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Protecting the Oceans

Oil Tanker Wallowing in Rough Seas

The Impact of Ocean Pollution

By Allan Hirsch

Fishermen haul in net on purse seiner off Korean coast.

Threats to the marine environment are increasing. The oceans are the ultimate repository for many of man's wastes, which arrive there through various routes. Continuing concentration of population and economic development in the world's coastal zones is increasing the potential for marine pollution through direct discharge to estuaries and coastal areas through ocean outfalls.

River flows also contribute contaminants from discharge points far upstream; the contamination of blue fish in Chesapeake Bay by Kepone released into the James River many miles above the mouth is an example. This incident resulted in the closing of the commercial fishery. Marine transportation activities contribute to ocean pollution, not only through highly spectacular, but relatively infrequent, major oil spills, but also through a continuing low level discharge of contaminants from small spills of oil and other hazardous wastes, and as a normal part of tanker operations.

Barging of wastes, both industrial and municipal, to sea for dumping is another source of marine pollution. In recent years the United States, through both national legislation and international agreement, has curtailed the ocean dumping of waste materials, particularly municipal sewage sludges. U.S. legislation requires the phase-out of "harmful" sewage sludge dumping by December, 1981. The legislation also requires testing of other wastes, such as dredged material, to ensure that harmful materials are not being dumped.

Deposits of contaminants from the atmosphere is now recognized as a major source of pollution and may be the major contributor of many pollutants to the ocean. Various pollutants are reaching remote oceanic areas far from the point of production or disposal. This was vividly demonstrated when high levels of DDT were found in Antarctic penguins. Contamination of the marine food chain is another significant contributor to ocean pollution. The explosion in production and use of synthetic chemicals, many of which are toxic or otherwise harmful, has helped increase this type of pollution. Pollution is not the only source of stress to the marine environment. Physical changes also are impacting the oceans. For example, alterations of freshwater flow caused by river basin development are changing salinity patterns and other environmental conditions in many coastal areas, sometimes with major ecological consequences. A striking example is the construction of the Aswan Dam which, by reducing nutrients and sediments in the Nile, adversely affected Mediterranean fisheries and changed the nature of coastal beach and dune formation. Large engineering works, such as the Suez Canal, can significantly alter the composition of marine ecosystems by permitting transmigration of species. Additional sea level canals may be built in the future. Dredging and filling bays can also alter current patterns and change flushing rates.

Extensive loss of coastal wetlands reclamation has resulted in loss of habitat for important fish and wildlife species and has altered nutrient exchange. In addition to the importance of wetlands as nursery areas for commercially valuable fish and shellfish, recent evidence suggests that they may play an even more important role in geochemical cycling than had been previously recognized.

The effect of the harvest of fish on marine ecosystems should also be mentioned. Fisheries management has long focused on issues relating to the management of commercially harvestable stocks. However, in addition to the determination of maximum sustainable yield for various species and populations, broader questions are beginning to emerge. One is whether over-fishing might in some way irreversibly alter basic ecological relationships. In the North Atlantic fishery, for example, will continued harvesting of fish high in the food chain result in permanent displacement by species at a lower level? Recent proposals for large-scale krill harvesting in Antarctica would remove many tons of these organisms from the food chain of fish, marine mammals, and birds and raise the possibility of changes in the structure and function of ocean ecosystems.

We have long been aware of the potential impacts of development in the coastal zone. Now, however, development is pushing out into marine areas hitherto considered remote and inaccessible and frequently of great biological sensitivity and importance. Until a few years ago, development of oil and gas in the North Sea was regarded as perhaps the most extreme example of ocean engineering under hazardous environmental conditions. New offshore development under the ice of the Beaufort Sea and in other Arctic areas is being considered. Oil and gas exploration is now scheduled on Georges Bank, an area subject to severe storm hazards. Waste disposal from oil and gas activities, coupled with already massive and increased fishing, could hurt the productivity of the world's richest fishing grounds. Deep ocean mining for manganese nodules in the Central Pacific and proposals for a superport in Palau in the Southwest Trust Territory of the Pacific Islands, provide yet other examples of the fact that no ocean area can be regarded as so remote or isolated as to be immune from development.

Prospects for large-scale tidal power, and possibly even electric power generation through harnessing ocean currents such as the Gulf Stream suggest that our capacity to alter the marine environment through physical and engineering changes may increase dramatically in the future. Ocean thermal energy conversion facilities currently being studied as a source of power depend on temperature differences between surface and deeper waters. The discharge of the cooler bottom waters and their associated nutrients near the surface and the use of biocides, such as chlorine, to prevent fouling on the condensers could produce adverse environmental impacts.

Fortunately, governments at all levels have increasingly recognized the importance of ocean resources and the need to protect marine environmental quality. Environmental legislation enacted within the last decade in the United States provides for regulation of ocean dumping and discharge of wastes, for protection of coastal wetlands, for establishment of marine and estuarine sanctuaries, for cleaning up spills of oil and hazardous materials, for coastal zone management and establishment of environmental safeguards in development of superports, marine minerals, and Outer Continental Shelf oil and gas reserves.

