine of up to one million Korean won (approximately $900 U.S.).
- Intentional throwing of waste into the ocean—a fine up to 20 million Korean won, or up to three years in prison.
- Unintentional throwing of waste into ocean—a fine of up to 10 million Korean won, or up to one year in prison.

The Maritime Police Authority is responsible for enforcement of the Act, turning cases over to the prosecutor's office for prosecution.

4.0. IMPLEMENTATION CHALLENGES AND WEAKNESSES OF MARPOL

4.1. MARPOL is a UN Agreement

MARPOL was concluded under the auspices of the International Maritime Organization, which also handles its administration. Due to this relationship, non-state entities, such as Taiwan cannot become a party to MARPOL or any of its Annexes. Taiwan has the sixth largest fishing fleet in the world (and the second largest fleet in the central and western Pacific Ocean) so its inability to be legally bound to the provisions of MARPOL and its Annexes weakens the effectiveness of the Agreement. Under these circumstances, such fishing entities could consent to unilaterally implement MARPOL, but this is not the optimal solution.

However, despite its inability to become a party to MARPOL or its annexes, Taiwan has taken steps to address the marine debris problem it is experiencing in its own marine habitats (e.g., coral reefs). Taiwan is drafting a marine pollution prevention law, which will contain provisions that discourage ships from discarding nets and other types of debris at sea and amendments to its Fisheries Act to increase the protection of marine resources.

4.2. Non-Parties

The activities of non-Parties to the Agreement and its optional Annexes weaken MARPOL. Non-Parties are not legally bound to abide by the provisions. Of the ninety-six present Parties to Annex V, nearly all of the nations with fishing fleets operating in the northern Pacific region are party to Annex V, except for Taiwan (see section 4.1) and the Philippines.

In this case, it appears, that non-Parties to MARPOL and Annex V are less of a problem then the effective implementation and enforcement of the provisions of Annex V by Parties operating fishing vessels in the Pacific region.

4.3. Lack of Capacity and Infrastructure to Comply with MARPOL Requirements

One significant obstacle to states becoming a party to MARPOL, or any of the optional Annexes, or adopting laws that have the same effect as generally accepted international rules and standards (as required under UNCLOS III), is the institutional capacity required to fully and effectively implement the regulations and provisions of the Agreement and its Annexes (i.e., enforcement, administration, and infrastructure). Understandably, states do not want to accept obligations that they may not meet. Increasing the capacity of states to comply with the regulations of MARPOL and its Annexes will not only encourage their ratification of the Agreement but also increase its effective implementation. This is especially important for small island and developing states. Joint development projects between intergovernmental organizations and donor institutions, such as the IMO-World Bank Wider Caribbean Initiative, could help to overcome this obstacle. This would also increase the number of Parties to the Agreement and promote effective implementation.

4.4. Enforceability

Due to the nature of fishing and marine transport operations, vessels spend a significant portion of their time far out to sea or on the high seas. The enforcement of regulations by States becomes very difficult in this case. Vessels must be observed violating the regulations or there must be some other type of clear evidence that can be attributed to that particular vessel to initiate enforcement proceedings. Methods of identifying the source of derelict fishing gear, which may have been either lost or intentionally discarded, could assist flag State enforcement efforts and the detection of violations by other Parties.

4.5. Penalty Action

MARPOL itself does not specify any penalties for violations of its Regulations. Parties are required to investigate alleged violations and, given sufficient evidence, initiate proceedings against the vessel. If found guilty of a violation of a MARPOL Regulation, MARPOL states that the law of Parties shall specify penalties that are "adequate in severity to discourage violations of the present Convention and shall be equally severe irrespective of where the violations occur." This allows a Party to develop a penalty scheme according to its law. However, MARPOL could be strengthened if it identified the types of penalties that should be imposed by Parties when a violation occurs. A range of penalty options for violations of increasing severity could be developed. This would help to standardize the types of penalties among Parties for specific categories of violations so that any penalties imposed are in fact "adequate in severity to discourage violations of the present Convention and shall be equally severe irrespective of where the violations occur." Moreover, IMO's efforts could be particularly enhanced if Parties would make available copies of domestic laws which have been adopted to implement the Convention (as required by Article 11).

5.0. REGIONAL FISHERIES MANAGEMENT ORGANIZATIONS (RFOs)

Fisheries that extend beyond the exclusive jurisdiction of one state, such as straddling fish stocks and highly migratory fish stocks, are most often managed by regional fisheries organizations or commissions established by multilateral agreements. In the Pacific there are two, the Inter-American Tropical Tuna Commission (IATTC) and the North Pacific Anadromous Fisheries Commission (NPAFC), and one under negotiation for the central and western pacific (referred to as the MHLC). These regional fisheries organizations could play an important role in trying to eliminate the discard of fishing gear and related debris.

RFOs and their members have a duty to comply with relevant international law and agreed upon standards, such as UNCLOS and the Food and Agriculture Organization's Code of Conduct for Responsible Fisheries. One of the general principles of the Code of Conduct is that the "harvesting, handling, processing, and distribution of fish and fishery products should be carried out in a manner which will… minimize negative impacts on the environment." The Code of Conduct has several provisions which assert that States and subregional or regional fisheries management organizations or arrangements should adopt appropriate measures to minimize catch by lost or abandoned fishing gear and its impact on non-target species, in particular endangered species (Article 7.2 [f][g]; Article 7.6.9), and that fishing activities ought to be conducted with due regard for the IMO requirements relating to the protection of the marine environment and the loss of fishing gear (Article 8.4.1; Article 8.7.1).

Therefore, RFOs should have among their mandates and binding conservation rules a prohibition on discarding gear, light-sticks, or other types of material related to fishing activities, which apply to its members fishing within its regulatory area. By expanding its mandate to include prohibitions on discarding fishing gear, RFOs will more fully implement the Code of Conduct and help to ensure that the requirements of IMO are more widely implemented and enforced. In addition, implementation of these requirements by RFOs (depending on their membership) could capture fishing vessels that otherwise could not be legally bound to the provisions of MARPOL Annex V (e.g., Taiwan).

6.0. SUMMARY

A number of international legal instruments are now in force which have various effects in limiting the discharge of persistent fishing gear and fishing gear fragments into the marine environment. Among the global instruments, the London Dumping Convention of 1972 regulates the deliberate disposal at sea of garbage and persistent plastics of land-based or land-generated origin (= "dumping"). MARPOL 73/78, and in particular Annex V to the Protocol to this Convention, addresses the operational and unintentional discharge of vessel-source pollution, including certain fishing gear, persistent plastics and other operational garbage at sea (i.e., ocean "dumping" is not covered by MARPOL 73/78). These instruments therefore act in concert to regulate the input of pollution, including derelict fishing gear, into the world's oceans, though Annex V of MARPOL 73/78 has emerged as the principal legal instrument regulating the disposal by ships at sea of all plastic materials. Certain exemptions or ambiguous definitions of terms, however, have arguably left the discharge of some forms of derelict fishing gear unregulated. UNCLOS also contains several provisions that have direct relevance for regulating discharge of

fishing gear by vessels at sea, though similar loopholes exist. A number of regional international agreements, most notably those within the United Nations Regional Seas Programme, apply to at-sea discharge of fishing gear. The language and terms in those agreements are similar, however, to that in global agreements leading to similar inadequacies in effective governance of reducing the impacts of derelict fishing gear to marine environments and human traffic. Implementation of domestic legislation by Parties to international agreements to govern such impacts coupled with State compliance of both international and domestic legal instruments are key to limiting future burdens to marine environments from the threats of these persistent pollutants. Elimination of the extant burdens through cooperative and collaborative programs, an issue not yet embraced by any of these instruments, is also a key issue for further international dialogue and action.

7.0. RECOMMENDATIONS FOR FURTHER DISCUSSION: OPPORTUNITIES FOR IMPROVEMENT AND ACTIONS NEEDED

- Develop public/private partnerships or enlist the aid of international donor institutions (e.g., the World Bank or the International Monetary Fund) to increase capacity in States, particularly developing states, so they can comply with MARPOL regulations and/or will be in a position to ratify and effectively implement the Convention and its annexes (Example: Wider Caribbean Project).

- Increase the flag state response to alleged violations by other Parties.

- Encourage all Parties to comply with Article 11 of MARPOL and establish an agenda item regarding this provision in the appropriate sub-committee (i.e., the IMO Marine and Environment Protection Committee).

- Enhance the enforcement provisions of MARPOL Annex V or develop new mechanisms to increase compliance with Annex V provisions.

- Parties should encourage those that have not already done so to become a party to MARPOL and/or ratify the optional Annexes.

- Address issues of inadequate reception facilities through development projects.

- Develop programs with positive incentives for proper disposal (e.g., a deposit system for light sticks and other types of plastics).

- Increase the fishing industry's awareness of the navigational hazards and potential economic costs of marine debris (i.e., fouling of props and damage to set nets).

- Strengthen the Port State Control procedures and guidelines for Annex V provisions.

- Encourage Parties to MARPOL to implement strong domestic legislation for regulating intentional and unintentional discharge of fishing gear from vessels either flagged or registered under their jurisdiction which applies to those vessels regardless of the location of their activities.

- Encourage the IMO to provide guidance and technical support to Parties to MARPOL for crafting effective domestic legislation for regulating the discharge of fishing gear from vessels at sea.

- Encourage regional and sub-regional fisheries organizations and arrangements to incorporate into their mandate and binding conservation measures a prohibition on discarding fishing gear and related fishing debris.

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IMPACTS OF MARINE DEBRIS:
RESEARCH AND MANAGEMENT NEEDS

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BACKGROUND

Although societies have altered natural environments since time immemorial, the magnitude, intensity, and rate of change have increased dramatically in the last seventy-five years. Nowhere is this more evident than in coastal areas, where growing populations, increased demands on natural resources, and powerful modern technologies have combined to bring about far-reaching changes in coastal and marine environments, not all of them favorable. Human-induced changes have been profound and continue to increase in scope, yet we have had neither the time nor resources to pause, study, and reflect on the remarkable impacts and how to mitigate them.

Marine debris is a good example of such change. Significant marine debris impacts can be traced to the 1940s when new synthetic materials began replacing natural fibers in the manufacture of fishing nets, line, and all sorts of everyday items. The low cost, light weight, and long life of new synthetic materials have resulted in more items being discarded, their transport to the most remote ocean shorelines and waters, and a much longer hazard life for marine species.

Although the roots of marine debris pollution date to the mid-1900s, its impacts on marine life were largely unrecognized until 1984 when the National Marine Fisheries Service (NMFS), at the recommendation of the Marine Mammal Commission, hosted the Workshop on the Fate and Impact of Marine Debris (Shomura and Yoshida, 1985). Data compiled at the workshop revealed that marine debris was affecting far more species in many more areas than previously realized. Its biological impacts were found to have two principal forms: (1) entanglement of animals in loops and openings of derelict line, nets, strapping bands, etc., and (2) ingestion of plastics causing damaged or blocked digestive tracks. Both are potentially lethal to marine life. In addition, human safety problems caused by fouling and disabling of vessel propulsion systems were noted.

The 1984 workshop spurred national and international efforts to investigate, monitor, and mitigate marine debris impacts (Laist et al., 1999). With regard to biological impacts, studies over the following decade documented entanglement and ingestion impacts in all the world's oceans. Interactions were reported in all but one of the world's sea turtle species, 74% (138 species) of all seabird species, 37% (28 species) of all cetacean species, 58% (19 species) of all pinniped species, and Florida manatees (Laist, 1996a). Many affected species were listed as endangered or threatened under national and international conservation programs. Entanglement was found to be more likely than ingestion to injure or kill marine life, and most entanglements involved fishing nets, monofilament fishing line,

rope, and strapping bands lost or discarded by commercial and recreational fisheries. Some seabirds and sea turtles, however, were especially prone to ingesting debris, such as plastic bags, cigarette lighters, light sticks, and small plastic fragments that were confused for floating prey. Potentially significant impacts to commercial fish stocks were also identified due to ghost-fishing (i.e., derelict fishing gear that continues to catch fish and shellfish for years after being lost or discarded [Laist, 1996b]).

Other studies focused on the types and amounts of debris in ocean areas (Pruter, 1987 and Ribic et al., 1997). They found that plastic items comprised the majority of marine debris, and that, in some areas, up to 90% of all debris was made of plastics. Still other studies focused on economic impacts, particularly those measured by diminished opportunities to use the marine environment for pleasure (see for example, Faris and Hart, 1995). Beaches, rivers, wetlands, and bays are used extensively by recreationists, and thus the consequences of aesthetic degradation, beach cleanups, and human health and safety impacts associated with marine debris may impose some of the highest economic impacts (Hoagland and Kite Powell, 1997; Holdnak, 1992; Smith et al., 1997). Over the years, countless news articles and anecdotes have been reported illustrating how marine debris, most notably sewage, medical items, and bottles and cans, threaten human health and safety and affect coastal communities.

Beginning in the mid-1980s, many notable actions were taken to address these problems. Among these were the following: (1) the U.S. Congress authorized funding for the Marine Entanglement Research Program in the National Marine Fisheries Service to improve understanding of marine debris problems and coordinate responsive federal actions, (2) in 1987, parties to the International Convention for the Regulation of Pollution from Ships 1973 and its 1978 protocol, (jointly known as MARPOL 73/78) took steps to implement Annex V, a convention annex for regulating the discharge of garbage from ships and prohibiting all at-sea discharges of plastics, (3) also in 1987 the U.S. Congress passed the Marine Plastics Pollution Research and Control Act (MPPRCA) to enact domestic authority for implementing Annex V, (4) the U.S. Navy implemented a program to develop and retrofit solid waste handling technology for all of its vessels, (5) a series of international meetings, workshops and symposia were held to review information on marine debris impacts and to identify priority research and management needs, and (6) the Center for Marine Conservation and other non-governmental groups organized a national beach cleanup campaign, that was expanded into an international program in 1990.

One region of the world that received intensive attention during the 1990s for its marine debris problems was the Caribbean. Twenty-two developing nations in that region received technical and financial support to implement the MARPOL 73/78 Convention and to help fulfill the requirements associated with the designation of the Wider Caribbean Region as a Special Area under Annex V of the Convention. The Special Area designation, adopted by the International Maritime Organization (IMO) in 1993, prohibits all at-sea discharges of vessel-generated garbage from ships, with the exception of ground food wastes that could be discharged beyond three miles from land (WCISW, 1997). Assistance for these nations became available in 1994 when the Wider Caribbean Initiative on Ship-Generated Waste Project (WCISW) was funded by the Global Environment Facility

through the World Bank and implemented by the IMO. Through the Project, half a dozen countries not already party to MARPOL 73/78 acceded to the Convention during the course of four years. Technical support was also provided to: (1) draft and implement marine pollution legislation in several countries, (2) develop regional and national strategies for handling vessel-generated wastes, (3) identify land-based waste management options (including reuse and recycling), and (4) increase and strategically place shore-based waste reception facilities.

SUMMARY OF RECOMMENDATIONS FROM PREVIOUS CONFERENCES, MEETINGS, AND REPORTS

As indicated above, several international meetings on marine debris were held during the 1980s and early-1990s to review and evaluate information on marine debris. Among these was a special session on marine debris at a 1986 ocean disposal symposium (Wolfe, 1987), a 1987 fishing industry conference on marine debris (Alverson and June, 1988), and two international conferences organized by the Marine Entanglement Research Program of the National Marine Fisheries Service in 1989 and 1994 (Shomura and Godfrey, 1990; Coe and Rogers, 1994) to follow up on the initial workshop convened in 1984. Participants at those meetings made recommendations on priority research needs, as well as steps to coordinate and guide mitigation work. Many of those recommendations remain unaddressed or only partly addressed.

With regard to assessing marine debris impacts, participants at the 1984 Workshop on the Fate and Impact of Marine Debris (Shomura and Yoshida, 1985) recommended steps to:

1. Assess marine debris impacts on living marine resources, including fish, northern fur seals, Hawaiian monk seals, seabirds, and marine turtles.

2. Determine impacts of ingestion of debris by seabirds and turtles.

3. Determine the severity of debris problems in areas other than the North Pacific Ocean.

4. Expand existing stranding networks for marine mammals, birds, and turtles to collect data on interactions with marine debris.

5. Obtain data on the amounts of gear lost by commercial fisheries, particularly high seas gillnet fisheries.

6. Determine the impact of marine debris on the sea floor.

7. Obtain worldwide data on vessel disablement as a result of interactions with marine debris.

In 1987 commercial fishing organizations sponsored the North Pacific Rim Fishermen's Conference on Marine Debris. The purpose of the conference was to identify research needs and industry outreach priorities from the fishing industry's perspective. Proceedings from the Conference (Alverson and June, 1988) urged that international

efforts be expanded to quantify population-level impacts of marine debris on marine species. It also recommended work to quantify economic impacts on commercial and recreational fisheries, and the development of fishing gear and fishing practices that would minimize ghost-fishing. Recognizing the long-term nature of work needed to address marine debris issues, conference participants also recommended that the National Oceanic and Atmospheric Administration provide long-term funding support to the National Marine Fisheries Service for its Marine Entanglement Research Program.

Also in 1987, President Reagan, at the request of thirty members of the U.S. Senate, directed the Office of Domestic Policy to establish an Interagency Task Force on Marine Debris to develop a coordinated strategy to address marine debris issues. Chaired by the National Oceanic and Atmospheric Administration, the task force completed its report in May 1988 (Office of Domestic Policy, 1988). The report called on all federal agencies to assess and mitigate marine debris impacts in cooperation with state and local governments, industry, academia, and private groups. It embraced advice developed at the earlier meetings, including recommendations for long-term support of the National Marine Fisheries Service's Marine Entanglement Research Program and for quantifying deleterious marine debris impacts on fish and wildlife and vessels. The task force report also recommended greater emphasis on: (1) documenting and resolving the aesthetic impacts of marine debris and its associated economic effects on coastal communities, and (2) determining and monitoring marine debris impacts on endangered, threatened, and depleted species. It also called for developing standards on the use of biodegradable plastics and for removing marine debris from beaches and other marine areas.

On 2–7 April 1989 and 8–13 May 1994, the National Oceanic and Atmospheric Administration convened the Second and Third International Conferences on Marine Debris in Honolulu, Hawai'i, and Miami, Florida respectively. Building on results of earlier meetings, participants at the 1989 conference recommended:

1. The preparation of a marine debris survey manual to standardize methodologies for monitoring marine debris on beaches.

2. Forming an international committee to coordinate collaborative efforts for collecting entanglement data and removing hazardous debris from habitats used by species, such as Hawaiian monk seals, sea turtles, and northern fur seals.

3. Studying potential lethal effects of plastic ingestion among sea turtles and seabirds, including studies to correlate ingestion of plastics and the occurrence of lesions in sea turtles, and to assess pseudo-satiation and possible toxic effects among seabirds.

4. Instituting measures to record and track the numbers of gillnets and traps lost during commercial fishing, to estimate ghost fishing rates in lost gear over time, and to develop mechanisms for reducing the length of time lost fishing gear could continue to catch fish and shellfish.

5. Evaluating economic impacts from vessel disablement, ghost fishing, cleaning debris off beaches, and reduced tourism.

The third international conference in 1994 made similar recommendations, but also noted needs to investigate the role of floating debris in transporting invasive, non-indigenous species to new marine areas and the potential for large-scale impacts from debris accumulations on the sea floor. They also reiterated the need to recover lost fishing gear in areas where it accumulates, to develop a system to record losses of commercial fishing gear, and to evaluate the types and amounts of fish and shellfish caught in lost gear.

In 1995, the National Research Council's Marine Board published the results of a comprehensive two-year study on actions needed to develop a national strategy for implementing MARPOL Annex V (National Research Council, 1995). Among other things, the report recommended that:

1. The National Oceanic and Atmospheric Administration, with help from the Environmental Protection Agency, establish a national program to monitor the flux of marine debris on beaches and benthos and marine debris impacts on wildlife.

2. The Environmental Protection Agency develop an overall framework for requiring and monitoring garbage discharges from ships and the availability of adequate port receptions facilities for ship-generated garbage.

3. The International Maritime Organization develop a garbage treatment technology program to develop new garbage handling technology.

4. Congress fund a foundation to coordinate a sustained, long-term program to educate and train the maritime sector in actions needed to properly handle and dispose of ship-generated garbage.

5. Congress establish a permanent national commission to provide consistent, independent oversight and coordination of actions to implement Annex V and the provisions of the Marine Plastic Pollution Control Act.

PROGRESS SINCE 1994

Since 1994 there has been a marked decline in efforts to address marine debris pollution. For example, despite progress made in the Wider Caribbean Region under the WCISW Project, funding for work ended abruptly in 1998 and the Wider Caribbean Special Area has not yet entered into force. Such designation will become effective only when countries and territories in the region notify the IMO that their ports, terminals, and marinas have adequate reception facilities. There is little likelihood of this taking place in the near term. There are many remaining organizational constraints, the necessary physical infrastructure in the form of reception facilities and solid waste management systems is, by and large, woefully inadequate, and operational aspects associated with national implementation and enforcement have not been formulated in many countries.

Attention to marine debris pollution in the United States also decreased sharply after 1994. In 1995 Congress eliminated funding for the Marine Entanglement Research Program as part of efforts to reduce deficit spending. In doing so, it effectively terminated the only

national-level program in the United States designed to coordinate and support federal activities to assess and mitigate marine debris pollution. Funded at between $600,000 and $750,000 per year, the program was the only source of federal funding available to investigate and mitigate the full range of marine debris impacts. In 1996 Congress amended the Marine Plastic Pollution Research and Control Act to direct that the National Oceanic and Atmospheric Administration convene a federal marine debris coordinating committee to oversee cooperative work by involved agencies to address marine debris pollution issues. However, no steps have been taken to convene such a committee. As a result, with three notable exceptions, most conference and report recommendations have received little or no attention over the past six years.

One area in which progress has continued is the development of a National Marine Debris Monitoring Program. In 1995 the Environmental Protection Agency, in cooperation with the Center for Marine Conservation, developed a national marine debris monitoring plan. Since 1996 the Agency has provided $100,000 per year to the Center to develop and implement a monthly sampling program to monitor derelict fishing gear and other marine debris at selected beaches around the nation. Although limited by funding, the program has established monitoring sites in several regions. Over time, the program will provide a means of assessing trends in the amounts of marine debris fouling the nation's shorelines. As a companion effort, with support principally from corporate sponsors, the Environmental Protection Agency, and the Coast Guard, the Center also has continued to coordinate international beach cleanups with volunteers annually removing trash from hundreds of beaches worldwide.

A ten-year study of beach trash along the 68-mile Padre Island National Seashore was completed in 1998 by researchers affiliated with the National Park Service and Texas A&M University-Corpus Christi. Padre Island, a barrier island located on the south coast of Texas, is annually visited by approximately one million people. The marine debris monitoring project, the most extensive of its type in the United States, used a variety of data collection methodologies, including quarterly beach transects and daily surveys over extended periods of time. During the decade, researchers collected nearly 400,000 trash items and concluded that most of the debris was from U.S. sources. The U.S. Gulf of Mexico shrimping fleet, and to a much lesser extent, the offshore oil and gas industry, were identified as the primary "point source" contributors to the problem (Miller and Jones, 1999).

The third area where efforts have been maintained concerns marine debris impacts on endangered Hawaiian monk seals and coral reefs in the Northwestern Hawaiian Islands. Since the early-1980s, the Honolulu Laboratory of the National Marine Fisheries Service has documented more than 200 monk seal entanglements, including a record high of 25 entangled seals in 1999. To address the problem, Service field crews routinely disentangled monk seals whenever necessary and possible, and removed hazardous debris from pupping beaches. To assess entanglement risks in surrounding waters, the Service conducted a dive survey for derelict fishing gear on reefs adjacent to pupping beaches in the winter of 1996–1997. Based on the results, it was estimated that there were 94 net fragments per square kilometer in waters less than 10 fathoms deep at French Frigate Shoals alone (Bowland, 1997). In response to the findings, the Service coordinated

cooperative reef cleanup efforts in 1998 and 1999 with other federal, state, and local agencies and private groups. Six tons of submerged net debris was removed from the reefs in 1998 and about 25 tons were removed in 1999. Most of the netting was from trawl nets that apparently had drifted into the area from distant fishing grounds. In addition to finding several monk seals entangled in net debris hung up on reef outcrops, the nets also were found to be damaging reef corals and other reef species. Because of the remote origin of the netting (there is no trawl fishing in the Hawaiian Islands), the State Department brought the problem to the attention of governments officials in key fishing nations around the North Pacific rim.

The few studies done to assess impacts on other species suggest that marine debris problems continue to exist. In one case, studies suggest that marine debris may provide a conduit for transferring toxic chemicals to marine life. Studies of plastic debris and plastic ingestion by albatrosses at Kure Atoll in the Northwestern Hawaiian Islands suggest that plastics, particularly cigarette lighters and light sticks, continue to be ingested frequently by albatrosses. Albatrosses in the Northwestern Hawaiian Islands also have high levels of PCB contamination. Recent studies suggest that this contamination may come from floating fish eggs and plastics that adsorb toxic chemicals as they bob through the surface micro-layer of the ocean, which may receive PCBs from contaminated land-based dust as it settles on the ocean. If such a transfer occurs, it could represent a significant, previously unrecognized concern for species that commonly ingest plastics and floating marine life. A recent study of plastic ingestion by sea turtles also concluded that post-hatchling sea turtles have an extremely limited ability to compensate for dietary dilution caused by debris in their digestive tracks and that they would experience sublethal effects from decreased energy and nitrogen intake (McCauley and Bjorndal, 1998).

A few studies have attempted to determine if ingestion and entanglement rates declined after MARPOL Annex V entered into force at the end of 1988. Shaver and Plotkin (1998) examined plastics in the digestive tracks of 473 sea turtles stranded along Texas between 1983 and 1995. They found ingested plastics in more than half of the turtles sampled, with no significant difference in the proportion of affected turtles before and after Annex V went into effect; ingested items were the primary cause of death for at least seven turtles. Arnould and Croxall (1995) examined entanglement rates of Antarctic fur seals at South Georgia Island in the Southern Ocean between 1988/1989 and 1993/1994. They found the incidence of entanglement declined by half after Annex V went into effect although the decline may have been related to a decline in fishing activity in the area. It was noted, however, that a decline in strapping band entanglements probably was related to education efforts urging fishers to cut strapping bands before discarding them. This conclusion was supported by a finding that all strapping bands found washed ashore on South Georgia during the 1993–1994 survey had been cut. Long-term efforts to monitor entangled northern fur seals on the Pribilof Islands also suggest a decrease in entanglement rates since MARPOL Annex V went into effect (Robson et al., 1999). Although funding decreases have reduced sampling efforts in recent years, work now is carried out largely by the local Native community during annual subsistence harvests. The results suggest that entanglement rates among juvenile male fur seals on haul-out beaches

declined from a high of about 0.7% in the mid-1970s to about 0.4% in the 1980s and about 0.2% between 1988 and 1997. As with Hawaiian monk seals, most net entanglements of northern fur seals have involved derelict trawl net.

Several studies to assess potential impacts from ghost fishing by derelict gear were undertaken prior to 1994 (Laist, 1996), some of which suggested significant impacts were possible. Since 1994, however, no further studies have been done to assess ghost-fishing rates or to estimate ghost-fishing impacts on commercially valuable fishery stocks. Other than the monk seal disentanglement work and related reef cleanup efforts in the Northwestern Hawaiian Islands, no efforts have been undertaken to mitigate entanglement impacts from derelict fishing gear.

UNRESOLVED ISSUES

Information on trends in the types and amounts of marine debris continues to be poorly understood. To detect statistically significant trends in the composition and quantities of marine debris, long-term monitoring studies, such as the U.S. National Marine Debris Monitoring Program supported by the Environmental Protection Agency and the National Park Service, need to be continued, refined, and expanded to cover new areas. Currently, monitoring programs comparable to the U.S. program do not exist in other countries. Such programs are needed to help determine which types and sources of marine debris require priority attention.

Other than ongoing studies to monitor entanglement of Hawaiian monk seals and northern fur seals on breeding beaches, little work is currently being done to monitor or assess impact of marine debris on living marine resources. The greatest unknown in this regard is the numbers of animals entangled and killed at sea that are never recorded by shore-based monitoring programs. One of the only instances where work has been undertaken to assess and mitigate entanglements away from shore is the above noted work in the Northwestern Hawaiian Islands to survey and remove debris in reef habitats adjacent to monk seal breeding beaches. Because of logistical challenges, the impacts of marine debris on living marine resources at sea remain poorly understood and documented. Currently there are no systematic studies to monitor long-term entanglement trends among pinniped populations other than Hawaiian monk seals and northern fur seals; nor are there systematic efforts to assess or monitor ingestion of marine debris by species, such as sea turtles or albatrosses, that frequently ingest large quantities of plastics. Although recommended at past marine debris meetings, no work has yet been done to correlate debris ingestion by sea turtles with the occurrence papilloma tumors in turtles.

Although several studies to assess and mitigate impacts of ghost-fishing were undertaken prior to 1994 (Laist, 1996), little appears to have been done since then. In some cases, ghost-fishing impacts may be significant. For instance, ghost-fishing losses for the sablefish trap fishery off British Columbia, Canada, have been estimated as high as 30% of actual landings (Faris and Hart, 1995). Carr et al. (1992) monitored ghost-fishing by two 100 m gillnets over a two-year period off New England and recorded a catch of 172 lobsters during just fourteen dive observations over that period. Considering the number of gillnets and other fishing gear lost in New England, such findings suggest that lost nets could catch

and kill a significant number of lobsters. The study also tested biodegradable float releases to minimize ghost fishing by reducing the net's vertical profile. Despite such work, no efforts have been made to gather data on the numbers or location of lost fishing gear, to estimate potential region-wide economic impacts, or to further develop potential mitigation measures.

Navigation hazards posed by marine debris, particularly for small craft, also remain poorly documented. Anecdotal reports of entangled motors, clogged water intakes, and propeller and hull damage are common. Despite several recommendations to compile data on such hazards, no systematic study of the economic costs of such damage has been conducted (Kirkley and McConnell, 1996).

A scan of the most recent literature on the benefits associated with a reduction of marine debris also indicates that the true social and economic costs remain unknown (Hoagland and Kite-Powell, 1997). For example, we do not have a complete picture of the magnitude of economic damages associated with the ecological effects of marine debris. No studies have been conducted to estimate the economic losses associated with the entanglement of marine mammals, turtles, birds and other aquatic wildlife and, as noted above, little has been done to estimate economic costs of ghost fishing. More in-depth investigations are also needed concerning costs to coastal tourism and recreation, as well as marine debris hazard costs to boat and ship owners. Investigations into economic costs to fisheries stemming from reduced public appeal for the products due to pollution from trash and inadequately treated sewage also have not been done.

OPPORTUNITIES FOR IMPROVEMENT AND ACTIONS NEEDED

To mitigate marine debris pollution, it is essential to document and monitor its occurrence. The National Marine Debris Monitoring Program supported by the Environmental Protection Agency and carried out by the Center for Marine Conservation has been designed to address this need on a national level. Its continuation as a long-term funding priority should be a fundamental component of any effort to resolve marine debris issues. Further work is needed to establish monitoring sites in all regions of the country, and conference participants should consider work done to date to develop this program as an opportunity to gather baseline data on regional marine debris problems and trends. In some cases additional surveys may be needed to identify particular problem areas, such as has been done in the Northwestern Hawaiian Islands.

There also is a need for further work to assess and monitor biological impacts of marine debris. Ongoing monitoring of entanglement rates for Hawaiian monk seal and northern fur seal populations should be continued, and opportunities may exist to develop similar programs for species in other areas. Further work also is needed to assess and monitor ingestion of plastics by species, such as sea turtles and albatrosses, that frequently ingest large quantities of marine debris. Recent improvements in regional marine mammal and sea turtle stranding programs and fishery observer programs provide an opportunity to collect data on ingestion of plastics, and consideration should be given to supporting routine collection and analyses of stomach samples from these sources. As a related matter, studies may be needed to determine whether floating plastics adsorb toxic chemicals that could be transferred to marine life via ingestion.

The impacts of ghost-fishing by derelict fishing nets and traps merit particular attention. In most cases, past recommendations to address its effects have received little or no funding. Studies of submerged fishing debris in the Northwestern Hawaiian Islands illustrate the type of problems that may exist and similar work should be considered for other locations where derelict fishing gear may accumulate (e.g., major fishing grounds or coastal waters where floating debris can be deposited). In addition to determining densities of lost gear in particular areas, such studies could be designed to assess: (1) the types and quantities of marine life, particularly commercially valuable crab and lobsters, caught in submerged derelict gear, and (2) the feasibility of dedicated cleanup efforts to remove lost gear from sea floor areas where it is most concentrated. Further work on gear modifications that would render lost gear less harmful to marine life also would appear to merit consideration. Long-term studies similar to Carr et al. (1992) to monitor interactions between marine life and derelict gear also should be considered. Their purposes could be twofold: (1) documenting the catch rates by different types of derelict gear in different areas over multi-year periods, and (2) testing gear modifications that could make lost gear less hazardous to marine life (e.g., the use biodegradable materials). Fishing industry grants made available by the National Marine Fisheries Service provide an opportunity to support such work; however, to date, grant applications in this area have received low priority and gone unsupported. Establishing a higher priority for work to resolve derelict gear issues in fishing industry grants could help address funding limitations.

Other actions that may merit consideration relative to ghost fishing include requirements for reporting when and where gear is lost, and the institution of fishing gear deposit systems to create an economic incentive for recovering and properly disposing of old or derelict fishing gear at land-based disposal sites. Because many land-based disposal sites discourage, or even prevent, disposal of fishing gear in landfills, steps may be needed to identify or arrange for disposal sites for fishing gear.

Although some studies have been conducted on the public's willingness to pay for the control of marine debris and a clean marine environment, more research in this field should be considered. A survey of users and nonusers of beaches and estuarine reserves in North Carolina and New Jersey concluded that individuals were willing to pay twice as much to clean up a beach than they were to clean up an estuary (Zhang, 1995). Also, incentive systems consisting of bounties, taxes, deposits, rebates, etc., may merit investigating in some locales. Hoagland and Kite-Powell (1997) recently concluded that the Gulf of Maine had seen modest reductions in bottle debris over time, and that this coincided with the adoption of bottle deposit and refund legislation. As noted above, incentive-based solutions may be particularly helpful for marine debris problems in fisheries and fishing communities. A Canadian study found that commercial fishermen, if adequately informed, are more likely to return garbage to port when waste collection facilities are readily available (Topping, 1997). Others have concluded that tax/subsidy systems are economically viable, but that they should be limited to selected items in the waste stream (Dinan, 1993; Palmer and Walls, 1994; Fullerton and Kinnaman, 1993). One such item might be fishing gear, particularly the netting, traps, and cordage that have been traditionally discarded or lost at sea.

To help address all of these issues, consideration also should be given to funding and coordination needs. For example, based on conference results, consideration should be given to recommending that: (1) Congress reinstate funding for a national marine debris research and management program similar to the former Marine Entanglement Research Program to help fund the broad range of projects needed to assess and mitigate marine debris impacts, and (2) the National Oceanic and Atmospheric Administration convene a national marine debris coordinating committee pursuant to directives of the Marine Plastic Pollution Research and Control Act.

TOPICS FOR FURTHER DISCUSSION

Based on information presented at the conference, participants should consider recommended actions in the following areas.

1. Monitoring studies to determine the types, amounts, and accumulation trends of derelict fishing gear and other forms of marine debris:
- Continued support for the National Marine Debris Monitoring Program.
- Additional studies to identify and document regional areas where marine debris accumulations may occur.

2. Assessing, monitoring, and mitigating impacts of derelict fishing gear and other marine debris on living marine resources:
- Continuation of shore-based studies to document and disentangle Hawaiian monk seals and northern fur seals.
- Studies to document other entangled marine species.
- Collection and analyses of ingestion data on albatrosses, sea turtles, and other species.
- Assessment of the adsorption of toxic chemicals by marine debris likely to be ingested by marine species.

3. Assessing and mitigating ghost-fishing impacts:
- Conduct underwater surveys to document densities of derelict net debris and traps in major fishing areas or areas where drifting debris may concentrate, and to test feasibility of dedicated cleanup work.
- Conduct multi-year studies of species and catch rates in different types of derelict fishing gear in different areas.
- Collect or require reporting of data on the when and where fishing gear is lost during commercial fishing operations.
- Study potential gear modification that would reduce the probability of fishing gear being lost, increase the probability of lost fishing gear being found, and reduce the hazard life of lost gear not recovered.

4. Considering economic incentive-based solutions for marine debris problems. A range of policy approaches should be investigated, including those that:
- Establish deposits, refunds, or bounties for gillnets, fish traps, light sticks, and other items frequently or occasionally lost during commercial fishing.
- Ensure convenient and affordable solid waste management systems are available to accept commercial fishing wastes, including old fishing gear.

- Consider that economically inefficient fishing effort has accompanied open access to most species. We need to investigate whether taxation designed to limit effort, and thus reduce the likelihood of gear losses, overboard disposal, etc., would result in societal benefits.
- Investigate higher taxation possibilities for items that cannot be recycled and subsidies for those that can be recycled.
- Determine whether penalty mechanisms, such as fines, are effective at controlling the problem or if there are better and more cost-effective options.

5. Continuing to support studies designed to assess the economic and social costs of marine debris to coastal tourism and recreation and navigation interests. This information can be used to continue educating policy-makers and stakeholders.

6. Establishing a framework to support and coordinate marine debris impact ssessment and mitigation activities:
- Request that the National Oceanic and Atmospheric Administration or some other agency establish and secure funding for a national marine debris research and monitoring program similar to the former Marine Entanglement Research Program.
- Request that the National Oceanic and Atmospheric Administration convene a national marine debris coordinating committee pursuant to provisions of the Marine Plastic Pollution Research and Control Act.

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SOURCE IDENTIFICATION OF DERELICT FISHING GEAR: ISSUES AND CONCERNS

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BACKGROUND

No fewer than four international conferences have convened to address the problem of marine debris and derelict fishing gear (Shomura and Yoshida, 1985; Alverson and June, 1988; Shomura and Godfrey, 1990; Faris and Hart, 1995). Each of these conferences has addressed identifying the land or maritime sources of debris, including the fisheries that generate derelict gear such as nets, net fragments, and traps. The impetus for source identification has been primarily to provide direction for activities designed to prevent continued accidental loss or intentional discard of such gear. These activities include improved port disposal facilities, public awareness campaigns, and gear modifications. With the ratification of Annex V of MARPOL 73/78, which prohibits the discharge of plastics from ships of nations party to the Annex, source identification gained added importance as a law enforcement tool, although any citation or enforcement action would require identification ascribed to a particular vessel.

Derelict fishing gear can be identified with increasing degrees of precision, from fishery, to manufacturer, to individual user. Source identification to a particular fishery requires a broad knowledge of fishing equipment and methods. This expertise no doubt exists collectively among fishermen, gear manufacturers and specialists, and biologists, and some compendia have been assembled (Uchida, 1985). However, summary publications quickly become outdated as technology and fishing methods change, and current information may not be published or readily accessible. Identification of a manufacturer requires unique elements which are introduced during construction of the particular webbing, net, or other gear implement. These may be intentional tracers introduced to function as a de facto trademark, or may be particular aspects of construction which result from the manufacturer's (patented) design or fabrication. Identification to individual user requires insertion or application of unique identifiers after the gear has been purchased from the manufacturer or supplier. These procedures are used in trap fisheries in which return of lost equipment is desired, including tagged crab or lobster traps, or color coded buoys. Set net fisheries may also have individual markings on buoys, although the webbing is not marked. Trawl or drag fisheries seldom have individual markings.

PREVIOUS RECOMMENDATIONS

Each of the previous conferences has provided a suite of recommendations related to the detection, management, and mitigation of marine debris. Some of these recommendations have related to the identification of debris sources, and are listed below.

1984 Recommendations

Recommendations from Marine Debris working group:

1. Fishermen groups and net manufacturers should be asked to assist in identifying specific types of nets and net components which are most involved in entanglement.

2. Requirement for identification of fishing nets to identify source and areas lost.

3. Confirm sources of marine debris and expand studies of their distribution in the marine environment.

Recommendation from Impacts working group:

1. Require Net Identification.

2. Develop a reference collection of debris, particularly nets.

Recommendations from Management Needs working group:

1. A reference catalogue of netting materials be developed.

2. Economical and effective systems be developed to mark gear through color coding or other means for retrieval and identification of source.

1988 Recommendation

1. Examination of cost-effective systems to facilitate the identification, recovery, and return of lost fishing gear to port or owners.

1990 Recommendation

Recommendation from working group on Entanglement of Marine Life:

1. The preparation of a guide to the types of lost or discarded nets.

1994 Recommendation

1. Where possible, sources of marine debris should be identified by countries of origin and user groups using item codes and shapes from industry, epiphytic organisms (that travel on ocean borne debris) and cargo manifests.

ACTIONS SINCE PREVIOUS CONFERENCES

Reference Collection

Commencing in fiscal year (FY) 1985, the U.S. Congress provided funds to the National Marine Fisheries Service (NMFS) for a comprehensive research and management program to address the problem of marine debris. The resulting Marine Entanglement Research Program (MERP) coordinated mitigation, education, and research activities for ten years,

until its funding was discontinued in FY 1996 (Marine Mammal Commission, 1997). MERP supported a wide suite of projects, but little support was garnered for identifying debris sources. A project was funded ($48 K) for one year, FY 1985, to establish a reference collection for nets, but by the following year this project was discontinued in lieu of funding for other, higher priority activities. The one-year effort resulted in an incipient reference collection at the Alaska Fisheries Science Center (AFSC) in Seattle, Washington, with notification that the AFSC would accept samples for identification (Herkelrath et al., 1991). Parts of the original reference collection remain at the AFSC (Jim Coe, AFSC, pers. commun.). No reports resulted from the project.

Since 1986 no formal effort has been undertaken to establish a reference collection of nets or other fishing gear. The original reference collection has not expanded, and has seldom been used (Dave King, AFSC, pers. commun.) One of the authors (JRH) used a collection of net samples collected by U.S. fisheries observers in the early-1980s to assist identification of debris collected from the Northwestern Hawaiian Islands in 1998. However, this ad hoc collection resulted in tentative identification of only 36% of the webbing samples collected, and only 14% with a high degree of certainty (NMFS Unpubl. data). The collection was obviously not complete, and may have been outdated.

Individual Gear Markers

Unique marking of fishing gear has progressed little beyond painting or tagging of buoys and floats to which traps or set nets are attached. These methods do not identify scraps of webbing or other gear fragments which become detached from the buoys. Identification of fragments requires small, unobtrusive markers which do not affect the performance or durability of the gear. One such marker is a coded wire tag (CWT) developed for biological applications (Jefferts et al., 1963). CWTs are used in fisheries worldwide, and have been suggested as suitable for use to tag gear (Jefferts, 1988). Tags would be implanted in line or webbing at intervals close enough to provide identification of even small scraps of debris.

It may be technically possible to more closely identify the source of derelict gear fragments, particularly if the full capability of forensic science is applied. Potentially useful forensic methodologies exist that could be brought into the identification of gear fragments.

Although the technology exists to identify derelict gear down to the user level, application of the technology requires careful consideration of many factors. Extra expense would accrue to any manufacturers providing gear containing the individual tags, which would likely result in higher costs to the consumer. A database of registered gear owners would need to be established and maintained, on either a national or a multinational scale.

Oceanic Regime, Drift Patterns

Knowledge of oceanic drift patterns is generally most useful in determining where pelagic flotsam is likely to accumulate. Kubota (1994) simulated the effects of Stokes drift, Ekman drift, and geostrophic currents on theoretical debris items placed throughout the North Pacific. The resulting movement predicted all debris becoming situated in a narrow band running approximately ENE-WSW, crossing the Northwestern Hawaiian Islands (NWHI) in the vicinity of Laysan and Lisianski Islands. Theoretical debris items placed

across the North Pacific Ocean at 45 N were predicted to concentrate, forming an area of high debris density at 27 N, 170 W, approximately 220 km NE of Laysan Island. Matsumura and Nasu (1996), summarizing six years of surveys documenting drifting debris, confirmed that the Pacific region north and northeast of Hawai'i showed relatively high densities of fishing gear and nets.

Ongoing analyses (Brainard and Foley, unpubl. data) have used scatterometer winds to compute oceanic convergence/divergence, a useful means to examine accumulation of debris by wind driven currents. These analyses reveal seasonal and interannual variability in the NWHI. Additional analyses will improve the ability to predict the fate of derelict gear.

Knowledge about drift patterns provides little information on the sources of derelict fishing gear. Variability in oceanic currents and wind drift prevents accurate "back calculation"of the site where debris would have been introduced. Moreover, the length of time which an item has been adrift is never precisely known; any derelict gear could have circulated in a gyre for long periods of time, having been lost or discarded in any area contacted by the circulating water mass.