The oceans are an international resource, and the protracted Law of the Sea negotiations attest to the importance placed on these resources. During the 1970's, international conventions on pollution by ships, on ocean dumping of wastes, and on protection of the Mediterranean Sea from pollution, as well as the laws of various nations regulating marine pollution, all demonstrated an awareness and willingness to address marine environmental problems. While we may take this awareness for granted today, it is a far cry from relatively recent times when the sea was considered a sink with unlimited capacity to assimilate man's wastes. This is illustrated by the fact that legislation to control ocean dumping in the United States was enacted only eight years ago, long after controls on conventional water pollution discharges had been initiated.

In implementing these laws, environmental managers have been, and increasingly will be, seeking information on the ecological consequences and trade-offs of their actions as a guide to many marine resource management issues they are confronting. Many of these questions deal with impacts and management options of a relatively limited scope. Others address issues which are global in nature, sometimes raising the spectre of possible "ecocatastrophies." From time to time there have been dire predictions of catastrophic changes in behavior of the oceans. For example, several years ago, an individual prominent for his activities in ocean exploration announced that the oceans were dying and could well be dead within 25 years. Most responsible scientists would probably dismiss such statements as wildly speculative at best. Few, however, would deny that the question of man's impact on the world's oceans merits serious attention and that, should global impacts occur, the stakes could prove very high indeed. For example, should long-term reductions in photosynthetic capability result from man-induced stress, the impacts on food production in the oceans and on atmospheric oxygen content could both have profound impacts.

The kinds of questions being asked are: What is the capacity of the oceans to receive and assimilate wastes without threat of serious impact? How can we measure this assimilative capacity? Are there significant and wide-scale trends in ocean deterioration? Are subtle, long-term alterations in marine ecosystems occurring as a result of man-induced stress? What are the consequences of marine waste disposal in relation to terrestrial alternatives? How can we monitor and detect deterioration in marine ecosystems, particularly for early warning purposes?

Although advances have been made, the answers to many of these questions have not been forthcoming from the marine science community to date, due to a combination of resource constraints and scientific limitations. Our current understanding of the response of marine ecosystems to stress falls far short of that which will be required for sound environmental management over the long run. If we think of marine systems as a continuum—ranging from estuarine and inshore areas at one end of the spectrum, through large enclosed seas or semi-enclosed coastal areas, to open oceans in areas at the other end of the spectrum—we know most about the impacts of man in confined and localized areas and least in the open sea areas.

There have been many intensive studies on individual bays, estuaries and nearshore areas, and these have provided useful information concerning environmental impacts. Despite this, we are often hard pressed to quantify the impacts of major disturbances on more than a local scale. Enclosed seas such as the Baltic Sea and large coastal regions such as the New York Bight and Southern California Coast have also been studied to assess the impact of pollution and other marine alterations. However, even in the New York Bight, which perhaps has been more intensively studied than any comparable oceanic area in the United States and perhaps the world, many questions concerning more than isolated, localized, or relatively discrete impacts still remain largely unanswered.

Thus, while evidence for specific situations has frequently been sufficient to support regulatory judgments, little is known concerning the broader impact of man on the open oceans. It is known that contamination is widespread. Plankton tows in the Atlantic have routinely picked up substantial quantities of tar and plastic debris. There is a general consensus among many marine scientists that chlorinated hydrocarbons, toxic metals, and petroleum hydrocarbons are all ocean contaminants of potential global concern. However, while widespread distribution of these contaminants has been detected in pelagic marine environments, relatively little is known about their significance in terms of ecosystem impacts. For example, although increased low level contamination of the oceans by petroleum hydrocarbons has been well demonstrated, the ecological consequences are not understood. This lack of information has clouded international discussions concerning the levels of control that should be imposed on oil discharges from vessel operations.

Clearly, there are major difficulties in providing reliable information on trends in marine environmental quality. On the one hand, we are unable to demonstrate clearly far-reaching impacts; on the other hand, we have a haunting concern that damages might later appear, perhaps far from the source and with devastating effect. The problems are perhaps more ambiguous and less tractable than such comparable global environmental issues as desertification and loss of tropical rain forests, which can be inventoried and quantified by remote sensing techniques. Acquiring the necessary information may pose some dilemmas which, while not unique to marine systems, are particularly difficult because of the large-scale, open, complex nature of the oceans. Marine ecosystems may exhibit great spatial and temporal variability. At any given time, they may be responding to natural stress, such as the aftereffects of severe storms. Tremendous difficulties have been encountered in attempting to establish baseline and monitoring approaches which can detect departures from a norm, particularly for early warning purposes.

So one dilemma marine scientsts face is that of trying to predict and detect increments of man-induced change in a dynamic, constantly changing natural environment. This poses a number of basic conceptual problems. A basic problem in detecting change is the so-called "noise-to-signal" ratio. That is, are we actually detecting a uni-directional change, or are we somewhere within the hands of cyclic or other natural variability? For example, is the substantial loss of submerged aquatic vegetation currently being experienced in Chesapeake Bay the result of pesticide run-off, Hurricane Agnes, or a cyclic natural event?