POLITICAL CONSIDERATIONS

Previous discussions between government regulators and fishing industry representatives (Anonymous, 1988) have revealed very serious concerns among fishermen regarding individual gear markers, such as CWT marking. Fishermen have expressed concerns about the potential legal liability of having their gear individually marked for debris fragment identification. Beyond the information collection infrastructure necessary, the political repercussions of gear tagging need to be carefully considered.

Dissatisfaction with a proposed regulation should not be grounds to abandon its consideration. Many regulations currently in place to protect the marine environment are not particularly popular, but are nonetheless effective and deemed necessary to protect the public interest. However, it is not currently evident that the potential benefits of gear marking would be worth the costs. If derelict gear is found at French Frigate Shoals, Hawai'i that had been sold to the "F/V Sloppy Seas" in Alaska, what exactly does that mean for regulators and educators? Moreover, do better ways than gear marking exist to reduce discards or lost gear from this and other vessels?

UNRESOLVED ISSUES

If source identification is to be practical, it must contribute substantially to reducing debris at its source. A central issue is to determine how source identification might contribute to debris reduction. Ignorance of how source identification could help mitigate the derelict gear problem may have contributed to the historic lack of attention by government regulators to the issue of source identification.

The overall intent of source identification is to detect spatial and temporal patterns or trends in derelict fishing gear entering the marine environment. Derelict fishing gear in the marine environment has two very distinct origins—intentional and illegal discards, and unintentional loss. The mitigation options for each scenario are distinctly different. If a sig-

nificant percentage of problem debris (such as derelict gear that is responsible for entangling sensitive marine organisms) were identified to a particular fishery, more investigation and mitigation could be directed toward that fishery. These could include such efforts as learning whether these gear fragments are intentionally discarded or accidentally lost, increased outreach/education activities, fishery management solutions, or fishery-specific incentives.

For example, if a significant amount of net and line fragments that are entanglement threats can be identified to, say, a Taiwanese shrimp trawl fishery in the South China Sea, then various mitigation options are available. If the fragments appear to have been intentionally discarded, as evidenced by trimmed edges characteristic of webbing patches removed for repair, then mitigation options for that fishery could include increased observation by onboard fishery observers, port/vessel inventory systems, gear marking, rewards for reporting violations, punitive fines for violations, market-based/consumer pressure, and education of deck hands and skippers regarding the deleterious effects of intentionally discarded fishing gear. If, on the other hand, the gear fragments appear to have been accidentally lost, evidenced by large, obviously stretched, frayed, chafed, and torn components, then other management solutions might be considered. Areas of known trawl hang-ups or rough bottom that contribute to a large amount of torn and lost gear could be closed to trawling, gear modifications might be instituted, or Individual Fishing Quotas (IFQs) might be implemented. IFQs assign fishing rights to individual vessels/owners, thereby allowing the fleet to fish in a more leisurely, safer manner and on less difficult bottom terrain. In serious cases, managers might consider closing fisheries entirely to specific problem gear types (as occurred in the high-seas driftnet fishery).

Mitigation options should be targeted as specifically as possible for three principal reasons: (1) to have maximum effectiveness, (2) to make the best use of limited financial resources, and (3) to avoid unfairly burdening other nonproblem fisheries. If derelict gear can be identified to a particular fishery, then mitigation options need not be applied unnecessarily to other fisheries.

POINTS FOR WORKING GROUP DISCUSSION

- What is the feasibility of developing a gear reference collection?
- How would a reference collection be used? By what groups? For what purposes?
- How would a reference collection be developed? Where would it be maintained?
- How could a reference collection be kept current?
- What is the feasibility of individually tagging gear?
- What are the benefits or disadvantages of gear tagging?
- How would the infrastructure be developed to establish a gear registry?
- What agency or agencies would maintain the registry?
- What would be some uses of a registry? MARPOL enforcement? education?
- What are the political ramifications of individually tagging gear?

SOURCE IDENTIFICATION OF DERELICT FISHING GEAR:
ISSUES AND CONCERNS

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INDUSTRY CONSIDERATIONS AND ACTION

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1.0. INTRODUCTION

More than 170,000 people work as commercial fishermen in the United States. In 1998, U.S. commercial fishermen landed about 9.2 billion pounds (4.2 million metric tons) of fish and shellfish at U.S. ports, valued at approximately $3.1 billion. An additional 400.8 million pounds (181,800 metric tons) were landed outside the United States. Purse seine nets and trawl nets accounted for more than 70% of the total catch. Among the other fishing gear used were longlines, gillnets, set nets, trolling gear, and pots. American consumers spend almost $50 billion each year for fish and shellfish products. Thousands of businesses located throughout the United States, produce, process, and distribute seafood products. These firms contribute more than $25 billion to the U.S. Gross National Product (National Fisheries Institute, 2000).

There are an estimated 15 to 17 million recreational fishermen in the U.S. In many fisheries, recreational fishermen harvest as many or more fish than commercial fishermen (e.g., bluefish, red drum, striped bass, summer and winter flounder, Spanish mackerel, spot, spotted seatrout). In 1994, recreational landings of finfish, from Maine to Texas and Oregon to California were over 173 million fish weighing almost 200 million pounds. In 1997, nearly 17 million recreational fishermen made 68 million marine fishing trips to the Atlantic, Gulf, and Pacific coasts. The estimated marine recreational finfish catch was 366 million fish or roughly 423 million pounds (NMFS, 2000). It has estimated that the recreational boating and fishing industries may put as much as $60 billion annually into the U.S. economy (Recreational Fishing Alliance, 2000).

While plastics were first developed in the 1860s, they did not begin to replace natural fibers in fishing gear construction until the 1940s. Shortages of materials such as rubber during World War II led to the rapid development of plastics. By 1964, the majority of nets manufactured in Japan, one of the major suppliers of nets to American fisheries, were constructed of plastics (Uchida, 1984).

Synthetic fibers have led to significant technological advancements in fishing gear design and construction. Modern fishing gear, constructed of synthetic fibers is cheaper, more durable, lighter, stronger, and more efficient than most traditional gear. While synthetic fibers have led to immeasurable benefits to society, there have been associated costs.

Because they are resistant to degradation, synthetic fibers persist longer than natural fibers in the marine environment. Once lost in the ocean they have the potential to continue to fish and adversely affect the environment. Known impacts of lost and discarded fishing gear include the entanglement of marine life (i.e., fish, mammals, sea turtles, and seabirds), navigational hazards to vessels, and habitat impacts. Because they are relatively inexpensive, synthetic fishing nets may provide an economic incentive to fishermen to discard damaged or worn nets and line instead of investing the time and energy to repair them.

An estimated 80% of the marine debris found in the ocean originates from land-based sources (Faris and Hart, 1995) and 20% originates from maritime sources. Plastic production pellets, transported by merchant ships to manufacturing sites where the are melted down and made into various plastic consumer goods are found throughout the world's oceans.

Commercial fishing gear accounts for approximately 5% of the total debris found in the ocean (O'Hara et al., 1988). Other maritime sources of marine debris include merchant ships, recreational boats, cruise ships, military vessels, and offshore oil rigs. Research has shown that the type and source of plastics vary by geographic location. While in most instances the predominant plastic debris was packaging (bottles, bags, and lids), in Alaska it was fishing gear, such as webbing, rope, and floats (Faris and Hart, 1995).

Because lost and discarded fishing gear has a great potential to impact marine life and habitat, its reduction is a high priority. Prevention is the key to the solution of this problem. Participation and input by the fishing industry is critical to developing reasonable solutions. The fishing industry has participated in a number of previous marine debris and derelict fishing gear conferences and will participate in this fourth international conference.

2.0. BACKGROUND INFORMATION

A. Fisheries Operating in the Pacific

The Pacific Ocean contains some of the world's most productive fisheries. A number of small and large scale fisheries operating around the margins of the Pacific employ a variety of gears and methods to target a wide range of species. Principal gears include bottom and mid water trawls, gillnets, pelagic longline, demersal longline, troll gear, hook and line, traps, and purse seines. The trawl fisheries of the northeastern and northwestern Pacific are among the largest fisheries in the world and take large volumes of gadoids (pollock and cod), sebastes (rockfish), and various flatfish.

High seas fisheries in the Pacific target schooling pelagic species, such as tunas and squids. Tunas are taken predominantly by purse seine vessels which target skipjack and juvenile yellowfin tuna and other small tunas for the canning industry. Larger, adult albacore, bluefin, yellowfin, and bigeye tunas are the principal targets of longliners, which in some cases also target swordfish. Other open ocean pelagic fisheries include albacore trollers and pole-and-line vessels fishing for skipjack. Squid are caught on the open ocean using light attraction at night and squid-jigs.

Major trawl fisheries, both domestic and international, occur in the North Pacific. Generally trawl fisheries may be classified as either bottom or mid-water trawl. Bottom trawls are cone-shaped nets that are towed on the bottom. Two cables are used to tow the net and retrieve it. Large rectangular doors attached to the cables keep the net open while deployed. Large circular rollers, called "rock-hoppers" attached to the nets foot rope are used to fish on hard, rocky bottoms.

Mid-water trawls also employ cylindrical shaped nets. Mid-water trawls are generally towed at various depths above the bottom. Table 1 summarizes the U.S. domestic fleet operating in the Gulf of Alaska and Bering Sea.

Table 1. **Fleet sizes of U.S. Vessels operating in the Gulf of Alaska and Bering Sea (1998)**

Vessel Type	Gear Type	Vessel Size	Fleet Size
Trawl catcher processor	Trawl	>125 feet	51
Trawl catcher	Trawl	50-150 feet	230
Longline catcher processor	Demersal longline	>100	43
Longline vessels	Demersal longline	-	2,000
Pot catcher processor	Traps	-	7
Pot vessels	Traps	-	800
Set net vessels (salmon)	Gillnet	-	4,000
Seine vessels	Seine	-	1,000

Source: NPFMC, 2000

Gillnets are widely used throughout the North Pacific including Canada, Japan, Russia, and the United States. Uchida (1984) provides a thorough review of existing fisheries. Gillnets are constructed of monofilament line and typically have a float lead lines. Typically a number of nets, or "panels" are joined together. Gillnets may be anchored to the bottom of the sea with the use of weights or allowed to drift. Fish are captured as they attempt to swim through the net.

In the early-1980s many of the Asian distant water fleets including Japan, Korea, and Taiwan begin to use large-scale drift gillnets in the North Pacific to catch salmon, tuna, and squid. Vessels involved in the fishery typically would set up to 40 miles of net per night. The United States and Canada expressed concerns about the amount of salmon being intercepted on the high seas by this fishery, thus depriving domestic fisheries the opportunity to harvest these fish. In addition, large numbers of other marine life were inadvertently captured and kill by the fishery including marine mammals, sea birds, and sea turtles. In 1991, the United Nations General Assembly, in response to mounting international pressure, adopted a Driftnet Resolution calling for a global moratorium on large-scale high-seas driftnet fishing effective December 31, 1992.

Major longline fisheries exist in the Pacific. Table 2 summarizes existing pelagic longline fleet sizes currently operating in the Central Pacific. The U.S. domestic longline for swordfish in the North Pacific is a relatively new fishery. The introduction of chemical light sticks in the late-1970s revolutionized the industry. Lights are attached by rubber bands or line clips to the branch lines above the hook. The light sticks produce a chemical luminescence for up to twenty-four hours. The lights are available in a variety of colors and are thought to attract either the bait upon which swordfish prey, or the swordfish themselves.

Table 2. **Fleet Sizes of Pelagic Longlines, Operating in the Central Pacific (1997-1998)**

Nation	Fleet Size
China	110
Japan	1,573
Korea	148
Taiwan	1,674
United States	125

Source: WPFMC

Major trap fisheries exist in the North Pacific for king, tanner, and dungeness crab. The traps used in these fisheries are typically large (8" x 8" x 3") constructed of iron rods covered with some type of netting. Large numbers of traps are set in the crab fishery. Traps are typically set individually with one to multiple buoys to mark their location. Traps are also used to target some species of fish such as cod.

The use of free floating, fish aggregation devices (FADs) by purse seiners operating in the eastern, central, and western Pacific is another source of derelict fishing gear. Purse seine vessels set either on free swimming schools of tuna on the surface of the ocean during the daylight hours or on schools found associated with drifting logs or man-made rafts. Just before dawn. The increasing use of drifting fish aggregation devices (FADs) is a relatively recent development in the fishery. In the Central Western Pacific, the U.S. fleet made 90% of sets on untethered FADs in 1999 up from about 30% in the previous year (Coan et al., 1999). These FADs are roughly 2 m x 2 m rafts with a radio beacon for tracking and recovery. Netting, often worn out purse seine nets, are suspended beneath the FADs to create habitat and attract fish.

Recreational fisheries are another source of lost fishing gear present in the ocean. Recreational fishing is a highly popular pastime throughout the Pacific. In Hawai'i, large amounts of light gauge, monofilament line lost by recreational fishermen is found on beaches and coral reefs. Monofilament fishing line presents an entanglement threat to various marine life including sea turtles. The line may get wrapped around the turtles flipper and restrict its movements and ultimately may sever the appendage. In Hawai'i in recent years the rate of stranded turtles having some sort of recreational fishing equipment around them has increased from about 5% to about 15% (Laurs, 2000). In 1999, 43 of the 299, or 15%, of documented turtle stranding the turtles had recreational fishing hooks in them. Twenty of the 43 turtles strandings related to recreational fishing were dead when recovered. The remaining 23 turtles were entangled in monofilament line (Laurs, 2000).

B. Causes of Gear Loss

Fishing gear is lost at sea through a number of ways. It can be lost inadvertently during the course of normal operations or, in some cases, through deliberate disposal. The following section briefly describes some of these pathways.

Bottom trawls may become snared on underwater hang-ups including rocky bottoms and the wrecks of sunken vessels. When fishing in areas of high relief bottom, nets must be constantly inspected and repaired as they are damaged in the course of normal fishing operations. When nets hauled back with tears and rips they must be mended either by sewing in new meshes or, when large sections have been badly damaged, entire new sections of net. As part of the mending process small sections of mesh are often cut out before sewing in the new webbing. Some of these damaged sections may be discarded, either unintentionally or intentionally.

Bottom trawls are occasionally lost entirely due to hang-ups on bottom features, such as ledges, pinnacles, rock piles, and wrecks. Because of the substantial cost of replacing a net (~$30,000) vessels go to great lengths to recover a lost net. One method used is towing a

grappling hook over the spot where the net was lost until the net is recovered. Because of the potential damage to gear and the subsequent loss of fishing time, vessels typically mark the location of hang-ups and wrecks on their charts and plotters. Nets lost in this fashion likely remain entangled on the bottom.

While mid-water trawls are designed to fish up in the water column they can be fished at or near the bottom and therefore may potentially be damaged due to hangups, particularly in rocky or high relief areas.

Gillnets may be lost as a result of a number of factors, including net repair, interactions with mobile gear, entanglement on bottom features such as ledges, wrecks, and storm events.

While the use of high seas driftnet gills has been banned since the early-1990s, illegal vessels are still reportedly using driftnets to poach fish within the U.S. Exclusive Economic Zone (EEZ) as well as on the high seas. Numerous documented cases exist of illegal driftnet vessels simply abandoning gear in the water once detected by surveillance aircraft in an effort to elude apprehension. The abandonment of illegal gear is another source of fishing gear entering the marine environment. Given the large amount of gear deployed, undoubtedly some was lost in the course of normal fishing operations. Due to the persistent nature of synthetic monofilament gillnets and the long residency time of gear once lost in the marine environment, there is likely large amounts of driftnet still circulating within ocean currents and large scale eddies.

In longline fishing, as the mainline is retrieved, the crew generally removes branch lines, buoy lines, lights, and radio buoys, which are readied for the next day's set. Throughout the haul damaged sections of the mainline are replaced. The damaged sections may be unintentionally or intentionally disposed of into the ocean. Light sticks are also lost during the course of normal fishing operations. The light sticks are positively buoyant and of a shape and size that, if inadvertently lost from the branch line or discarded improperly, can create problems if ingested by marine mammals, seabirds, or marine turtles. Naval and merchant marine shipping also reportedly use large quantities of light sticks.

Traps are lost through a variety of ways. In heavy seas it is not always possible to locate all the buoys marking the lobster pots. Major storm events can also lead to the displacement and loss of crab traps. Tides may run so strongly in areas that the buoys marking lobster and fish traps are submerged. Thus, vessels may not be able to locate and retrieve all the gear it set.

Vessels often operate at or near the edge of the ice front and may lose traps as the ice edge advances. The buoy marker lines may be severed by ice. Interactions with mobile gear such as trawls may result in traps being displaced and lost. It is estimated that trap loss in the North Pacific king crab and tanner crab range from 10% to 25% (Kruse and Kimker, 1993; High and Worlund, 1979 in Carr and Harris, 1997). In Alaska, current regulations require that the trap escape panel be constructed of some type of biodegradable material to reduce the potential for lost traps to continue to fish.

As previously noted, interaction between different fisheries and gear types are another potential means by which fishing gear may be lost. In the case of areas where both fixed gear (i.e., trap and gillnets) and mobile gear (trawl) fisheries operate simultaneously, gear interactions result in the displacement and loss of fishing gear. Mobile fishing gear may displace lobster traps and damage gillnets. Fixed gear such as gillnets and traps may be displaced, damaged, or destroyed by vessel traffic. Longlines may also be parted and sections lost if cut by the propeller of transiting freighters or vessels.

Purse seine vessels reportedly set large number of FADs, some of which are lost. Once lost FADs could be a marine debris issue if washed up on beaches or coral reefs. Purse seine nets are rarely lost during normal use.

Under extreme circumstances, vessel emergencies and matters of safety at sea may contribute to the discarding of fishing gear by vessels. Fixed gear fisheries such as the North Pacific crab fishery operates under some of the most inclement weather conditions found anywhere on earth. In heavy seas and arctic conditions stacked crab pots may begin to "ice up" due to spray and sub-freezing temperatures. As ice accumulates on the stacked pots the vessel can rapidly become unstable due to the excess weight and ultimately, unless the situation is remedied, sink with a loss of part or all the crew. Under such conditions crews most often "break ice," removing ice from railing, decks, superstructure, and stacked gear. Under extreme conditions it may be necessary to jettison stacked traps to ensure the vessels stability and safety.

Non-compliance with existing domestic and international laws is another source of derelict fishing gear present in the ocean. As is the case under any regulatory regime, there is a some non-compliance. Despite MARPOL, fishing gear continues to be deliberately discarded by some unscrupulous vessels and crew. Enforcement alone will not achieve compliance with MARPOL Annex V. Industry education and outreach programs, such as U.S. Coast Guard's SeaPartners campaign are an important part of the solution.

C. Past Efforts

The International Convention for the Prevention of Pollution from ships at sea (MARPOL) was drafted and signed in 1973. MARPOL established specific guidelines governing the discharge of wastes by vessels at sea. It was amended in 1978 to include five annexes on ocean dumping. Annex V deals specifically with the disposal of plastics, including synthetic fishing nets by vessels. The Marine Plastic Pollution Research and Control Act (MPPRCA) of 1987 is the U.S. domestic legislation that implements MARPOL Annex V in U.S. waters.

Under the MPPRCA, any vessel greater than 26 feet in length are required to prominently post a 4" x 6" MARPOL placard that explains the garbage dumping restrictions. Vessels 40 feet and larger are required to develop a written waste management plan that describes how the procedures used by the vessel for handling the vessel's garbage in accordance with MARPOL Annex V laws. The plan also must name the crewmember in charge of carrying out the plan. In addition, vessels are required to maintain a detailed waste logbook that details the handling and disposal of plastics and other wastes. These records

are to be maintained onboard the vessel for at least two years and are to be available to the USCG for inspection upon request.

Under MARPOL and the MPPRCA, it is illegal for any U.S. vessel to discharge plastics in any navigable waters within the EEZ or on the high seas. Violations can result in fines of up to $50,000 for each incident. If criminal intent is proven, an individual may be fined up to $250,000 and/or imprisoned up to five years. If an organization is responsible, it may be fined up to $500,000 and/or six years imprisonment. One exception to the plastic disposal requirements of Annex V is the accidental loss of synthetic fishing gear incidental to its repair, as long as reasonable precautions to avoid such loss have been taken (Koehler et al., 2000).

D. Net Disposal and Recycling

Under MARPOL, all ports, terminals, or marinas, whether public or private, are required to provide trash reception facilities for wastes generated at sea and are responsible for the handling and disposal of the wastes once received.

In 1987, the Port of Newport Oregon, with funds provided by the National Marine Fisheries Service, began a one-year pilot project to help provide fishermen with convenient refuse disposal facilities. Under this program recycling and re-use was encouraged, including a popular program that allowed fisherman to leave off unwanted trawl net for public re-use (as baseball backstops, gardening supports and erosion mats, jungle gyms, and the like). The other goals of this project were to increase public awareness about the problems caused by marine debris and to evaluate the program so that other ports could benefit from the Port of Newport's experiences.

Due to the positive response from the fishing community to this program and with the aid of Saltonstall-Kennedy funds, the Pacific States Marine Fisheries Commission (PSMFC) took on similar disposal, recycling, and awareness projects in other ports in Oregon, Washington, Alaska, and California. Gillnet recycling was initiated in Bellingham, Washington and Cordova, Alaska under this program and trawl and seine net "public re-use" was encouraged in Seattle and Bellingham in Washington, and in Astoria and Coos Bay in Oregon. Gillnet recycling was further promoted by the PSMFC with a follow-up grant from the Environmental Protection Agency (EPA). Seattle, Bellingham, Anacortes and Everett, Washington, Astoria, Oregon and Cordova, Naknek, Kenai, Dillingham, and Petersburg, Alaska participated in this Program (Recht, 2000).

The dockside recycling receptacles initially focused on bulky materials such as cardboard, wood (for re-use), metal, and nets (for re-use) as well as oil. Later, paper, aluminum, and other scrap metal recycling was promoted in Alaskan communities involved in gillnet recycling. These facilities not only provided convenient refuse disposal for the fishermen and provided a source of scrap materials, they helped gain the acceptance of the program by port officials by keeping port disposal costs down, especially in areas where recycling pick up services for oil, cardboard, and scrap metal exist kept logistics streamlined. In some areas, e.g., Alaska, where dump space is limited and the siting of new waste dumps costly, reduction in the amount of materials entering the waste stream was an additional

benefit. However a belief that recycling should 'pay for itself', an unrealistic expectation, moderated some community's commitment to the programs (Recht, 2000).

The recycling of gillnets has proven to be an economically viable operation and a benefit for the ports in several Alaska and Washington communities and thus has continued as a private enterprise relationship.

Though trawl net re-use is still promoted in a number of ports (e.g., Newport and Anacortes), no recycling has been workable, due to the low value of the polypropylene nets and the presence of gear such as chains and rollers, making the effort too labor intensive unless subsidized (Recht, 2000).

Due to re-prioritization of policy objectives and programmatic goals (e.g., EPA focus changed from recycling promotion to pollution prevention), additional funding to help develop, streamline, and coordinate these projects was not available after the initial funding ran out. While many of the Port's involved in this project continue the programs initially established and while the private recycler also helps to promote the effort, additional funding would have helped strengthen industry and community involvement and buy-in into the program and expand opportunities in other ports (Recht, 2000).

Skagit River Steel and Recycling, located in Burlington, Washington, is the only company currently involved in net recycling in the United States. This company works with ports in the Northwest and Alaska. The principal markets are in Hong Kong, Taiwan, China and Japan. Recently markets have begun to develop in the U.S.

The company deals almost exclusively with nylon nets: gillnet and driftnets. Past experience has shown recycling nylon seine nets can be economically viable. Many seine nets are coated to preserve and extend their life which complicates their recycling.

The synthetic materials used to construct trawl gear, polypropylene, and polyethylene is problematic for recycling because they degrade. If some type of photo-degradable material is added to synthetic trawl materials, it would further make trawl nets more difficult to recycle. Skagit River Steel and Recycling currently does not handle trawl gear. The company did handled trawl nets in the past but stopped doing so because it lost money.

One of the major obstacles is the need for consistent support for net recycling at the local level, whether it is a fisheries organization or local government. Another problem is the plastics market is very fickle (Hendrickson, 1999). The port of Newport, Oregon reportedly has made used trawl net available to the public for use in landscaping and for other purposes (Recht, 1999).

Carr and Harris (1997) report that in New England changes in minimum mesh size requirements forced fishermen to buy new gear and dispose of old nets. Many landfills reportedly were not willing to accept the old gear for disposal (Carr and Harris, 1997). Similarly, in the central western Pacific problems with disposal of worn out purse seine gear has led to some nations refusing to dispose of these nets in limited land fill capacity (McCoy, 1999). This presents a dilemma as to how to legally dispose of gear.

E. Industry Action

As noted, the MPPRCA requires all U.S. vessels greater than 40 feet, including commercial fishing boats to: (1) develop a written waste management plan that describes the procedures used by the vessel for handling the vessel's garbage in accordance with MARPOL Annex V laws, and (2) maintain a detailed waste logbook that details the handling and disposal of plastics and other wastes. These records must be maintained onboard the vessel for at least two years and are to be available to the USCG for inspection upon request.

In addition to compliance with MARPOL, the fishing industry has initiated a number of waste reduction programs and policies designed to prevent, reduce, and re-use vessels' wastes. Fishermen have taken a leading role in addressing the problem of marine debris and lost nets. The fishing industry has spent its own funds to produce educational materials such as posters and stickers intended to educate the public about the problem of marine debris. Fishermen have been actively involved in efforts to encourage ports to provide dockside waste disposal and recycling receptacles to facilitate the proper disposal of fishing gear (Leipzig, 2000). The fishing industry has organized and funded at least one major conference examining the problem of lost fishing gear.

In Kodiak and Dutch Harbor, Alaska, the fishing industry works closely with port authorities to ensure proper disposal of damaged and worn nets and vessel wastes. Approximately 800 tons of net are land filled every year in Dutch Harbor and Kodiak. In Kodiak, nets disposed in the landfill are buried. In Dutch Harbor nets are stockpiled while efforts to arrange for barge service to make annual trips to recycling centers are pursued. Kodiak makes used nets available to the public for a multitude of uses, including erosion control, landscaping, and pest control for gardens. The local Chambers of Commence have begun work on a feasibility study on burning used nets for power generation. In Kodiak, a program to recycle and re-use motor oil from vessels has reportedly resulted in savings of approximately $100 thousand a year on waste oil disposal. Some of the waste oil is used for heating purposes while the rest is recycled for re-use (Burch, 2000).

Some industry trade associations and vessels operators provide new crewmembers orientations that include a review of the requirements of MARPOL and company waste disposal policies. Some employee contracts also stipulate that the individual agrees to abide by all relevant laws and regulations, such as MARPOL and the MPPRCA. Most vessel operators, whether formally or informally, provide new crewmembers an orientation and overview of the policies and procedures they are expected to follow including waste disposal.

Some U.S. vessels operating in the North Pacific employ incineration as a waste management strategy. The Groundfish Forum is an industry trade association that represents nineteen of the twenty-five head and gut (H & G) catcher-processor vessels operating in the North Pacific. The average length of these vessels are 140 feet. Some of the vessels incinerate wastes at sea, including plastics. While most vessels employ burn barrels to incinerate wastes, a few vessels have incinerators on board. Incinerated ashes are brought to port for disposal (Henderschedt, 2000).

The fishing industry in Washington State is involved in several ongoing initiatives to

address the problem of lost fishing gear. Working with local dive groups, it has been involved in efforts to remove derelict gillnets from Puget Sound. A number of fishing vessel owners have donated their time and vessels as dive platforms to help remove these nets. Industry has initiated a program by which the location of lost nets in Puget Sound is provided to the Washington Department of Fish and Wildlife. The State reportedly is maintaining a database of this information and has produced maps showing the locations of nets (Zuanich, 2000).

The participants of the North Pacific Rim Fishermen's Conference on Marine Debris (1987) drafted and adopted the "Fishermen's Pledge to a Clean Ocean" (Appendix 1). The pledge is a commitment to: return all discarded fishing gear and other plastics to port and dispose of them properly; to make every effort to prevent accidental loss of fishing gear, make an effort to safely collect lost fishing gear found at sea return it to port for proper disposal; to follow the marine debris regulations required by MARPOL Annex V; and encourage all fishermen to follow this example. This pledge was distributed to fishermen as a plaque suitable for mounting on a vessel's bulkhead.

Many Japanese longline vessels operating in the Pacific, which typically average between 150 to 180 feet in length, are equipped with incinerators. Items not suitable for incineration are bundled for disposal at port (Araki, 2000).

Toppings et al. (1997) studied the waste disposal practices of fishing vessels on the East Coast of Canada in 1990 and 1991. Their study examines several industry actions and practices for managing wastes including damaged and worn gear. During the early 1990's, the Nova Scotia Maritime Fishermen's Union worked to encourage fishermen to bring their waste back to port. One of the major goals of this project, supported by Environment Canada, was to educate the fishing industry about the problem of marine debris. Another goal was to ensure that adequate disposal facilities, (e.g., barrels and dumpsters) were provided by various ports. In response, several Canadian fishing corporations reportedly initiated company policies prohibiting the discharge of their vessels' wastes at sea (Topping et al., 1997).

Toppings et al. (1997) reports that many of the non-U.S. fishing vessels operating off the Atlantic coast, particularly large factory trawlers of the former Soviet Union, incinerate their wastes. The authors note that Canadian vessels do not incinerate their waste because they are smaller vessels and Canadian law requires expensive air pollution reduction control equipment for operations that incinerate their waste.

In 1992, the United Nation's Conference on Environment and Development introduced the concept of responsible fisheries. Subsequently, the Food and Agriculture Organization (FAO) of the United Nations elaborated the concept in the "Code of Conduct for Responsible Fisheries," which was adopted in 1995. Compliance with the Code is voluntary.

The FAO Code of Conduct proposes inter alia the following actions to prevent marine pollution: (1) nations should introduce and enforce laws and regulations based on MARPOL; (2) fishing vessel owners and operators should fit their vessels with appropri-

ate equipment as required by MARPOL and consider fitting a shipboard compactor or incinerator if possible to treat garbage and other shipboard wastes generated during normal vessel operations. In addition the Code of Conduct recommends efforts be made to develop new technologies, methods and materials to reduce the loss of fishing gear and reduce the impacts of lost or abandoned gear (FAO, 1995).

The associated technical guidelines for responsible fisheries contain the following recommendations to reduce marine debris:

Vessels should attempt to recover all lost fishing gear and when not possible, report the type, extent, and position of the lost gear. In the event that any lost gear is encountered, it should be recovered if possible and returned to port. Again, if this is not possible the position and type of gear should be reported.

- Fishing gear should be marked in order to facilitate the identification of the owner.
- Attempts should be made to reduce conflicts between active and passive gear.
- When a fishing vessel fouls or interferes with gear that does not belong to it, it should take all practicable measures to minimize the extent of damage caused to the gear.
- All ports should be maintained and managed in such a manner as to ensure compliance with relevant marine pollution laws, particularly MARPOL Annex V.

Some segments of the fishing industry have endorsed the concept and principles of responsible fisheries. The Responsible Fisheries Society (RFA), an industry trade association affiliated with the National Fisheries Institute (NFI), has developed and adopted the "Principles for Responsible Fisheries." These principles are intended to provide guidelines to fishing and seafood firms and organizations to ensure responsible use of fishery resources and protect the environment. The groups that have adopted them are reportedly developing specific action plans to implement them.

3.0. UMMARY OF RECOMMENDATIONS FROM PREVIOUS CONFERENCES

Beginning in 1984 there have been several conferences convened to examine the issue of Marine Debris including the issue of derelict fishing gear. These include: the First International Conference on the Fate and Impact of Marine Debris, Honolulu, Hawai'i (Shomura and Yoshida, 1985); the North Pacific Rim Fishermen's Conference on Marine Debris, Kailua-Kona, Hawai'i (Alverson and June, 1988); an Interagency Task Force on Persistent Marine Debris, established by President Ronald Reagan in response to a letter from thirty U.S. Senators expressing concern about the growing problem of marine debris, published a report recommending various actions to address the problem (Cottingham, 1988); the Second International Conference on Marine Debris, Honolulu, Hawai'i (Shomura and Godfrey, 1990); and the Third International Conference on Marine Debris, Miami, Florida (Faris and Hart, 1995). Each of these group efforts produced a number of recommendations to address the problem of marine debris. The following recommendations, relevant to the fishing industry, are drawn from the previous conferences. Table 3 summarizes these recommendations.

First International Conference on Marine Debris (1984)

1. Undertake efforts to advise user and interest groups of the nature and scope of the marine debris problem. Such groups should include the fishing and plastics manufacturing industries, merchant carriers, the military, appropriate international groups, and the public.
2. Develop a means of identifying derelict gear through creation of a reference collection.
3. Obtain worldwide data on vessel disablement as a result of interactions with marine debris.
4. Develop alternative methods for both fishing and non-fishing activities to replace those methods that contribute significantly to the marine debris problem.
5. Investigate use of biodegradable materials in gear construction and the recycling of net materials.

North Pacific Rim Fishermen's Conference on Marine Debris (1987)

1. Tag fishing gear using the same technology as coded-wire tagged salmon.
2. Identify fishing gear and methods for which alternate materials or operating procedures may reduce their likelihood of becoming hazardous marine debris.
3. Assess the feasibility of and impediments to the recycling of waste fishing gear and other vessel-generated wastes.
4. Improve shore-side reception and management of vessel-generated wastes. In particular, to assist in the development of integrated waste management systems. This need is particularly acute in remote fishing communities.
5. Develop safe and effective shipboard incineration methods and other technologies for shipboard waste handling, storage, and transfer to shoreside facilities.
6. Examine cost-effective systems to facilitate the identification, recovery, and return of lost fishing gear to port or owners.
7. Quantify the economic losses to fishing and recreational vessels caused by marine debris.

Table 3. **Previous Conference Recommendations, Industry Actions**

	First International Marine Debris Conference (1984)	North Pacific Fishermen's Conference (1987)	Interagency Report on Persistent Marine Debris (1988)	Workshop on Derelict Fishing Gear (1988)	Second International Marine Debris Conference (1989)	Third International Marine Debris Conference (1994)
Recommendations						
Gear Modification	X		X	X	X	
Degradable Materials	X		X	X	X	X
Source Identification	X	X				
Economic Impacts	X	X	X		X	X
Education	X		X	X	X	
Gear Recycling	X	X	X	X		
Shoreside Disposal Methods		X				
Shipboard Disposal Methods		X				
Gear Recovery Methods		X	X			
Enforcement			X			
Gear Loss Reduction Methods		X	X		X	
Monitoring	X					
Regulatory Measures					X	X
Economic Incentives				X		

Report of the Interagency Task Force on Persistent Marine Debris (1988)

1. The U.S. Coast Guard should begin a public education campaign on the requirements of the Marine Plastic Pollution Research and Control Act as soon as possible to assure that owners and operators of all vessels, ports and the boating public are aware of requirements prior to enforcement.

2. The U.S. Coast Guard and other federal enforcement agencies should make enforcement of regulatory requirements of the Marine Plastic Pollution Research and Control Act a high priority.

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

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

5. NOAA should work with fishermen and equipment manufacturers to develop pragmatic ways to:
   a. reduce loss of fishing equipment, particularly traps, trawl nets, and gill nets;
   b. improve ways to recover lost fishing traps and nets; and
   c. recycle used fishing nets and nets fragments.

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

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

Oceans of Plastics: A Workshop on Fisheries Generated Marine Debris and Derelict Fishing Gear (1988)

1. Explore financial incentive-based solutions for reducing gear discard and loss. These could include net deposits, gear inventories, and bounty systems.

2. Pursue programs to educate the public and users groups to help reduce marine plastic debris.

3. Pursue technological solutions to reduce marine plastic debris including the use of degradable plastics in packaging as well as in fishing gear, recycling plastics and marking nets at the time of manufacture to identify owners at some point in the future.

Second International Conference on Marine Debris (1989)

1. Pursue technological and procedural solutions to the marine debris and solid waste problems while avoiding policies and regulations that may restrict solutions.

2. Expand marine debris and solid waste disposal education to people and institutions worldwide, recognizing regional and cultural differences in the perception of these problems.

3. Design and implement experiments to evaluate ghost fishing in gillnet and trap fisheries with high gear loss rates, developing mitigative measures as needed.

4. Evaluate 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.

Third International Conference on Marine Debris (1994)

1. Research and implement mechanisms to reduce fishing gear loss. These could include technological changes in gear design or incentives to recover lost gear. Given the appropriate incentives, the collection of derelict gear may be feasible.

2. Establish an impact reporting system to promote and collate observations by beach users, fishermen, oceanographers, scuba divers, and others. Start by compiling past records.

3. Make efforts to recover lost fishing gear in areas where it is likely to be concentrated. Also, take steps to better evaluate the kinds and amounts of fish caught and the potential effectiveness of such work to clean up hazardous ghost fishing gear. Establish a system to record gear loss by commercial fishermen.

Table 4 provides a summary of comments received from several Pac-Rim nations concerning the types of ongoing governmental and industry programs and actions needed to deal with the issue of derelict fishing gear.

Table 4. **Summary of Governmental and Industry Actions for Derelict Fishing Gear**

	Nation					
	Cook Islands[1]	Fiji[2]	Japan[3]	Philippines[4]	Korea[5]	Taiwan[6]
Recommendations						
Degradable Materials					X	
Education	X	X	X	X		X
Gear Recycling	X			X	X	
Shoreside Disposal			X	X	X	X
Shipboard Disposal Methods			X			
Gear Removal & Recovery Methods					X	X
Enforcement	X	X	X			
Gear Loss Reduction Methods					X	X
Monitoring		X		X		
Regulatory Measures	X	X				X
Gear Marking				X		
Industry Code of Conduct	X					
Regional/International Cooperation	X	X				
Gear Restrictions	X	X				X
Clean-ups					X	

1. Ministry of Marine Resources, Cook Islands
2. Ministry of Agriculture Fisheries and Forests, Fisheries Division, Fiji Islands
3. Office of Ecosystem Conservation, Resources and Environmental Research Division, Fisheries Agency Government of Japan
4. Bureau of Fisheries and Aquatic Resources, Republic of the Philippines
5. Ministry of Maritime Affairs and Fisheries, Republic of Korea
6. Fisheries Administration, Republic of China

4.0. POTENTIAL TOPICS FOR WORKING GROUP DISCUSSION

A. Gear Modification

1. Degradable materials

Synthetic fibers currently used in fishing gear construction degrade primarily due to exposure to UV radiation from sunlight and heat. As the material degrades it becomes more susceptible to microbial degradation. While the technology exists to chemically modify plastics to accelerate degradation and decomposition very little is known about the effectiveness of these techniques in the marine environment. Degradable escape panels are widely used in crab, lobster, and shrimp traps. The cost of degradable materials that could potentially be used in fishing gear construction remain significantly higher than those synthetic fibers currently used (e.g., nylon and polyethylene). Questions remain about both the performance and safety of degradable plastics in fishing gear construction (Andrady, 2000).

2. Lightstick modifications

Lightsticks are lost during the course of normal longline fishing operations. Lightsticks are positively buoyant and if ingested by marine mammals, seabirds, or marine turtles can cause health problems. Proposed solutions to the problem have included requiring a deposit for lightsticks, increasing the length of the light stick to make it more difficult for marine life to ingest and developing sinking light sticks.

Lindgren and Pittman, a major manufacturer of lightsticks used in longline fisheries, has developed a battery-powered sinkable light stick. While initially more expensive than disposables, it is estimated that over time the costs will be cheaper than chemical disposables. Based on initial trials conducted in Florida there may be an increase in catch rates associated with the new lightsticks.

B. Gear Marking

1. Gear Marking

The concept of marking fishing gear during manufacture for future identification has been proposed. The marking of nets through the use of some type of tracer has been proposed as a mains to help identify and reduce sources of lost fishing gear. Concerns have been expressed about the concept. During the lifetime of a net it may be sold, traded, or loaned and thus used by multiple vessels. Another consideration is the long residency time of lost fishing gear in the marine environment. Recovery of lost fishing gear may not occur until years after its loss. The vessel operator that lost or discarded the gear may no longer be involved in fishing. Gear marking is a potentially useful tool to help focus prevention, reduction, and enforcement efforts on specific domestic and international sources of derelict fishing gear.

2. Color coding trawl web

Developing a color coding system to has been proposed as one possible means to identify sources of derelict webbing. In addition to the fishing industry, merchant shipping reportedly uses webbing that is indistinguishable from that used in some fishing net construction.

C. At-sea Disposal Systems
The U.S. Navy has spent millions on developing vessel disposal systems for waste. The problem is scaling these systems down to a typical commercial fishing vessel. Some systems require more power than available on average commercial vessels. Some of the large, factory vessels might be able to accommodate the waste disposal systems developed by the Navy. The Government of Japan has provided support for the installation of on-board incinerators by the fishing industry.

At sea disposal systems include incinerators, burn barrels, and compactors. A number of issues related to the use of the type of disposal methods include safety, effectiveness, and costs.

D. Education and Outreach
Educational programs, designed to inform all user groups and the public, have wide support among the fishing industry. Education is seen as one of the most effective means of influencing members of the public including fishermen (Anonymous, 1988).

E. Enforcement
Enforcement of MARPOL is difficult. Nonetheless, the USCG has vigorously pursued enforcement of the law. Fines for MARPOL violations are high and have served as significant determent to the illegal disposal of nets and other plastics by fishing vessels. Review and inspection of fishing vessels waste management plans, procedures, and logbooks by the USCG has led to enhanced compliance with MARPOL by the fishing industry.

F. Fishing Gear Disposal
Net disposal and recycling programs have proved popular with fishermen and have generally received industry support where implemented.

G. Economic Incentives
Providing economic incentives to help prevent and reduce the problem of derelict fishing gear has been proposed. Possible incentives include gear deposits, inventory, and bounties for lost gear.

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Appendix 1.

"Fisherman's Pledge For a Clean Ocean"

I recognize that a clean, productive ocean is necessary for the livelihood of fishermen throughout the world.

I realize that pollution and marine debris, particularly plastics, threaten marine life and my safety at sea.

Therefore, I pledge to:

Return all discarded fishing gear and other plastics to port and dispose of them properly;

Make every effort to prevent accidental loss of fishing gear;

Make an effort to safely collect others' lost fishing gear and debris I find at sea and return them to port for proper disposal;

Follow the marine debris regulations required by the international treaty, MARPOL Annex V; and

Encourage all my fellow fishermen to follow my good example.

Through these actions I will preserve a clean ocean today and for fishermen of the future.

MITIGATION OF ENVIRONMENTAL IMPACTS OF DERELICT FISHING GEAR THROUGH DEBRIS REMOVAL AND ENVIRONMENTAL MONITORING

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BACKGROUND

Prior to the 1950s, discarded or lost fishing gear posed little long-term environmental threat, as nets were almost exclusively composed of natural fibers (linen, cotton, jute, hemp, manila, and sisal) susceptible to environmental degradation (Uchida, 1985). Nylon webbing first appeared in Japanese nets in 1949, and by 1964, 95% of nets produced in Japan were composed of synthetic fibers (Japan Chemical Fibers Association, 1971). Currently, almost all of the fishing gear in developed countries is composed of durable synthetic fibers (Klust, 1973). The production and availability of synthetic fibers, coupled with mechanization and echo sounding, revolutionized the fishing industry (Kristjonsson, 1959) by producing nets that were functionally impervious to degradation (Andrady, 1990). The durability of fishing gear composed of synthetic fibers, when discarded or lost, generates persistent waste in the marine or littoral environment.

Fishing gear loss appears to be increasing as a result of economic pressures that have contributed to modifications in fishing operations and efforts in a wide variety of fisheries (Carr and Harris, 1997). Carr and Harris (1997) link dwindling target stocks, advances in equipment handling and materials technology, solid waste disposal limitations and loss reimbursement programs to increased potential for fishing gear loss or discard. Estimates of gear loss have primarily been inferred based on fishery effort, limited fishery observer data or beach surveys, with much emphasis on the Pacific region. Uchida (1985) reported that in the mid-1980s, 170,000 km of gill net, 2,000 km of purse seine, 5,500 km of trawl net and 8,900 km of miscellaneous net gear were available to North Pacific net fisheries and provided this as an estimate of the size of the source from which derelict fishing gear was generated. Uchida (1985) speculated that gear losses were highest in the gill net fisheries, followed by trawl fisheries and set net fisheries. Low et al. (1985) utilized observer data to generate minimum estimates of gear loss in Alaska trawl fisheries from 1954 to 1983, which they reported at sixty-five nets total. Sighting surveys conducted in the North Pacific from 1986 to 1991 identified two regions of high derelict fishing net density, 20 to 30 N, 150 to 130 W and 30 to 40 N, 140 to 150 E (Matsumura and Nasu, 1997). A significant

high density area of derelict fishing gear was also reported northeast of Hawai'i by Mio et al. (1990). Kubota (1994) proposed a convergence zone associated with the North Pacific subtropical high as a mechanism for the disproportionate accumulation of marine debris from the greater North Pacific in the area north of Hawai'i. Recent oceanographic measurements support Kubota's model (see Brainard et al., 2000) and suggest a non-homogenous distribution of marine debris. The amount of derelict fishing gear accumulating in this region has not decreased since the early-1980s, despite the ratification of MARPOL Annex V (1973/1978) by the majority of the world's fishing nations (Henderson, in review).

Derelict fishing gear, once in the marine and littoral environment, has widespread environmental and economic impacts. One hundred thirty-six species of marine animals have documented records of entanglement in marine debris, including numerous threatened and endangered species (Laist, 1996). Eighty-six percent of the world's sea turtle species and 28% of the world's marine mammal species, as well as seabirds, fish, and crustaceans have been recorded entangled in derelict fishing gear. Mortality resulting from entanglement in fishing gear has been proposed to explain population level declines in the northern fur seal (Callorhinus ursinus), a seal listed as depleted under the Marine Mammal Protection Act of 1973 (Fowler et al., 1990). The critically endangered Hawaiian monk seal (Monachus schauinslandi) suffers the greatest entanglement rate of any pinniped (seal or sea lion) reported to date, nearly twice that of the northern fur seal (Henderson, in review). Derelict fishing gear may also negatively affect target stocks, as well as noncommercial species, by continuing to fish after becoming lost or discarded, thus removing animals otherwise potentially available to active fishing operations. The greatest potential for this "ghost-fishing" is associated with gillnets, followed by trap or pot gear (Carr and Harris, 1997). Derelict fishing gear may also function as a vector for the introduction of alien species. As nets circulate around ocean gyres they are subject to colonization by encrusting, epibiont, or other biota and may subsequently transport these organisms to novel environments (Winston et al., 1997). Recently, derelict fishing gear has been identified as a direct threat to coral reef ecosystems through the abrading and scouring of coral substrate, as circulating nets snag on shallow reefs (Brainard et al., 2000; Donohue, unpublished data).

Here we briefly review recommendations pertaining to debris monitoring and removal from previous meetings, followed by a discussion of survey techniques used to monitor marine and littoral environments for derelict fishing gear. We also describe selected methods employed to remove derelict fishing gear from these environments. Lastly, we discuss the use of remote-sensing technology to aid in the prediction of areas where marine debris is likely to accumulate, and the potential utility of remote-sensing technology to monitor and manage ecosystem health, including marine debris burden. We hope this abridged summary will stimulate further discussion on the monitoring and removal of derelict fishing gear and direct the reader to the primary literature for additional detail.

SUMMARY OF PREVIOUS CONFERENCE RECOMMENDATIONS

Over the past 16 years, several international meetings have convened to address the problem of marine debris in the world's oceans. These included the Workshop on the Fate and Impact of Marine Debris (1984, Honolulu, HI), The North Pacific Rim Fishermen's Conference on Marine Debris (1987, Kailua-Kona, Hawai'i), The Second International

Conference on Marine Debris (1989, Honolulu, Hawai'i) and The Third International Conference on Marine Debris (1994, Miami, Florida). In addition, The Alaska Sea Grant College Program, under the direction of the United States National Oceanic and Atmospheric Administration (NOAA), Office of the Chief Scientist, published a Report of the Interagency Task Force on Persistent Marine Debris in 1988. Selected fishery-related recommendations and conclusions from these meetings are presented in Appendix 1.

Despite the passage of over sixteen years since the first workshop, the recommendations and conclusions of subsequent meetings with regard to monitoring and removal (mitigation) of marine debris are notably consistent. Certainly, in part, this speaks to the wisdom of early conference and task force participants in identifying seminal conclusions and recommendations that have remained relevant. Equally as certain, the persistence of recommendations and conclusions over time reveals both the need for continued monitoring, and increased mitigation, of this persistent problem. Following are synopses of the four most frequently cited recommendations and conclusions from previous meetings with specific regard to environmental monitoring and marine debris removal:

1) **Identify the distribution, abundance, density, and type of persistent debris in the marine environment.**
   The first Workshop on the Fate and Impact of Marine Debris (Shomura and Yoshida, 1985) affirmed the widespread occurrence of debris of terrestrial and aquatic (shipborne) origins in the marine environment and concluded that research on marine debris distribution was needed. Subsequent conferences reiterated the need for research to enhance understanding of marine debris dynamics in the world's oceans to facilitate mitigation efforts (Shomura and Godfrey, 1990; Alverson and June, 1988; Coe and Rogers, 1997; Faris and Hart, 1995). Specifically, information on distribution, abundance, density, and macro- and meso-scale movements of marine debris were deemed incomplete. Also noted was the paucity of information on marine debris in oceanic regions other than the North Pacific (Shomura and Yoshida, 1985; Alverson and June, 1988).

2) **Determine the fate of persistent debris in the marine environment.**
   Where marine debris is present, it poses variable risks depending on its persistence in the marine or littoral environment. Further, the susceptibility, or lack thereof, of plastic debris to nonchemical deterioration and chemical degredation (bio-, photo-, thermooxidative and hydrolytic; see Andrady, 1990) affects its potential for environmental damage such as ghost fishing, entanglement and ingestion by wildlife, and substrate damage. Recommendations for research pertaining to the fate of marine debris were presented at the 1984 Workshop on the Fate and Impact of Marine Debris (Shomura and Yoshida, 1985) and reiterated in 1994 at the Third International Conference on Marine Debris (Coe and Rogers, 1997; Faris and Hart, 1995).

3) **Recover (clean) marine debris from the marine and littoral environment.**
Once in the marine environment, the recovery of debris is the most straightforward mechanism to mitigate environmental damage. The North Pacific Rim Fishermen's Conference on Marine Debris advocated an examination of cost effective systems to facilitate the recovery and return of lost fishing gear (Alverson and June, 1988). The Interagency Task Force on Persistent Marine Debris recommended that U.S. NOAA collaborate with fishermen and equipment manufacturers to develop pragmatic ways to improve recovery of lost fishing gear (Alaska Sea Grant, 1988). Recovery of lost gear, through incentives or other means, and the evaluation of the effectiveness of efforts to clean up ghost nets were included in recommendations of the Third International Conference on Marine Debris (Coe and Rogers, 1997; Faris and Hart, 1995).

4) **Conduct research on environmental impacts of marine debris.**
Efforts to establish, and continue, examinations of the effects of marine debris on the environment have been repeatedly recommended. Early recommendations sought to document evidence of wildlife interactions with debris (Shomura and Yoshida, 1985). Subsequent conclusions advocated increased support of studies of entanglement of wildlife in marine debris, particularly threatened, endangered or depleted species (Alaska Sea Grant, 1988; Shomura and Godfrey, 1990). Also noted was the need to investigate impacts of persistent debris ingestion on such organisms as seabirds, marine turtles, and marine mammals (Shomura and Godfrey, 1990; Coe and Rogers, 1997; Faris and Hart, 1995). The Third International Conference on Marine Debris included discussion on the potential for the introduction of alien species by marine debris and recommended investigations addressing this concern (Coe and Rogers, 1997; Faris and Hart, 1995).

DERELICT FISHING GEAR MONITORING AND REMOVAL ACTIONS

Beach Surveys

The first systematic assessments of derelict fishing gear resulted from beach surveys, which continue to provide valuable information on the prevalence of derelict fishing gear (see Ribic et al., 1992). These studies are often a more cost effective way of monitoring debris trends than at-sea efforts, and may be completed concurrently with environmental monitoring of wildlife populations (Torres et al., 1997; Hucke-Gaete et al., 1997; Henderson, in review). Ribic and Johnson (1990) classify beach surveys as either beach-focused or ocean-focused. Beach-focused surveys estimate the amount of debris on a specific beach at a specific time. Ocean-focused surveys examine trends in marine debris on specific beaches over time as an indicator of oceanic conditions. Ocean-focused surveys have provided important information on large or very large derelict fishing gear (nets and rope) trends. If derelict fishing gear is removed from beaches during these studies, mitigation of further environmental damage, such as wildlife entanglement, is possible.

An opportunistic study on Alaska's Amchitka Island was begun in 1972 by Theodore Merrell of the U.S. National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS). The majority of anthropogenic debris on Amchitka Island was composed of derelict fishing gear components (Merrill, 1985). Over time, the focus of this project evolved from the amount and type of debris present to the use of trawl web dynamics to assess the impacts of MARPOL Annex V (for a more detailed

chronology of this study see Ribic et al., 1992). Derelict fishing gear on these beaches was routinely removed in later years of the study (Ribic et al., 1992).

Beach surveys of derelict fishing gear on the remote Northwestern Hawaiian Islands (NWHI) from 1982 to 1986 documented the presence of 773 net or net fragments and were completed in conjunction with studies on entanglement rates of the endangered Hawaiian monk seal (Henderson, unpublished data). Recently, Henderson (in review) reported no decline in the amount of derelict fishing gear on the NWHI from 1982 to 1999, suggesting a failure of MARPOL Annex V to reduce the impacts of derelict fishing gear in this region. Until the late-1990s, derelict fishing gear was regularly burned on the beaches of these atolls to reduce the entanglement hazard to monk seals and other wildlife. Subsequently, due to concern over toxic byproducts, burning of debris was restricted in areas under the jurisdiction of the U.S. Fish and Wildlife Service, tasked with management of the Pacific Remote Island National Wildlife Refuges. Presently, derelict fishing gear that accumulates on these islands is analyzed and stored in bins and later removed to ships by a multi-agency partnership led by the U.S. NMFS. In 1999 alone, 12,500 pounds of derelict fishing gear were removed from the beaches of just two NWHI (Donohue, unpublished data).

Slip and Burton (1991) examined the beaches of two islands in the Southern Ocean, Heard Island and Macquarie Island. Heard Island, in the Indian Ocean sector, is near fisheries supported by the Kerguelen Plateau (Williams, 1988). Macquarie Island is in the Australasian sector, which does not support a regional fishery. Fishery related debris accounted for 40% of all artifacts at Heard Island and 29% on Macquarie Island.

Beach surveys for marine debris have also been conducted in other regions, most often coupled with cleanup efforts. These beach cleanups have been conducted in the USA, the UK and Australia, often relying on volunteers and conducted near metropolitan centers (Jones, 1994; Ribic et al., 1996; Rees and Pond, 1995). For example, in Australia, fishing debris accounts for 2%-41% of the total debris on beaches (Slater, 1991; Edwards et al., 1992; O'Callaghan, 1993; and see Jones', 1994 review). Derelict fishing gear is also a notable component of beach surveys for marine debris in Puerto Rico, Mexico and Barbados (Coe et al., 1996).

Concerns associated with beach surveys include logistical limits to geographical areas surveyed or cleaned, potential inherent biases associated with differential fates of marine debris types at sea (Dixon and Dixon, 1981a) and inconsistent or statistically weak sampling designs which prevent meaningful comparisons between efforts. Nevertheless, beach surveys for derelict fishing gear provide valuable information, particularly where a time series of data exist, and provide a mechanism for large numbers of the public to involve themselves in marine management issues. Lastly, volunteer beach cleanups are the primary mechanism for the removal of marine debris from the littoral environment.

Shipboard Sighting Surveys

Shipboard sighting surveys for the assessment of marine debris distribution and amount consist of visually inspecting the ocean surface for floating debris. This method is particularly suited for medium to large derelict fishing gear items (see Ribic et al., 1992 and Hess et al., 1999), and requires dedicated or opportunistic sea craft, good visibility and favorable

weather. Observers stationed on the flying bridge or other elevated sections of the ship visually search for debris items in strip or line transects. During strip transects, debris items are counted on the side of a ship within a specified distance, commonly ranging from 50 m (Day and Shaw, 1987; Day et al., 1990a) to 100 m (Dixon and Dixon, 1983). During line transects all debris items visible are counted regardless of their distance from the ship. When the perpendicular distance of the objects to the ship can be accurately measured, the line transect method is preferable (Ribic, 1990; Burnham et al., 1985). Platforms of opportunity are often used as a result of cost constraints and thus the sampling area, the height of the observer above the water, ship speed, etc. may not be controlled by the researcher. These factors affect the accuracy of the assessments (Mio and Takehama, 1988; Ribic et al., 1992). Furthermore, as the characteristics of the debris (size, color, buoyancy, shape) affect its visibility to surveyors, accurate characterization of debris is not readily accomplished (Mio and Takehama, 1988).

Despite these challenges, numerous informative sighting surveys have been completed. Dedicated vessels combined with vessels of opportunity have been used in Pacific-wide surveys conducted by the Fisheries Agency of Japan from 1986 to 1991 (Matsumura and Nasu, 1997). Matsumura and Nasu (1997) reported derelict fishing net density to be relatively higher in the midlatitudinal area of 20 to 30 N, 150 to 130 W of the eastern Pacific Ocean. They also noted a high density of derelict fishing nets on the Pacific Ocean side of Japan from 30 to 40 N, 140 to 150 E. The distribution of derelict fishing gear other than nets was found to have a wider general distribution, with the greatest densities (greater than 120 pieces per 100 square nautical miles) found from 25 to 35 N, 130 to 180 W. Mio et al. (1990) and Mio and Takehama (1988) previously reported a high-density area of derelict fishing nets northeast of Hawai'i during sighting surveys conducted in 1986. Day and Shaw (1987) also completed a multiple year study in the Gulf of Alaska in 1984 and 1985. Other baseline studies have been conducted in the North Pacific (Dahlberg and Day, 1985; Ignell, 1985; Jones and Ferrero, 1985; Ignell and Dahlberg, 1986; Day et al., 1990; Shaw, 1990). Additional regional sighting surveys were conducted around the Pribilof Islands in the Bering Sea, the main breeding islands of the northern fur seal (Callorhinus ursinus) (Yoshida and Baba, 1985; Baba et al., 1988, 1990). Fewer sighting surveys for marine debris have been completed in oceans other than the Pacific; however, the North Sea and Mediterranean Sea have been surveyed using vessels of opportunity (Dixon and Dixon, 1983 and Morris, 1980, respectively). Removal of derelict fishing gear is not a customary component of sighting surveys.

Shipboard Trawl Surveys

Shipboard trawl surveys can be used to survey marine debris on the surface of the water or on the seafloor. Neuston-type nets can be used to sample small floating marine debris and larger nets can be deployed to sample debris that has sunk to the benthos (Ribic et al., 1992). The latter are useful for the assessment of medium to large derelict fishing gear items. Trawling techniques mimic those used for fishing, with the net deployed to sample or "catch" debris resting on the seabed (see Ribic et al., 1992). The mesh size of the net used determines the minimum size of debris that may be caught. Thus, when comparing trawl-sampling studies, mesh size must be accounted for in the interpretation of results. Other factors that may affect trawl-sampling studies include vessel variability, weather, footrope variability, depth variability and measurement variability (Ribic et al., 1992).

Trawl sampling studies may be conducted opportunistically in association with commercial, experimental, or managed fisheries or with dedicated cruises targeting marine debris. The common occurrence of marine debris in benthic trawls on the continental shelf of the Northeast Gulf of Alaska was reported as early as 1976 (Jewett, 1976). Bering Sea fishing areas were also found to have greater amounts of benthic debris than areas not fished (Feder et al., 1978). More recently, working with the Alaska Department of Fish and Game, Hess et al. (1999) investigated fishery-related items caught during benthic trawls to survey crab and groundfish resources around Kodiak Island, Alaska. In the three years of their study, fishery-related items comprised 46%, 42%, and 38% of the total benthic debris recovered. Fishery-related debris densities ranged from 4.5–25.0 items/km2. After evaluation of fishery effort near Kodiak Island, and the subsample of fishery-related debris deemed potentially harmful to wildlife by the investigators, Hess et al. (1999) concluded that annual benthic trawl surveys for debris around Kodiak Island were unwarranted. The debris densities reported by Hess et al. (1999) were less than those reported for other benthic trawl surveys in the Bay of Biscay (203 items/km2; Galgani et al., 1995a) and on the continental shelf of the Western Mediterranean Sea (1935 items/km2; Galgani et al., 1995b) and were between those reported by June (1990) for the Eastern Bering Sea (2–7.5 items/km2) and off the Oregon Coast (150 items/km2).

Although shipboard trawl surveys have been used most extensively for surveying benthic marine debris, they cannot be employed in very shallow waters, on steep slopes or in sea canyons. A result of the shipboard trawl survey technique is the removal of sampled derelict fishing gear from the environment. Shipboard trawls have not been used in dedicated cleanup efforts.

Benthic Diving Surveys

Other methods investigated or proposed to survey benthic marine debris involve submersibles, towed camera systems and divers. The latter is the main focus of this section, as diving survey and removal efforts have recently been particularly successful for removing large amounts of derelict fishing gear from coral reef environments of the NWHI (Donohue, unpublished data). The cost and availability of manned submersibles and remotely operated vehicles (ROVs) have limited their use in marine debris surveys (Ribic et al., 1992). A manned submersible equipped with an external-mounted video camera was used by Carr et al. (1985) to survey commercial gillnetting sites in 1984. Carr et al. (1985) surveyed over 40.5 ha and documented ten derelict gill nets. Galgani and Andral (1998) investigated the use of a towed camera array to survey benthic marine debris, but the inability to quantify small debris items and difficulties with the deployment and positioning of the array prevented its successful use.

Diving surveys for benthic marine debris have not been widely conducted, but have recently been utilized extensively in the NWHI. Carr et al. (1985) used scuba divers to monitor the ghost-fishing of a simulated derelict gill net set in Cape Cod Bay. Benthic debris in McMurdo Sound, Antarctica, was also documented with divers (Lenihan et al., 1990).

A large-scale project utilizing divers to conduct surveys for, and remove, derelict fishing gear in the NHWI began with a pilot study in 1996 (Boland, unpublished data). The U.S. NMFS Honolulu Laboratory identified marine debris of a maritime origin, particularly derelict fishing gear, as a threat to the coral reef ecosystems of the NWHI (Brainard et al., 2000; Henderson, in review). In 1996 and 1997, the U.S. NMFS Honolulu Laboratory refined diver survey and removal techniques, removing 10,000 pounds of derelict fishing gear from the shallow coral reefs of the NWHI (Boland, unpublished data). In 1998 and 1999, the U.S. NMFS Honolulu Laboratory expanded efforts by partnering with a consortium of state, federal, and private organizations. Presently, the U.S. NMFS leads annual multi-agency, multiple ship efforts to survey and remove derelict fishing gear from the NWHI. The distribution, density, type, and organic fouling of derelict fishing gear is documented using snorkel divers towed in systematic parallel track survey transects behind small boats. Debris is documented using a global positioning system (GPS) and still and video photography. Derelict fishing gear is subsequently recovered using small boats and snorkel and scuba divers supported by U.S. NOAA and U.S. Coast Guard vessels. In 1999 alone, 18,500 pounds of derelict fishing gear was recovered from the NWHI coral reefs (Donohue, unpublished data). To date, over 77,000 pounds of derelict fishing gear have been recovered from the NWHI by these efforts (Boland, unpublished data; Donohue, unpublished data). Coral reef debris density ranged from 1.0–62.2 items/km2 (Donohue, unpublished data).

Human divers can execute surveys for derelict fishing gear in areas too shallow to employ submersibles or ROVs, and where seabed topography restricts trawl surveys (Ribic et al., 1992). Furthermore, human divers can remove derelict fishing gear from the substrate in a surgical fashion, reducing additional environmental damage to reefs during removal. Small sea craft towing divers can be deployed from ship platforms at oceanic sites or from land-based laboratories for coastal surveys. Diving surveys are most easily executed in benign climates and relatively shallow waters where diver safety can be maximized.

Drawbacks associated with the use of divers to survey and remove marine debris include expense, logistics, reliance on favorable weather, and good water visibility. Although supported through in-kind contributions, the thirty-day multi-agency derelict fishing gear survey and removal effort in the NWHI in 1999 cost in excess of one million U.S. dollars. These costs include two large ship platforms for housing and deploying divers and small boats, transport of recovered debris back to Honolulu, Hawai'i. Once derelict fishing gear is recovered it must be disposed of properly at port either through landfill, incineration, or recycling. Additionally, in ecologically sensitive areas where endangered or protected species occur, studies must be planned so as to minimize impacts to wildlife.

Remote-Sensing/Oceanography

Recently, the utility of remote sensing to monitor and assess marine debris has been investigated. Over the past two years, the U.S. NOAA Fisheries and NOAA CoastWatch oceanographers have been developing methods to apply knowledge of oceanographic processes and use of satellite remote sensing of ocean surface properties to identify and monitor regions where derelict fishing gear and other forms of marine debris would most likely accumulate (see Brainard et al., 2000).

Using an array of satellite environmental sensors, oceanographers are now able to observe properties of the ocean surface with much improved spatial and temporal resolution. These properties include surface winds (QuikSCAT and other scatterometers), sea surface temperature (AVHRR and GOES), sea surface height and computed geostrophic currents (TOPEX/Poseidon) and ocean color or chlorophyll (SeaWiFS and earlier CZCS). With these modern tools, scientists are now better prepared to assess the extent of the threat posed by marine debris over the vastness of the global ocean.

Using high-resolution scatterometer winds to compute wind stress curl over the Pacific Ocean, Brainard et al. (2000) have confirmed and expanded upon Kubota's (1994) finding of a marine debris accumulation region centered north of the Hawaiian Islands. Regions of oceanic convergence are most likely to accumulate marine debris while regions of oceanic divergence are least likely to accumulate marine debris. Brainard et al. (2000) found oceanic convergence to be highly nonstationary with pronounced seasonal and interannual variability. Convergence in the North Pacific is highest along the subtropical front in the western half of the basin during the winter months. In the vicinity of the NWHI, and in the main Hawaiian Islands, accumulation would be expected to be highest to the northwest and lowest to the southeast. During the summer, convergence is generally much weaker and more diffuse across the North Pacific with the region of highest convergence shifted to the eastern portion of the ocean basin several hundred miles off the California and Oregon coasts. The region of high convergence, or likely accumulation of marine debris, is strengthened and enlarged during periods identified as El Niño warm events in the tropical Pacific. During the 1992 and 1998 El Niño events, the region of convergence was observed to expand much further south to include the main Hawaiian Islands. This result partially explains the documented increase of marine debris found on beaches and reefs of the main Hawaiian Islands during 1998 (Brainard and Foley, unpublished data).

Presently, oceanographic knowledge and satellite observations of ocean conditions are being used to assist marine debris removal efforts by helping to locate areas in the NWHI and elsewhere that are most likely to have the highest concentrations of marine debris. From an oceanographic viewpoint, the coral reef ecosystems at Kure, Midway, and Pearl and Hermes Atolls are expected to have the highest average encounter rate of marine debris since these areas are more centrally located in the strongest mean convergence zone. Of course, bathymetry, reef structure and local processes such as small-scale flow regimes and wave forcing, also play a significant role in entangling debris on coral reefs and beaches.

These oceanographic analyses suggest that much lower accumulation rates of derelict fishing gear and other marine debris would be expected at most of the other tropical islands and atolls of the Pacific. Exceptions include the Japanese islands of the Ogasawara Archipelago, Kazan Group, and Minami-Tori, where moderately high accumulation rates might be expected. The same analysis predicted very low accumulation of marine debris in the U.S. Line and Phoenix Islands of the central equatorial Pacific; this was verified during a coral reef assessment cruise to these islands in March 2000 (Brainard, unpublished data). A similar analysis is currently underway for the entire Pacific basin (Brainard, unpublished data). Preliminary results indicate that wind-driven ocean convergence is less intense in the South Pacific Ocean. However, there are broad regions of

moderate ocean convergence, which may play a significant role in the transport and accumulation of marine debris. The utility of oceanographic analyses in other oceans to direct marine debris removal efforts should be investigated.

The removal of derelict fishing gear at sea, before it encounters reefs or damages wildlife, may be the most advantageous mitigation action once debris enters the marine environment. An ambitious proposal by the NMFS Honolulu Laboratory aims to investigate the feasibility of such efforts. Once the majority of the derelict fishing gear is removed from the coral reefs and beaches of the NWHI, Honolulu Laboratory scientists are proposing a comprehensive multi-agency program to begin removing marine debris at sea. By so doing, they hope to prevent much of the ecological damage, which is now threatening the coral reef ecosystems and protected species of the region. This plan takes advantage of the fact that ocean currents and convergence processes do an efficient job of accumulating marine debris from around the Pacific Ocean into relatively well-defined zones. Combining satellite observations of winds, sea surface temperatures (SST), ocean color and sea surface height, they believe they can identify general regions to direct aircraft and ships to interdict debris at sea. These regions of highest convergence would be along frontal zones of the order 100 km by 1000 km. These scales are well covered by satellite-based measurements. However, the oceanographic tools (e.g., SST, ocean color, and wind) are useful only for inferring likely positions; they do not have sufficient resolution to image the actual debris. Using aircraft equipped with synthetic aperture radar (SAR) or hyper-spectral visible light sensors, scientists could resolve scales less than 1 m, allowing them to map individual pieces of derelict fishing gear on the ocean surface (see below). This information would then be transmitted to surface debris removal vessels. Provided with maps of areas of highest concentration, the vessels could then use helicopters to guide them to individual derelict fishing gear items for at-sea removal. Although this multi-level scenario presently seems fanciful and costly, at-sea removal would potentially be no more expensive per ton of debris removed than the existing methodology of using divers to locate and cut away debris from the coral habitat.

Remote-Sensing/Geographic Information Systems (GIS)

Although significant efforts to find and remove derelict fishing gear have been ongoing for a number of years, particularly in the NWHI, traditional beach cleanups and ship-supported recovery efforts are limited to relatively small areas. For example, less than 5% by area of the NWHI reef habitat has been surveyed and even less of the habitat has been cleared of debris. To facilitate efforts to identify and remove derelict fishing nets from the NWHI management area, the NMFS Honolulu Laboratory has begun to investigate the use of remotely sensed imagery from a variety of sources linked with a broad range of other data (ocean winds and shear lines, field surveys, bathymetry, political boundaries) within a geographic information system (GIS). Remote imagery combined with in-situ survey data will be used to map and assess marine debris and to inform and improve debris removal efforts planned in 2000 and 2001. Although remote sensing has proved useful in a wide array of marine environmental applications, the ability to use imagery from a variety of airborne and satellite sensors to locate and identify derelict nets and other marine debris is unproved. Until recently, remote-sensing applications have been hampered by inaccurate base maps and low-resolution imagery available from U.S. government mapping agencies and satellite sensors. Full utilization of the GIS has been limited by the lack of accurate geographic data and limited amounts of marine debris survey data collected.

MITIGATION OF ENVIRONMENTAL IMPACTS OF
DERELICT FISHING GEAR THROUGH DEBRIS REMOVAL AND
ENVIRONMENTAL MONITORING

In 2000, a number of proposals to obtain high-resolution imagery from three separate sources have been submitted by NMFS Honolulu Laboratory and tentatively approved. As part of the Hawai'i Coral Reef Initiative, funding has been promised: (1) to obtain high resolution IKONOS satellite images of some of the NWHI that can be used to create valid base maps and assist in the identification and removal of marine debris, derelict nets particularly, that threaten the health of NWHI coral reef ecosystems, (2) to identify alien species that may be introduced to those ecosystems on such nets, and (3) to begin to develop a GIS-based remote sensing capability to monitor and model changes to shallow-water (<20 m) coral reef habitat in the NWHI. The privately owned and operated IKONOS imager satellite can provide 1 m resolution panchromatic and 4 m resolution multispectral (red, green, blue bands) imagery at 12 m horizontal and 10 m vertical accuracy with no ground control. With ground control stations, an exceptional 2 m horizontal and 3 m vertical accuracy can be attained. The IKONOS instrument can be tasked to provide complete coverage of the area, and if it can be used to identify derelict nets, will allow resources currently devoted to finding the nets to be dedicated to removing nets. Combined with other imagery and modeling efforts that have been successful in identifying wind convergence zones that influence the movement and accumulation of derelict nets (see previous section), the IKONOS imagery should be useful for identifying nets that are entangled on shallow reefs. At the resolution available with the IKONOS imagery, nets of ~2 m diameter should be identifiable if fieldwork is able to provide the necessary classification parameters. At minimum, this high-resolution imagery will be used to create accurate base maps of the land and emergent and shallow water (<20 m) reef areas of the NWHI. The major constraint on the use of IKONOS imagery is cost. Funding available this year will enable the acquisition of only three of the ten major reef areas of the NWHI. Through a series of cooperative arrangements with other government agencies, IKONOS imagery of other areas may become available in 2001.

A second NMFS Honolulu Laboratory proposal that was recently approved involves the use of ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) imagery. ASTER is an imaging instrument that is flying on Terra, a satellite launched in December 1999 as part of NASA's Earth Observing System (EOS). ASTER is the only high spatial resolution instrument on the Terra platform. Although the resolution from ASTER imagery may be too coarse to detect derelict nets, high-resolution IKONOS images could be used to develop a spectral library for derelict nets and this library used to determine if reflectance signatures of nets can be identified in the ASTER imagery. ASTER imagery will also be used to improve base maps, categorize and map shallow-water bottom types, and perhaps map and monitor coral reefs. One major advantage of the ASTER imagery is that it will be obtained for no charge and will provide summer and winter imagery for the next five years of the entire NWHI chain, as well as the other U.S. possessions in the Pacific.

A final source of imagery may be the AVIRIS (Airborne Visible InfraRed Imaging Spectrometer) imager. AVIRIS is a unique optical sensor that flies aboard a NASA ER-2 airplane at approximately 20 km above sea level, providing a ground resolution of 20 m.

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The main advantage of AVIRIS is that it is a true hyperspectral instrument that allows very precise spectral segregation, to possibly identify the reflectance or equivalent signatures of derelict fishing nets. The disadvantages include the relatively coarse resolution and the cost of the imagery for those other than co-principal investigators. Data from a series of flights over the NWHI in Spring 2000 may become available to NMFS researchers from the principal investigators.

Remote-sensing methods may prove effective at identifying and mapping derelict net accumulations. The success of the methods will depend on the ability to correctly classify the unique spectral signatures of the nets and to be able to distinguish the nets from their surroundings. Since proper classification depends on verification through in-situ field-work, precise field mapping is a key component to the success or failure of such initiatives.

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APPENDIX 1.

FISHERY RELATED RECOMMENDATIONS AND CONCLUSIONS FROM PREVIOUS MARINE DEBRIS CONFERENCES.

Workshop on the Fate and Impact of Marine Debris, 1984, Honolulu, Hawai'i (Shomura and Yoshida, 1985)

Conclusions and Recommendations

Studies should be undertaken to:

1. Determine the sources and distribution of debris, possibly through development of a sampling methodology.

2. Determine the fate of lost gear and debris once it is deposited in the marine environment.

3. Develop a means of identifying derelict gear through creation of a reference collection.

4. Obtain worldwide data on vessel disablement as a result of interactions with marine debris.

Additional efforts should be undertaken to:

1. Obtain data on gear problem in areas other than the North Pacific

2. Expand existing stranding networks for marine mammals, birds, and turtles, and incorporate examinations for evidence of interactions with debris.

North Pacific Rim Fishermen's Conference on Marine Debris, 1987, Kailua-Kona, Hawai'i (Alverson and June, 1988)

Identified research needs as follows:

1. Expansion of national and international studies of the density, distribution, and movement of marine debris in the world's oceans.

2. Examination of cost-effective systems to facilitate the identification, recovery, and return of lost fishing gear to port or owners.

3. Continuation and expansion of beach surveys to monitor trends in marine debris abundance and type. This is particularly important in the North Pacific, but warrants consideration in other ocean regions.

Report of the Interagency Task Force on Persistent Marine Debris, 1988: Booklet produced and published by the Alaska Sea Grant College Program under the direction of the NOAA, Office of the Chief Scientist (Alaska Sea Grant, 1988)

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

2. The administration should support the NOAA Marine Entanglement Research Program by including it in the administration's fiscal year 1990 budget and for at least five years thereafter.

3. The topic of persistent marine debris should be included in the five-year Federal Plan for Ocean Pollution Research, Development, and Monitoring.

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

5. EPA, NOAA, U.S. Coast Guard, and other agencies should carry out research to determine contributions of land-based and vessel sources of plastic refuse to the overall problem, as well as ways to reduce plastic debris from all sources.

6. NOAA should work with fishermen and equipment manufacturers to develop pragmatic ways to improve ways to recover lost fishing traps and nets.

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

8. Federal agencies that manage coastal properties should set up actions to remove persistent marine debris.

9. Federal agencies should support local volunteer beach cleanup efforts as well as the collection and interpretation of data on materials that the volunteers remove. Federal managers should encourage employees to participate in volunteer cleanups.

Second International Conference on Marine Debris, 1989, Honolulu, Hawai'i (Shomura and Godfrey, 1990)

General conclusion: "The recommendations from the 1984 FIMD workshop have not been fully met. Efforts to measure the sources and amounts of persistent debris have been greater in the North Pacific than in any other ocean area, but a full understanding of the dynamics of input, output, and circulation remains well in the future."

Recommendations:

1. Development of a set of standard methods for surveys of the amounts, types, and sources of marine debris.

2. Establishment of an international committee or organization to further collaborative research on the impacts of entanglement on living marine resources.

3. Design and implementation of baseline experiments to establish the lethal and sub-lethal impacts of persistent debris ingestion by sea turtles and seabirds.

4. Design and implementation of experiments to evaluate ghost fishing in gillnet and trap fisheries with high gear loss rates and developing mitigative measures as needed.

Third International Conference on Marine Debris, 1994, Miami, Florida (Faris and Hart, 1995; Coe and Rogers, 1997)

1. Focus on and publicize the problem of combined sewer overflows. Continue research on terrestrial sources of debris.

2. Rigorously investigate the sub-lethal impacts of debris ingestion among turtles and birds—how it creates a false sense of satiation, dilutes nutrients, impairs digestion, and affects reproductive capacity.

3. Research and implement mechanisms to reduce fishing gear loss. These could include technological changes in gear design or incentives to recover lost gear. Given the appropriate incentives, the collection of derelict gear may be feasible.

4. Investigate the fate of plastic and other debris after they break down into minute particles in the marine and littoral environment. Research their potential impact on marine organisms.

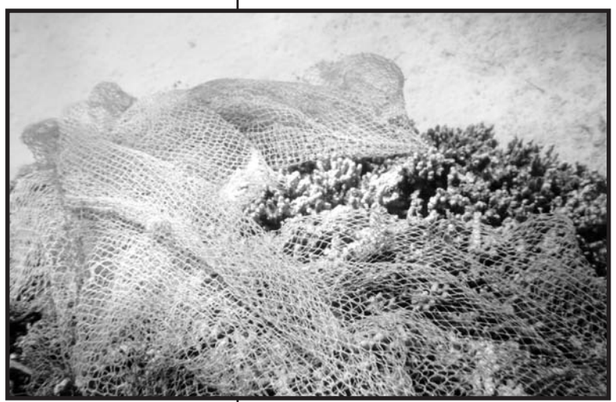
5. Investigate the scope and importance of organism transfers by marine debris, especially the introduction of invasive alien species that could disrupt native communities and ecosystem functions.

6. Investigate the amounts, accumulation rates and impacts of debris on the seafloor and the potential for large-scale impacts by smothering.

7. Monitor rates of entanglement and ingestion among selected species at specific sites. Collaborate with existing studies in certain regions. For instance, records of entanglement and ingestion in the Antarctic Treaty region are collated by the CCAMLR (Convention on the Conservation of Antarctic Marine Living Resources) Scheme of International Scientific Observation. Flagship species such as marine turtles and cetaceans can be used to promote field observations.

8. Establish an impact reporting system to promote and collate observations by beach users, fishermen, oceanographers, scuba divers, and others. Start by compiling past records.

9. Make efforts to recover lost fishing gear in areas where it is likely to be concentrated. Also, take steps to better evaluate the kinds and amounts of fish caught and the potential effectiveness of such work to clean up hazardous ghost fishing gear. Establish a system to record gear loss by commercial fishermen.



Carolyn Sramek (NOAA), courtesy of NMFS

EDUCATION AND OUTREACH APPROACHES TO REDUCE AT-SEA DISPOSAL OF FISHING GEAR

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INTRODUCTION

Marine debris pollution was brought to the public's attention in the early-1980s when research on this issue was consolidated and presented at the First International Conference on Marine Debris in 1984. This conference has been followed by almost twenty years of further study to determine the breadth and scope of the problem, the development of a myriad of educational and outreach programs to mitigate the effects, and the passage of key legislation to control at-sea solid waste disposal.

Education and outreach efforts have been viewed as an integral component of virtually all strategies to mitigate the effects of marine debris. Education programs are generally built around various motivational themes, with the ultimate goal of changing the disposal behavior of marine user groups. The importance of and the need for marine debris education has been upheld at international conferences and meetings throughout the years, including the 1984 International Workshop on the Fate and Impact of Marine Debris; subsequent International Conferences on Marine Debris (1989 and 1994); the 1988 North Pacific Rim Fishermen's Conference on Marine Debris; and in the U.S., the 1988 Oceans of Plastic Workshop; and the 1989 Interagency Task Force on Marine Debris.

In the United States, legislators also mandated that the U.S. National Oceanic and Atmospheric Administration (NOAA) and the U.S. Environmental Protection Agency (EPA) conduct a three-year public education program as part of MARPOL Annex V enacting legislation entitled the Marine Plastic Pollution Research and Control Act of 1987.

This paper reviews the recommendations made by previous international and U.S. domestic forums regarding educational needs to address the marine debris problem, briefly outlines the history of marine debris education and outreach efforts, and provides examples of successful educational approaches that have been used around the world. We have also attempted to lay the groundwork for this conference's working group on Education and Outreach by formulating several draft recommendations for future marine debris educational work.

A summary of recommendations that have been forthcoming from previous conferences and workshops on marine debris is given in Appendix A. The summary pertains to only those recommendations related to education and outreach on the marine debris issue.

RECOMMENDATIONS FROM PREVIOUS MARINE DEBRIS CONFERENCES AND WORKSHOPS

History of Marine Debris Education and Outreach Efforts

In 1973, The Tidy Britain Group, the United Kingdom's agency responsible for the prevention and control of litter, responded to the growing public concern over marine debris by establishing a Marine Litter Research Program (Dixon, 1990). As described by Dixon, 'the program's overall strategy has been to quantify the nature and scope of the problem in the coastal and oceanic waters of Western Europe, and to persuade governments, intergovernmental organizations, and the shipping industry of the need for remedial actions.' The program included a beach survey component as well as public awareness campaigns and other educational initiatives. One such initiative provided background expertise and knowledge in the development of a training package for ships' crews that was incorporated into the IMO Guidelines for the Implementation of Annex V of MARPOL 73/78 (Dixon, 1990).

In 1984, in a report prepared for the U.S. Marine Mammal Commission, the Environmental Defense Fund assessed U.S. and international authorities that may be applicable in studying and/or addressing the problem of lost or discarded fishing gear (EDF, 1984). Several of the report's recommendations regarding the fishing industry are listed below:

- Research into enhancing biodegradability and recycling of plastics pollutants should be a national priority.
- Sea Grant sponsored compilations of fishing hangs and bottom obstructions should be incorporated into the National Ocean Service's "Notice to Mariners" and reflected on official nautical charts.
- Sec. of Commerce should develop a gear inventory requirement that will aid the tracking of nets from original use to ultimate disposal.
- Observer reporting forms should be reviewed to determine whether they allow for adequate reporting of gear disposal by the observed vessel as well as sighting of lost, discarded or inadequately marked gear from other vessels.
- Observer reports should be reviewed to determine the extent of noncompliance with the prohibition against gear disposal at sea by foreign vessels.
- The regulations implementing fishery management plans should be amended to include provisions respecting the disposal of gear at sea and the reporting of abandoned gear.

In 1986, a study conducted by the Center for Marine Environmental Education (CEE), in cooperation with Centaur Associates, Inc., looked at the sources of marine debris in the Western North Atlantic and Gulf of Mexico, and characterized the nature of the threat to living marine resources posed by each debris type. The study identified manufacturers of the debris items, as well as the target audiences within each manufacturer and depositor group that might be susceptible to education programs designed to promote voluntary reduction of their contributions to the marine debris problem. Subsequently, educational materials were developed targeted for specific marine user groups which included: a series of four slide shows and taped scripts for commercial fishers in the North Atlantic, Mid-Atlantic, Southeast Atlantic, and Gulf of Mexico; a video and education packet for petroleum industry employees; and three print public service announcements and accompanying brochures for commercial fishers, merchant shippers, and plastic industry manufacturers and processors (Centaur Assoc. and CEE, 1986).

In 1987, CEE expanded the development of educational materials on the marine debris problem targeting additional marine user groups. The Society of the Plastics Industry (SPI) joined forces with CEE to inform marine user groups of the marine debris problem and the need for proper disposal of plastic. This awareness campaign included the production and dissemination of print public service announcements and accompanying brochures for recreational boaters and fishers, commercial fishers, merchant shippers, and plastic industry manufacturers and processors. CEE also produced a "Citizens Guide to Plastics in the Ocean," a primer on the marine debris issue and actions that can be taken to mitigate the problem.

In 1989, the National Oceanic and Atmospheric Administration, under contract with the Center for Environmental Education, established two Marine Debris Information Offices (MDIO) in the United States. The objective of these offices was to establish and maintain a center for distribution of information and materials to educate industries and the general public about the impacts of persistent marine debris, and their roles in its creation, removal, and proper disposal. These offices were operated by CEE from 1989 through 1996.

In 1989, funded by a Saltonstall-Kennedy grant from the National Marine Fisheries Service and conducted by the Center for Marine Conservation and Kearney/Centaur Division of A.T. Kearney, Inc., a study was designed to develop, test, and evaluate marine debris education for commercial fishers and recreational boaters as part of an effort to develop cost effective methods to comply with the prohibition of at-sea disposal of plastics and other wastes. The project was conducted at four sites: Bayou La Batre/Coden, Alabama; Martin County, Florida; Hampton, Virginia; and Taylor County, Florida (O'Hara and Wallace, 1990).

The main goals of this project were to: (1) assess the level of understanding of the marine debris problem among commercial fishers and recreational boaters, (2) inform these marine users about the marine debris problem, (3) increase awareness of and encourage compliance with federal regulations on at-sea dumping of plastics and other trash, and (4) evaluate the role of education in increasing awareness about the marine debris issue and in encouraging compliance with federal regulations.

Recommendations based on the experience of this project were to:

- Continue to evaluate marine debris education as a cost-effective means of encouraging compliance with the prohibition of at-sea disposal of plastics and other wastes.
- Test difference evaluation techniques such as case studies and more extensive surveys to assess marine debris education.
- Establish a two-tiered marine debris presentation strategy incorporating the "train-the-trainer" approach so that a sufficient number of volunteers/presenters could be educated about marine debris issues.
- Establish and maintain contact with the press and media to promote awareness about the problems of marine debris and the proactive steps being taken to manage this issue.

The list of marine debris educational materials and programs developed in the United States in the 1990s is extensive. A number of state environmental agencies, Sea Grant offices, non-profits, and aquaria developed excellent materials to educate the public on this issue. Several curricula were developed on the subject, including "Ripples" and "Splish Splash" for elementary students from North Carolina Sea Grant, "Turning the Tide on Trash" from the EPA (produced in both Spanish and English), and "Save Our Seas" produced by the California Coastal Commission and the Center for Marine Conservation. A number of resource materials were created for different marine user groups including boaters, recreational fishers, cruise line passengers, shipping companies, offshore oil and gas operations, and the fishing industry.

In Australia, education programs have been the main strategy used to reduce debris. A range of educational programs has been conducted at both the national and local level that target users of the marine environment. Educational materials developed for marine users include brochures, information leaflets, stickers, posters, and magazine articles. Clean Up Australia conducts annual coastal cleanups that also serve as public awareness programs and Greenpeace also conducts an Adopt-A-Beach Program, another important outreach tool. Other programs conducted throughout Australia include a project that distributes education video to commercial fishers (Jones, 1995).

Environmental groups, government agencies, and industry trade associations in a multitude of countries around the world have developed marine debris resource materials and education campaigns. These groups, such as the Hellenic Marine Environment Protection Association (HELMEPA) in Greece; Japan Environmental Action Network (JEAN) in Japan; FUDENA in Venezuela; the International Marinelife Alliance in Hong Kong; Philippines, Indonesia and many others, have all played an important role in combating the marine debris problem in their respective countries.

BEACH CLEANUP PROGRAMS SERVE AS IMPORTANT OUTREACH EVENTS

Beach cleanup campaigns have long been recognized as an important tool for raising public awareness of the marine debris problem. These highly visible events often attract media attention, which only helps to increase the visibility of this issue. Informal beach cleanup efforts have been conducted for decades and perhaps even centuries. The Aleut native peoples of the Pribilof Islands have been cleaning the Northern fur seal rookeries each spring for generations, removing debris they believed would impede the seal's recognition of traditional pupping grounds and their progress ashore (Bourdukofsky, 2000).

Only in the last several decades have citizen volunteers organized on a much larger scale to participate in beach cleanup events that range across several states or countries and often times includes a data collection exercise.

As early as 1973, the Tidy Britain Group in the U.K. established a Marine Litter Research Program. An important component of the program has been the establishment of data collection methods to assess marine debris on coastal beaches. The two main goals of the data collection effort were to: (1) develop standardized field survey techniques and analytical methods for the surveillance of marine litter, and (2) identify the major trends in

the composition, distribution, and origin of litter occurring in the coastal and oceanic waters of Western Europe (Dixon, 1990). Early analysis of data revealed that containers of all types including bottles, cartons, drums, etc. were common components of the overall total. Samples of the most frequently occurring types were recorded and a technical support network of packaging and product manufacturers was established to discover the wastes' geographic origins, contents, and dates of production. Analysis of the data collected from shoreline transects has enabled Tidy Britain to assess 'major trends in the composition, distributions, geographical origins, and persistence of litter in the surface waters of Western Europe' (Dixon, 1990).

Also in the early-1970s, Japan led efforts to clean not only beach areas but also the fishing grounds of coastal communities. Concern over the accumulation of debris such as bottles, cans, worn-out tires, plastic bags, and other plastic items on shorelines as well as on the sea floor prompted the government of Japan to launch a Cleanup Program. The Fisheries Agency developed a two-pronged approach, conducting educational programs for coastal communities and cleanup activities of the seashore and sea bottom. More information on this program is given below in the Education and Outreach Approach section A.2. (Yagi and Otsuka, 1990).

Judy Neilson with the Oregon Department of Natural Resources in the United States first conceived of the idea of holding a state-wide beach cleanup of Oregon's 350 miles of coastline in 1984. Ms. Neilson organized a task force, dividing the coast into fourteen zones and recruiting local residents to serve as "zone captains." Held in October in conjunction with Coastweek activities, the cleanup attracted 2,100 volunteers who collected over 26 tons of debris in just three hours. Volunteers filled out questionnaires to document the quantity of fishing gear, six-pack rings, polystyrene foam, plastic bags and bottles, rope, and strapping bands (Neilson, 1990).

Encouraged by her success, Ms. Neilson recruited environmental leaders in eight other states to join the Cleanup and went on to write the "Nuts and Bolts Guide to Organizing a Beach Cleanup," to help them organize their own efforts. By 1986 there were fourteen states participating, including an effort in Texas, led by the Center for Marine Conservation. The Cleanups have always been held during Coastweeks, a national celebration of our coasts.

Ms. Neilson's idea inspired the Center for Marine Conservation to organize coastal cleanups across the United States in both coastal and inland states. Starting in Texas in 1986 with 2,800 volunteers, the Cleanup has expanded to include inland lakes, rivers, and streams, as well as underwater sites. Today, the International Coastal Cleanup (ICC) is the planet's largest volunteer effort on behalf of the marine environment. Cumulatively, more than three million people in over 100 countries have participated in the cleanup since it became an international event in 1989. Volunteers use standardized data collection cards, developed by CMC, to record more than eighty specific debris items in eight categories: plastic, foamed plastic, glass, rubber, metal, wood, and cloth. The data analysis is returned when completed to each state and country partner for their use in formulating education and public awareness campaigns in their locales.

SOURCES OF MARINE DEBRIS

The data recorded by volunteers can often times be analyzed to identify the sources of beach debris collected during a cleanup. Marine debris researchers traditionally classify debris source as either land- or ocean/waterway-based, depending on where it enters the water. Other factors such as ocean current patterns, climate and tides, and proximity to urban centers, industrial and recreational areas, shipping lanes, and commercial fishing grounds influence the type and amount of debris that is found in open ocean areas or collected along our beaches and waterways—including underwater areas.

Land-based debris blows, washes, or is discharged into the water from land areas. Sources include: recreational beach-goers and fishers; materials manufacturers, processors and transporters; shore-based solid waste disposal and processing facilities; sewage treatment and combined sewer overflows; inappropriate or illegal dumping; and littering.

Ocean/waterway-based debris is generated by people who discard debris at sea and in inland waterways. Identified contributors are: recreational boats; commercial fishing vessels; cruise ships; merchant, military, and research vessels; and offshore petroleum platforms and associated supply vessels. Debris ends up in the water due to accidental loss or system failure; historical waste management practices; or illegal disposal and indiscriminant littering.

Commercial fishing activities introduce marine debris into the ocean and waterways through intentional disposal by discarding trash overboard and by not retrieving excess gear and through unintentional loss when gear wears out and is lost while deployed or the equipment operator makes a mistake and the gear breaks loose. Commercial fishing is associated with debris items such as nets, salt bags (large, reinforced plastic bags used by commercial fishermen to preserve or separate their catch), bait boxes and bags, fish baskets or totes, fish and lobster tags, and gill-net or trawl floats (Wallace, 1995).

STAKEHOLDERS RELATED TO COMMERCIAL FISHING AND DERELICT GEAR MARINE DEBRIS ISSUES

For educational purposes, there are several audiences related to commercial fishing and derelict gear issues. The core of this group consists of fishers ranging from single, subsistence individuals who may or may not own their own boats to crews on large trawlers. Business and industry associated with equipment and boat manufacturing and marketing are also part of this audience as they are responsible for the production and sales of the materials used by fishers. Individuals who are part of the fish processing industry including marketing are also part of this group. And last, but not least, are the governmental regulatory and resource management entities, which are needed to complete the entire scope of this issue.

EDUCATION AND OUTREACH APPROACHES

For discussion purposes the following approaches are organized into two categories: (1) education and outreach approaches directly involving fishers, the primary stakeholders, and (2) approaches that target other stakeholders, for example, non-fishing members of coastal fishing communities, ports and reception facilities, and gear manufacturers.

A. Education and Outreach to Fishers as Primary Stakeholders

When dealing with the problem of marine debris, the issues of concern and/or interest to the fishing industry as a whole and to individual stakeholders within fisheries revolve around several topics:

- Laws and regulations governing at-sea disposal.
- Economic impacts from direct costs such as damage to or disabling of vessels from entanglement in lost gear.
- Safety issues related to vessel disablement due to involvement with debris.
- Hidden costs such as:
    1. Fines and related penalties.
    2. The opportunity cost from downtime while a vessel is disabled.
    3. Loss of valuable time while removing debris from nets.
    4. Loss of revenue from "ghost fishing."
- Degradation of essential fish habitat related to underwater marine debris accumulation.
- Deposition of marine debris on beaches.
- Impacts to wildlife species (especially those revered by their cultures).

In 1989, in a survey conducted in four coastal fishing communities in the United States by CMC, under contract to A. T. Kearney Inc., and as part of a project funded by the National Marine Fisheries Service, more than 95% of fishers surveyed had seen plastic trash floating in the water. Over 45% had had vessel propellers caught in plastic, over 30% had gear caught or fouled by debris, and almost 40% had vessel cooling intake systems clogged by debris. About 94% of those surveyed viewed plastic debris in waterways as a safety hazard for mariners, a source of mortality for marine animals, and a source of beach litter (Wallace, 1990).

During this same survey, commercial fishers were asked which of seven techniques were the best ways to encourage fishers to retain debris on their vessels for disposal ashore. Close to 60% cited fines and penalties as effective, followed closely (~55%) by the availability of dockside disposal facilities. Other techniques noted as effective were posters (~39%), word of mouth (~35%), brochures (~32%), and magazine and newspaper articles (~31%). Presentations were considered the least effective tool and were noted by only ~17% of those surveyed. Respondents to the survey were also given the opportunity to make suggestions on outreach approaches. Among the suggestions were reminders on the marine radio channel, incorporation of information on proper garbage disposal into the licensing procedure, and the use of advertisements and stickers (Wallace, 1990).

Around the world, the range of stakeholders in the fishing industry is wide, running from owners and operators of large factory trawlers down to members of small subsistence artesnal fisheries. Different approaches for education and outreach need to be devised not only for different size industries but also for different cultures. Various approaches that have been used with commercial fisheries are listed below. For each approach, several examples are given.

1. ***Industry Programs*** – industry education and mitigation programs devised by and for the fishing industry.

Fishing industry trade associations in the **United States** often provide orientation sessions for new employees that review the MARPOL regulations and a company's waste disposal policies. Companies may make compliance a condition of employment, and employee contracts will sometimes stipulate that the employee agrees to adhere to all relevant laws and regulations, such as MARPOL and MPPRCA (Minton, 2000). According to Mark Minton with the National Marine Fisheries Service, 'most vessels, whether formally or informally, provide new crew members an orientation and overview to the policies and procedures they are expected to follow, including waste disposal.'

Currently, in **Kodiak and Dutch Harbor, Alaska, U.S.**, the fishing industry is working closely with port authorities to ensure that vessel wastes and worn and damaged nets are disposed of properly. Collectively, approximately 800 tons of nets are landfilled each year in these communities. In Dutch Harbor many of the nets are stockpiled and removed once a year on barges, which transport them to recycling centers (Minton, 2000). In Kodiak, many of the nets are collected from the port by individuals in the community, who re-use them for erosion control, landscaping, and pest control for gardens. The Kodiak Chamber of Commerce is also studying the feasibility of burning the worn nets for power generation. Kodiak also has a program to recycle and re-use motor oil that reportedly has saved approximately $100,000 (U.S.) annually on waste oil disposal (Minton, 2000).

In **Nova Scotia, Canada** the Maritime Fishermen's Union ran a successful program in the early-1990s, supported by Environment Canada, to educate fishing communities about the problem of marine debris, encouraging fishers to bring their waste back to port and also encouraging port managers to provide facilities (i.e. barrels and dumpsters) for disposal of wastes and used nets (Topping, Morantz, and Lang, 1997). Similarly, the Nova Scotia Dragger Fishermen's Association disseminated educational materials to their members to improve compliance with MARPOL regulations (CMC, 1990).

In **Oakland, California, U.S.** the Vietnamese Fishing Association has played an active role in educating their members about the marine debris problem and MARPOL regulations. They translated a MARPOL Annex V placard outlining disposal restrictions into Vietnamese for their own and other Vietnamese fishing communities (CMC, 1990).

In 1987 at the North Pacific Rim Fishermen's Conference on Marine Debris, a **Japanese** representative from the Japan Fisheries Association stated that 'each Japanese industry association responsible for its respective fishery has been educating its member fishermen on the importance and urgency for setting up measures to control marine debris under the guidance of the Japanese government' (Nakamura, 1988). A recycling program was set up to recycle nets used in the driftnet fisheries, processing the recycled plastic into bobbins, plastic dishes, panel materials or other construction materials, and other containers. One recycling company processed approximately 1,200 tons of worn nets per year (Nakamura, 1988).

The Highliners Association, based in **Seattle, Washington, U.S.** (a member trade association of fishermen, vessel owners, operators, and processors involved in fishing activities off the contiguous Pacific Coast states and Alaska), was one of the first industry groups to initiate programs to address the marine debris problem. In July 1986, in conjunction with Oregon Sea Grant and NMFS, the Highliners organized a workshop in Newport, Oregon for the trawl fishing industry, to raise awareness of the magnitude of the debris problem and look for workable solutions. Following this meeting, they assisted in the design and distribution of marine debris posters to West Coast commercial fishermen's groups, port authorities, recreational boaters, and others.

In 1988, as a result of a recommendation from the Pacific Rim Fishermen's Conference on Marine Debris, the Highliners Association developed a plaque entitled "Fishermen's Pledge for A Clean Ocean." The plaque was designed to remind captains and crew of fishing vessels of their responsibility to maintain a clean ocean environment and includes a pledge to return all discarded fishing gear and other plastics to port. It also encourages fishers to make every effort to prevent accidental loss of gear, and to make an effort to collect other vessels derelict gear when encountered at sea. The Highliners Association had great success in distributing this plaque to numerous fishing fleets for display in prominent locations such as wheelhouses or galleys (Uri, 1988).

2. ***Government Programs*** – federal, state, and local government initiated programs to educate the fishing industry and mediate the effects of discarded gear and other debris.

In 1999, the county government of the **Penghu Islands**, a 64 island archipelago off the west coast of **Taiwan**, spent $20,000,000 NT$ (~$600,000 U.S.) to buy back trammel nets (gillnets with three layers of nets with different size mesh) from local fishers and banned the future use of this type of gear. During this buy back program, about 640 km of trammel netting was purchased. The county government also commissioned a local SCUBA divers' association to investigate and record locations where substantial discarded trammel nets exist. After twenty-one locations were found, a plan was formulated to remove over 10 km of gear in a two-month period using divers operating off of five ships. Local citizens were also encouraged to report locations of discarded gear to facilitate cleanups. In the first ten minutes of the first day of cleanup (June 2000), more than 100 m of nets with fresh and decomposing fish were removed. The county government has vowed to continue the program until the local waters are free of discarded trammel nets. According to Dr. John Wang, scientific advisor to Kuroshio Ocean Education Foundation, who provided this report, this is a positive first step in Taiwan and should be a model for fisheries and other counties of Taiwan to follow (Wang, 2000).

In the 1990s, steps were taken by the **Australian** government to increase compliance with MARPOL regulations within the Australian Fishing Zone (AFZ), the world's third largest fishing zone. Working with Japanese officials, the government provided information sheets to Japanese vessels in Japanese, that spelled out the requirements of MARPOL. Discussions with Japanese authorities and industry officials on the benefits of using plastic-free bait boxes were also held. Subsequently, an observer reported that 50% of bait boxes used on one vessel were strap-free (Jones, 1995).

The **Canadian** government has also been active in outreach to their commercial fishing fleets. In the early-1990s, Canadian Department of Fisheries and Oceans developed and produced a bi-lingual brochure on the problem of marine debris for distribution to Canadian fleets (CMC, 1992). Canada's Fisheries and Oceans Communications Branch in Halifax, Nova Scotia distributed marine debris posters to over 400 ports and marinas in 1990 (CMC, 1990) and Environment Canada provided funding for marine debris educational programs to fishers in the early to mid-1990s (Jones, 1995).

As early as 1973, the Fisheries Agency of **Japan** initiated a program to recover its deteriorating fishing grounds. The amount of marine debris accumulated in the coastal areas of Japan had been shown to be an obstruction to the fisheries operating in these waters, causing habitat destruction of key commercial species and interfering with fishing operations. The Fisheries Agency's two-part program contained an educational aspect and a cleanup aspect. The educational aspect involved alerting regional residents, including fishermen, of the need to preserve the environment through radio and television broadcasts, newspaper articles, lectures, public ads, posters, leaflets, and calendars.

The cleanup aspect involved using trawl vessels to remove accumulated debris on the sea floor, cleanups of the rocky bottom using divers, removal of floating debris using dip nets, and manual cleanups of beaches as well as inland rivers, lakes, and streams. Although the cleanup program was initiated under the leadership of the government, programs were taken over willingly by local residents as years passed. Interest has grown as the educational programs have continued and some communities have formulated their own new initiatives such as the establishment of "Fishing Ground Preservation Month" to promote stewardship of their coastal environment (Yagi and Otsuka, 1990).

Through the Marine Environmental Protection arm of the **United States** Coast Guard (USCG), the "Sea Partners" Campaign was created to support environmental education and outreach program activities. Sea Partner programs focus on working to develop community awareness of maritime pollution issues and to improve compliance with marine environmental protection laws and regulations. As part of the Sea Partner's program, regional Marine Safety Offices (MSOs) Coast Guard staff and Auxiliary members conduct pollution prevention programming relating to the effects of: marine debris, waste, chemicals, and oil on the environment; the application of marine environmental protection laws and regulations; and the actions that groups and individuals can take to protect the marine environment.

One of the ways that the Sea Partners Campaign reaches the commercial fishing industry is through attendance at industry-related trade conferences, including Fish Expos, where they distribute information on safety and environmental issues. Some MSOs conduct voluntary inspections on fishing vessels where they also provide information on environmental practices and strategies.

3. ***Organization Education Programs*** – developed by NGOs and other groups in conjunction with, and in support of, the fishing industry's educational programs.

From 1988–1996, the Center for Marine Conservation (CMC), under contract with the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, established two Marine Debris Information Offices (MDIO) in the **United States**. They were the Atlantic Coast and the Gulf of Mexico MDIO located in Washington D.C. and the Pacific Coast MDIO located in San Francisco, California. The objective of these Offices was to establish and maintain a center for distribution of information and materials to educate industries and the general public about the impacts of persistent marine debris, and their roles in its creation, removal and proper disposal. As part of this function, CMC developed extensive informational packets, which were used to address a variety of marine debris issues and respond to stakeholders associated with marine environment. Information to promote marine debris prevention activities for commercial fishers was compiled and distributed at major trade shows, conferences, regional fisheries management council meetings, and a host of other public venues.

A **United States** government supported program that supports efforts to educate the fishing community is the National Sea Grant College Program. Sea Grant is a partnership between U.S. universities and the National Oceanic and Atmospheric Administration (NOAA) that began in 1966, when the U.S. Congress passed the National Sea Grant College Program Act. Today, of the twenty-nine Sea Grant Colleges, many have outreach or education programs that aid the commercial fishing industry. Examples of marine debris programming conducted by Sea Grant Offices include:

- Maine/New Hampshire Sea Grant—addresses issues associated with fishing cooperatives, marine mammal/fishing gear interactions, alternative species/bycatch, and fisheries management. Maine Sea Grant produced an important resource for marine users that spelled out the requirements of MARPOL Annex V.

- Washington Sea Grant—developed an innovative program in the late-1980s in the Port of Bellingham to establish a net recycling facility; produced a series of pamphlets combating the marine debris problem including one entitled "Marine Debris: How Commercial Fishermen Can Help Solve a Growing Problem."

- Oregon Sea Grant—has conducted an extensive marine debris campaign since the late-1980s. A program was developed for the Port of Newport called "Don't Teach Your Trash to Swim" where boaters were encouraged to bring debris to shore for disposal; it also focused on changing fishing gear to prevent ghost fishing if the gear was lost.

- Hawai'i Sea Grant—conducts an extensive marine debris prevention campaign for recreational and commercial fishers, which includes a local program for derelict net and gear retrieval (Marine Bounty program).

- Alaska Sea Grant—sponsored a workshop in 1988 to discuss incentives for fishers to bring back old gear and retrieve lost gear.

4. ***Incentive Programs***

In 1997 the Center for Marine Conservation developed a community-based program to

address marine debris sources through education and the development of improved waste management practices. The Model Communities program provides communities with tools to encourage changes in waste disposal habits so as to reduce debris entering waterways and works to transfer and replicate management approaches and educational materials to other communities with similar marine pollution concerns. One such program is being conducted in the **United States in Hawai'i** and includes an incentive program for local coastal fishers called the "Marine Bounty Program." This program was developed and piloted in Kaneohe Bay, on Oahu, where recreational and commercial fishers were awarded points for reporting the location of abandoned nets found while fishing. Points were redeemed for fishing products and other prizes donated by local retailers. Arrangements were made with a local fisher (Randy Cates of Safety Boats Hawai'i) by the University of Hawai'i Sea Grant office to have the nets retrieved and disposed of in the local landfill. The program continues with over three tons of recovered nets and gear to date. Plans are underway to expand this effort to other areas of Oahu tying this to a net monitoring program being implemented in Hawai'i through the Coastal Zone Management Program and the Department of Land and Natural Resources.

Other incentive programs have been conducted in the **U.S. in Florida and Louisiana** using recreational fishing rodeos or tournaments as the venue. While not targeting traditional commercial fishing, individuals involved in coastal commercial sport fishing ventures are oftentimes interested in or participants of local sport fishing tournaments and may benefit from this type of outreach activity. Typically, these incentive programs are set up in a similar fashion and may carry a slogan such as "Stow it, Don't Throw It." When participants register for the rodeo or tournament, they are given a garbage bag and the rules of the "contest" are explained. Entrants are asked to retain their garbage onboard and often are also asked to retrieve floating debris they encounter during the day. For those entrants who return to shore a bag filled with their day's garbage they are given a ticket for a special drawing for valuable prizes. Some contests also give extra prizes for entrants who return two bags of trash—one containing separated recyclables (Laska, 1990; CMC).

5. Observer Programs

Informal education of fishers related to MARPOL regulations is conducted in **Australia** by observers on Japanese vessels as part of the Australian Fishing Zone (AFZ) Observer Programme. A study of observer reports for 1992-93 indicates that in 1992, 57% of the vessels carrying observers complied with MARPOL; in 1993 compliance was 46%. One-third did not comply, and the remainder was either doubtful or complied only after being advised of regulations by the observer. The observers' reports noted that the reasons for non-compliance included a lack of knowledge of MARPOL regulations, the attitude of the Captain and/or the crew, and lack of facilities for proper disposal due either to a lack of incinerators on board the vessel or inadequate facilities at the port (Jones, 1995).

While the study showed that informal education of fishing crews by observers was only sometimes successful in changing disposal practices, it was concluded that continued collection of observer data would be helpful in monitoring the situation and useful for planning future actions (Jones, 1995).

A similar study was conducted in **Canada** by the Fisheries Observer Program, operated by the Department of Fisheries and Oceans, in 1990–91. Observers on both Canadian and foreign fishing vessels operating in the Canadian Exclusive Economic Zone in the Atlantic, collected data on the vessels' waste disposal methods and the types of waste disposed, including the types of plastics. A "marine plastic debris occurrence report form" provided standardized categories for four basic disposal methods and eighteen types of waste and was used to collect data on 739 trips during the two-year study. Waste was discharged into the ocean, either directly over the side or through a galley chute during 76% of all trips; it was offloaded at port during 26% of all trips and incinerated on 14% of all trips (vessels used more than one disposal method during some trips) (Topping, Morantz, Lang, 1997).

Over the course of the study, the disposal practices of Canadian fishing vessels improved, showing a decrease from 96% of trips discharging waste into the ocean during the first five months of the study to 57% discharging at sea during the last five months. Foreign vessels discharge rates at sea remained fairly constant during the study (72% of trips) period but their rate of incineration also remained constant (46% of trips). The study concluded that the data 'suggest that the effect of the observer's presence was minimal on foreign vessels but almost certainly is responsible for the trend toward port discharge by the observed Canadian vessels.' Rather than attributing the decline to educational efforts by the observers themselves, the study credits educational efforts of the industry itself in concert with the Canadian government (see section 1 above). The study speculated that the continued practice of at sea disposal by over 50% of trips might be due to 'the limited availability of waste reception facilities and the disposal fees charged by ports.'

Interestingly, the study concluded that one reason foreign vessels favored incineration was energy recovery—waste incinerators also provided heating for the crew. Another waste reduction practice, reusing of plastic materials, especially containers and nets, was observed to be practiced by some foreign crews. Vessels from the former Soviet Union had the lowest estimated disposal frequencies for most waste types (Topping, Morantz, Lang, 1997).

While the Canadian study did not include a formal educational component (by observers) both studies show this as a potential means of outreach to commercial vessel crews and, more importantly, as a viable means to measure the success of a targeted education program to a specific fishery by assessing the amount of debris discarded before and then after such a program is implemented.

B. Education and Outreach to Other Groups as Secondary Stakeholders

This part of the discussion will focus on education and outreach approaches that target other stakeholders, for example, non-fishing members of coastal fishing communities, ports and reception facilities, and gear manufacturers. All of these groups may have a direct or indirect effect on the disposal practices and compliance rate achieved by various fisheries. For example, without adequate disposal facilities at ports of call, compliance with MARPOL becomes extremely difficult. Gear manufacturers and suppliers can contribute to

a higher level of compliance by changing technology to meet the fishing industries needs. Public awareness in coastal fishing communities generated by events such as beach cleanups may have an indirect effect on the members of fisheries associated with these communities.

6.Outreach Efforts Directed at Gear Manufacturers and Suppliers

In 1990 in **Tasmania, Australia** an initiative was begun to develop a plastic-free bait box containing no plastic liner or plastic straps. This represents one of the first successful attempts to modify fishing gear in an effort to reduce plastic debris. The plastic-free bait box was a result of a cooperative effort by the Tasmanian Parks and Wildlife Service, a bulk supplier of fishing bait, and a container manufacturing company. The box, after some refinements, is now also made by other manufacturers and is reported to be cheaper than the strapped bait box (Jones, 1995).

In the **Gulf of Mexico** region of the **United States** beach cleanup volunteers were repeatedly retrieving large, durable plastic bags with the Morton Salt name and logo prominently displayed. These distinctive blue bags held a salt product used primarily by the shrimp fishing industry in the Gulf to sort their catch on board. When Morton was approached by the Center for Marine Conservation and asked to help in rectifying the problem, they readily agreed. They test-marketed a reinforced paper bag but this did not prove durable enough to stand up to weather and sea conditions. Morton then agreed to put the environmental slogan "Stow It, Don't Throw It—Don't be a Litter Boat!" on their bags to promote proper disposal.

In the mid-1990s an environmental group in the **Hiroshima** area of **Japan** began working with local fishing cooperatives, port authorities, and government agencies to address the problem of polystyrene pollution of beaches. It was believed that the abundance of this material on the area's beaches could be traced to local oyster farming companies who use polystyrene foam floats for oyster rafts. Cleanups held by Cleanup Kansai Office, a regional member organization of Japan Environmental Action Network (JEAN), as early as 1992 have shown polystyrene pieces to be one of the most prevalent types of beach debris in the region. In the fall 1999 cleanups of three sites along Hiroshima's coastline, styrene foam pieces accounted for 60% of all trash items, and in two of these sites oyster-farming piping represented 17% of the total (Ohkura, 2000).

Through Cleanup Kansai Office's efforts, Molton, the manufacturer of the oyster raft floats, has developed and begun marketing a hard resin float that does not break apart and therefore poses less of a risk to marine life. Cleanup Kansai distributed the results of their beach cleanup data and information on the "eco-floats" to local supermarkets in January of this year. As a result, some local shops have started buying oysters produced from farms using the new floats, on a preferential basis. Furthermore, the company who developed the hard resin float has begun to apply this product to the gunwale protection material of vessels, replacing polystyrene material. This may help to further reduce the styrene foam trash on Japan's beaches.

Cleanup Kansai has worked out an agreement with Miyajim Fishing Cooperatives to return pipes found and collected at beach cleanups for reuse in oyster farming. The

plastic pipes, used to hang oysters on shelves, have been washing ashore on beaches around Hiroshima and other Seto-inland Sea coastlines (Ohkura, 2000).

7.Outreach Efforts Directed at Ports and Reception Facilities

Between February 1991 and June 1992, in four port areas in the **U.S. Pacific Northwest** region (Bellingham, Seattle and Anacortes, Washington and Cordova, Alaska), a gill net recycling program was conducted by the Pacific States Marine Fisheries Commission. During the sixteen-month run of this program, 47,000 pounds of old, nylon netting was collected at these sites. In this Pacific Region experiment, the baled nets were stored, marketed, and sold to a plastics broker. The nets were then recycled into bicycle seats in Taiwan. This was the first net recycling program attempted in the United States and provided many lessons for those wishing to explore the feasibility of this type of program. The success of net recycling in other communities depends on the quantities of old netting available, their market value, and the ability to manage the collection and handling systems. This study showed that gill net recycling was economically viable for the three ports in Washington. The operating costs in Alaska related to shipping were high resulting in costs to the port for transporting the nets. The success of net recycling in Alaska was dependent upon the availability of storage space for the nets until there was a sufficient volume of product that could be directly marketed to the end users bypassing the recycling brokers in Washington (Recht, 1995).

The Port of **Newport, Oregon, U.S.**, was the test site for the Marine Refuse Disposal Project from January 1987 through March 1988. This project focused on the return of refuse to the port through education of port users and to make available the facilities required to receive this refuse. The port increased the number of receptacles available for dumping and recycling, made them easily accessible, and worked with the port users to make this program a success. Public education played a large part as well, making this a community-wide effort. At the close of the project, 80% of the local fishers were voluntarily returning their refuse to the port, and encouraged others to do the same (Recht, 1988).

8.Outreach Efforts within Coastal Fishing Communities

Commercial fishing associations in the **United States** and **Canada** have been actively engaged in marine debris public awareness programs within their communities. The Virginia Waterman's Association developed their own sticker to distribute to fishermen and boaters, through local marinas, reading "PLEASE, Don't throw it, stow it!" In Alaska, the Bristol Bay Driftnetter's Association in the early-90s organized a MAPROL May Day event with a "Give a Hoot—Don't Pollute" message and distributed MARPOL placards to vessels in the area. The Maritime Fishermen's Union of Nova Scotia distributed marine debris brochures as part of their educational efforts to teach their communities about the marine debris problem. Their program also involved conducting a poster contest for elementary children. The Nova Scotia Dragger Fishermen's Association conducted a public school education campaign, visiting elementary schools in Shelburne School District to talk to close to 2,000 students about the marine debris problem. They distributed information packets, videos, and slide shows to teachers and posters, brochures, and activity sheets to the children (CMC, 1990).

In **Kosrae and Pohnpei, Micronesia** fishing debris is often found in reef areas, primarily consisting of monofilament line and longline fishing gear, as well as buoys and other associated gear. In Kosrae, the local resorts and civic organizations are involved in public awareness campaigns that are tied to beach cleanup events and general litter control. Marine debris education programs are continued year round in the schools as all the schools are located along coastal beaches, making informal beach cleanups and cataloging of debris possible as part of the curricula. Local women's groups, church groups, and other civic organizations have made litter prevention one of their focuses for community activism. Interestingly, it has been reported that due to Kosrae's location in an equatorial region, the strong sun breaks down plastic in a very short amount of time—reported to be no more than six months for many plastic items such as tarps (Edward and Adams, 2000).

Beaches debris found in coastal areas of the **Republic of Kiribati** often includes debris from both local and offshore fisheries. Floats and trawl gear, empty drums, as well as discarded gill nets are not uncommon. The Ministry of Environment and Social Development has begun a public awareness campaign that includes education via radio, organizing of coastal cleanups, and an annual program related to waste management control. Because of lack of space for landfilling waste, minimization of waste and programs such as composting have become increasingly important (Pulefou, 2000).

In **Hualien County**, on the east coast of **Taiwan**, Mr. Hung-Chi Liao, the director of the Kuroshio Ocean Education Foundation (KOEF) who is also a retired fisherman, guides monthly beach walks for the public to show and describe the beauty of and the conservation problems with Taiwan's marine ecosystem. The problems with discarded fishing gear and the types of fishing practices are described to participants, many of whom are professional educators who will, it is hoped, pass along this information to their students. This educational activity began about two years ago and is one of KOEF's main educational activities. KOEF is working to infuse into Taiwan's educational curricula, some instruction in marine conservation with development of workbooks, activity books, and slide presentations (Wang, 2000).

In **St. Paul Island of the Pribilof Islands of Alaska, U.S.**, the Aleut community has been involved in conducting an annual island-wide spring cleanup for generations. One of the island's most important natural resources is the seal rookeries, where approximately 70% of the world's population of Northern fur seals comes ashore every summer. Over the past four years a team of dedicated Aleut youth have been conducting a summer long disentanglement program—surveying the coastline on a daily basis looking for entangled seals, and, using long poles and a holding device, removing deadly nets and strapping bands from the necks of entangled seals. The "Disentanglement Team" has become highly proficient in the process of disentangling fur seals and has plans to share their knowledge with other high school students in other areas of the Bering Sea and throughout the Pacific Rim (Bourdukofsky, 2000).

In a project conducted in the United States by A. T. Kearney, Inc. in 1989 to devise a marine debris education plan for the shipping industry; a strong focus was placed on developing case studies of how this industry was dealing with new disposal laws and regulations. This was done through interviews with key contacts within industry and a review of documents provided by these contacts. The case studies provided examples of positive actions different companies were taking to change the way they handle plastics and garbage disposal and demonstrate the range of techniques that companies were using to comply with MARPOL Annex V. They also identified some of the problems encountered and how these were addressed and overcome (Wallace, 1990).

While recognizing that this project focused on an entirely different industry, this approach could also be successfully used with the commercial fishing industry—an industry that presents many of the same challenges to effective education due to its diversity. It is widely recognized that because of this diversity different education approaches are needed, and associated with that, as stated by A.T. Kearney, 'no one method of compliance with MARPOL Annex V will work for all vessels because of differences in such things as size, routes, cargo, and owners.' The case studies approach presents an effective way to document the success stories of various types of fisheries and can successfully address problems associated with vessel size and type, gear type, voyage length, and other factors that play a role in determining a workable waste management strategy. The case studies method also promotes a positive approach and involves industry directly in problem solving. This approach may be a better tool to use in reaching a goal of compliance than a more negatively focused education approach that identifies the fishing industry as a major source of debris and tries to convince them that their practices are causing problems. Various methods of disseminating these case study "success stories" may include distribution of information through fishing industry trade associations and membership organizations, seminar and workshop presentations at international fora, trade shows, publication in trade journals, and any other forum where industry representatives would have the opportunity to network and share information.

The positive approach is also supported by social scientists as the educational philosophy of choice. Laska (1990) states 'messages should be structured to enhance the self-image of the mariner as someone who conforms to environmentally sound behavior voluntarily rather than seeking conformity imposed by an external control. When external control is the only means used to persuade, the desired behavior will stop as soon as the external control is stopped. Also, the educational process should encourage the reinforcement of the message through group dynamics. The desire to conform to group norms and the power of group pressure to accomplish conformity should not be overlooked, for they are very powerful tools that can be employed to support implementation.'

In a related argument, there are differing views on an outreach approach outlined in section A above, namely, incentive programs involving a reward system for retrieval and proper disposal of worn gear. While incentive programs appear on the surface to be an effective tool for raising awareness of the marine debris problem, experts who believe they do little to change long-term behavior patterns have criticized them. Laska, in her study of the attitudinal basis of marine littering, cited a behavior modification theory related to

self-perception that can be successfully applied to changing littering behavior. The theory proposes that a change in behavior will occur once an individual has changed the perception of him or herself (self-image) as capable of a new behavior. Laska states that 'based on this theory, educational programs which encourage refuse disposal by giving prizes would not be expected to work over the long run because individuals do not have to change their self-image. The motivation to dispose correctly remains external to them, i.e., a prize given by someone else.'

However, there are those with a differing view of incentive programs. The U.S. Congress has demonstrated a preference for incentive-based policies based in part by its successes such as the Clean Air and Water Acts, which make extensive use of tradable pollution rights (Sutinen, 1997). Some believe the success of incentive programs is based in good evidence and is founded on sound economic theory. According to Sutinen, 'in almost any group of individuals subject to regulation there is often a core subgroup (usually small) of chronic, flagrant violators. Chronic, flagrant violators tend to be motivated only by the direct tangible consequences of their actions. Moral obligation and social influence have little or no effect on their behavior. Only changing the economic incentives… can control the amount of marine debris contributed by this subgroup.'

While disagreement exists between these two camps, it would appear that the long-term effectiveness of incentive programs needs to be thoroughly assessed, before initiating widespread adoption of this method of waste control.

Another important factor that needs to be considered in developing any program that has the goal of increasing compliance with anti-dumping regulations, is the attitude of modern society to convenience. Experts theorize that proper disposal of trash items is an inconvenience to an individual if a receptacle for the waste is not in the immediate vicinity (Laska, 1990). Laska states that 'the inconvenience is defined by the length of time the individual may have to maintain the item which no longer has utility within his or her personal domain—often extended if out at sea—and by the fact that it is occupying part of a very limited space—fishing boat, oil rig, freighter, camper.' Laska recommends that studies be conducted to 'determine the most convenient refuse disposal configuration at beaches, boat launches, marinas, and harbors.' The issue of convenient reception facilities, and more importantly, of adequate facilities, is essential to any waste management regime.

UNRESOLVED ISSUES AND CONSIDERATIONS

The following points have been identified as issues and considerations that need to be taken into account regarding the development of a comprehensive strategy for outreach to the commercial fishing industry:

1. There is currently a deficiency of educational programs and/or materials, which target the fishing industry, upon which to model new programs.
2. There is a lack of clear understanding of cultural factors, and motivational factors.
3. The range of stakeholders in the fishing industry runs from owners and operators of large factory trawlers to members of small subsistence artesnal fisheries. Different approaches for education and outreach need to be devised for different size industries.
4. The issue of whether education and outreach programs are highly effective in motivating changes in behavior is not yet conclusive; in addition, there has been no assessment of various types of outreach approaches to determine which are most effective.
5. The technology sector's interest in developing alternatives to present technology is unclear.
6. Is there a lack of education and participation by government, regulators, and resource managers to take regulatory action? This needs to be assessed.

OPPORTUNITIES FOR IMPROVEMENT AND ACTIONS NEEDED

The following points represent just a few of the opportunities and actions that are needed to begin to implement a region-wide outreach and education campaign for the commercial fishing industry.

1. Need for regional commitment to tackle the issue of the derelict gear issue, and the willingness to incorporate education as an important tool.
2. Need to be able to identify, communicate, and work with local agencies and organizations to support outreach efforts and develop programs.
3. Funding sources need to be identified for outreach and education programs.
4. Government and resource managers need to commit to both outreach programming and enforcement regimes.
5. Strong need for development of information sharing mechanisms and building of networks to disseminate educational models that have proven effectiveness.
6. Need to develop flexible models of outreach (two-pronged approach):
   - models that are readily adapted to local cultures and conditions (for coastal fisheries), and
   - models that are targeted at large pelagic fleets and commercial ventures.
7. New avenues of outreach need to be explored, such as government observer programs.

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Appendix A.

RECOMMENDATIONS FROM PREVIOUS MARINE DEBRIS CONFERENCES AND WORKSHOPS

In 1984, the First International Conference on Marine Debris, the **Workshop on the Fate and Impact of Marine Debris**, provided several conclusions and recommendations that focused on the need for marine debris education programs (Shomura and Yoshida, 1985). The working group on Management Needs recommended placing significant emphasis on public education and that steps specifically be taken to:

1. Work with fisheries organizations and the fishery management councils to develop and carry out comprehensive information and education programs for foreign fishermen, working within the Exclusive Economic Zone, and U.S. fishermen;

2. Work with appropriate national and international organizations to undertake cooperative information and education programs; and

3. Work with relevant industries, such as has been done with elements of the plastics industry, on public education programs.

The working group also noted that 'to encourage the removal of debris from the environment and prevent the discarding of additional debris, positive incentives such as financial rewards for the return of discarded netting material should be considered as should possible negative incentives.' Additional conference recommendations for outreach efforts included recommendations to:

4. Identify and publicize geographic areas where fishing gear is likely to be snagged and lost.

5. Expand existing stranding networks for marine mammals, birds, and turtles, and incorporate examinations for evidence of interactions with debris.

In October 1987, the **North Pacific Rim Fishermen's Conference on Marine Debris**, held in Kailua-Kona, Hawai'i, recognized that 'fishing industries should make every effort to prevent the deterioration of the ocean environment by promoting education programs and initiating procedures which will lead to a reduction of marine debris into the world's oceans' (Alverson and June, 1988). Attending the conference were representatives of the fishing industry from Canada, Japan, the Republic of China, the Republic of Korea, and the United States. Further resolutions to come out of the conference included:

1. Fishing groups participating in the Conference should focus their efforts to encourage other industries contributing to the marine debris problem to become involved in seeking solutions.

2. Fishing groups should be encouraged to promote local programs to further the education of fishermen, port authorities, resource managers, other seafarers, and

the general public regarding the scope, magnitude, and consequences of the growing marine debris problem.

3. Fishing vessel operators in the North Pacific should be encouraged to post in plain view notices to officers and crews that discharge of plastic materials into the oceans is contrary to international law.

In February of 1988, **Oceans of Plastic: A Workshop on Fisheries Generated Marine Debris and Derelict Fishing Gear**, funded by NOAA, was conducted in Portland, Oregon. Fishermen, marine researchers, educators, plastics manufacturers and government representatives from across the United States met to examine ways to reduce fishing related marine debris and to explain new plastic pollution legislation (Alaska Sea Grant, undated). Workshop participants unanimously agreed that more education about the marine debris issue is needed and that different users groups need different types of education. Recommendations for future education programs included:

1. Promulgation of successful programs such as the Port of Newport Refuse Project, as well as information on the consequences of plastic pollution and pertinent information on the Marine Plastic Pollution Research and Control Act, to the fishing industry and other members of the fishing community, such as fish processors and fishing port administrators.

2. Development of a mechanism for the timely delivery of information, as it becomes available, on new technology to cope with or prevent marine plastic pollution. The concept of a national clearinghouse consisting of a network of various government agencies, port authorities, fishermen's associations, and environmental groups was endorsed.

3. Educational programs for the fishing industry should be spearheaded by fishers and other user groups. Sea Grant and other agencies should provide support but should not take leadership away from the fishing industry or others who already are addressing the issue.

In the 1988 **Report of the Interagency Task Force on Persistent Marine Debris** the following recommendations where made by the various U.S. government agencies involvedin the study:

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

2. Federal agencies should continue to participate actively in international forums to reduce persistent marine debris.

3. NOAA should coordinate and disseminate information related to persistent marine debris. NOAA should call at least two meetings of appropriate federal agencies each year to discuss each agency's education, regulatory and research programs, and to ensure that a continued coordinated effort is made to maximize the effect of existing federal programs.

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

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

6. The U.S. Coast Guard, U.S. Navy, and other federal agencies should include material relative to persistent marine debris problems in all educational material for employees and candidates for licenses.

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

8. The U.S. Coast Guard should begin a public education campaign on the requirements of the Marine Plastic Pollution Research and Control Act as soon as possible to assure that owners and operators of all vessels, ports, and the boating public are aware of requirements prior to enforcement.

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

10. Federal agencies should support local volunteer beach cleanup efforts as well as the collection and interpretation of data on materials that the volunteers remove. Federal managers should encourage employees to participate in volunteer clean-ups.

In April 1989, the **Second International Conference on Marine Debris** was held in Honolulu, Hawai'i. The Report of the working group on Marine Debris Education contains these recommendations (O'Hara, 1990):

1. New marine debris outreach programs should be conducted for new audiences including the packaging industry; municipal sewage treatment operators; government officials and enforcement agencies; coastal tourist industries; tackle manufacturers; operators of small ports, docks, marinas, and yacht clubs; suppliers of stores for vessels; boat manufacturers; employees of retail stores (including fast-food and convenience stores, and fishing and boating stores); environmental and conservation organizations; the media; employees of shipyards; longshoremen; and coastal hunters.

2. A public awareness campaign should be developed that uses the media to effectively disseminate educational information. In developing this campaign an initial assessment of human behavior and public perception of the marine debris problem needs to be made.

3. Dissemination of educational materials could be facilitated with assistance from established education organizations such as the National Marine Educators Association; existing government distribution mechanisms such as licensing and registration procedures for fishing and boating.

4. Specific international agencies such as the United Nations Environmental Programme, Food and Agriculture Organization, and the International Maritime Organization should be encouraged to take part in information exchange.

5. There is a need to evaluate the success of educational programs. Mechanisms such as formal surveys, monitoring of beach debris, and monitoring of shore side refuse reception facilities should be put in place to assess changes in attitude and behavior.

6. The following educational approaches were endorsed:

   - involve members of the target audience in the development of educational materials and distribution;
   - be familiar with the audience and personalize the message to specific target audiences, keeping the information as locally relevant as possible;
   - make educational experiences positive and enjoyable; highlight positive steps taken by groups or individuals to reduce marine debris; and
   - emphasize the benefits to a group for their involvement in efforts to reduce marine debris, including, where appropriate, economic impacts.

Other conclusions of the conference identified the need for:

1. Broad international acceptance and implementation of the terms of MARPOL (73/78) Annex V, especially the provision of port reception facilities.

2. Recognition of the marine debris problem as a symptom of the worldwide solid waste disposal crisis.

3. 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.

The **Third International Conference on Marine Debris** held in May 1994 in Miami, Florida produced these recommendations on education and outreach (Coe and Rogers, 1997):

1. Explore the effectiveness of sensational appeals, which aim to reduce marine debris through graphic displays, posters or media campaigns showing animals wounded by debris or through strongly worded slogans about its effects on oceans and wildlife. Consider alternative, more stringent policy measures to reduce debris.

2. Focus on and publicize the problem of combined sewer overflows. Continue research on terrestrial sources of debris.

3. Explore mechanisms to reduce entanglement of marine animals and produce a guide to disentangling and rehabilitation techniques.

4. Establish an impact reporting system to promote and collate observations by beach users, fishermen, oceanographers, scuba divers and others. Start by compiling past records.

Chad Yoshinaga, courtesy of NMFS

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