Then there are problems determining causal relationships. Once we have detected a change, is it in any way related to the stress we are monitoring? This is complicated by the fact that a number of stresses, both man-caused and natural, may be simultaneously impacting the system under study. Failure to identify the correct cause of change could result in either regulation or failure to regulate.

There is also the problem of defining the significance of effects. If we have detected a change and find it is man-induced, what is its significance? Is it irreversible? Is it catastrophic? Is it important? An example is the destruction of estuarine or anadromous fish populations by electric generating plants. We may be able to estimate that a plant is reducing the numbers of fish eggs and larvae by 50 percent through its water intake system, but how significant is such a loss of eggs and larvae in determining the size of the mature population? We do know that populations may compensate to some extent for such losses through increased survival rates of the remaining eggs and larvae. Another example is found in questions dealing with bioconcentration of pollutants in food-chains. We can determine if biomagnification occurs and predict whether this may have an impact on selected populations. But impacts on or risks to man are much more difficult to determine.

All this, of course, says nothing about the question of how much environmental damage society is willing to accept. This obviously is a public policy, rather than scientific determination. But sound understanding of "significance" may assist in resolving "acceptability."

There are inherent difficulties involved in providing clear-cut answers to many of these questions. In laboratory experiments, scientists can control the variables and obtain clear-cut results, but how do laboratory findings relate to what actually exists or will exist in nature? Yet, when we try to study the marine ecosystem itself, we have a hard time controlling the variables and distinguishing the impacts. And, if we conduct microcosm studies such as the EPA-sponsored studies at the University of Rhode Island, which are using large tanks with natural seawater and communities of organisms from nearby Narragansett Bay to provide controlled experimental ecosystems, then we still must question whether or not we have really replicated the environment or whether we are measuring experimentally induced anomalies.

In the final analysis, to make progress in this area, we must seek to improve not only our ability to predict the consequences of marine pollution, but also our ability to detect, measure, and understand the significance of damage after it has occurred. Improved predictive capability will depend upon an integrated approach to the use of such research approaches as laboratory toxicity studies, ecosystem simulation models, and field investigations. Our predictions must then be complemented by improved monitoring capability which can detect actual impacts, and serve as a feedback mechanism with respect to the accuracy of our original predictions and adequacy of our regulatory actions.

New and innovative approaches will be required to monitor and detect subtle and long-term changes in ocean ecosystems. One promising approach is biomonitoring. An example of biomonitoring is the Mussel Watch program. This effort utilizes mussels and oysters as sentinel organisms for recording relative levels of pollutants, such as heavy metals, petroleum hydrocarbons and halogenated hydrocarbons, in coastal environments. These organisms have the ability to bioconcentrate these pollutants, which makes analysis much easier, and to integrate pollutant exposure over time. This program has been used to identify pollutant "hot spots" around the coast of the United States.

Other organisms can also serve as bioindicators. For example, a conference held several years ago on long-term ecological measurements identified seabird populations as important potential indicators of marine environmental quality. The conference report discussed the fact that many marine birds are long-lived, widely dispersed during much of the year, but highly concentrated during their nesting seasons. Because of their role high in the food chain, marine birds are potential accumulators of contaminants as well as integrators of ocean ecosystem conditions. It might be feasible to design long-term sampling programs which could combine tissue analysis with the monitoring of nesting areas through aerial photography, thus sampling populations representing a vast coverage of ocean conditions in a very small space and possibly providing a vehicle for detection of widescale oceanic change. This approach still remains to be tested.

In addition to the conceptual and scientific problems involved, marine pollution studies present major organizational challenges. The very nature of ocean systems calls for investigations which are integrated, truly inter-disciplinary, and sometimes international in scope. This requires major manpower and financial resource levels and logistical support, as well as organizational skills more characteristic of the space program than of most environmental research. In this regard, it is encouraging to see studies such as the Coordinated Mediterranean Pollution Monitoring and Research Program, supported by the United Nations Environment Program, which involves a sustained and integrated attack by scientists of various nations.

I have described the difficulties involved in providing answers to some of the questions concerning marine pollution facing decision makers. I would like to conclude by stressing the importance of making progress in this area. For the present, concern about the future of the oceans, coupled with the technical difficulties of monitoring and detecting harmful effects early enough to assure they will not become irreversible, has been great enough to result in adoption of a cautionary approach to many marine environmental issues. Under current legislation, many existing pollutant discharge regulations are technologically based, rather than reflecting ecological cause and effect. That is, they require adoption of waste controls that are feasible from an economic and engineering standpoint, rather than defining what is required to avoid unwanted environmental impacts, based upon analysis at a particular site. However, a concern on the part of some communities that secondary waste treatment requirements for waste discharges to the ocean could impose unnecessary costs in relation to environmental results led to enactment of Section 301(h) of the Clean Water Act of 1977. This section of the law allows EPA to issue permit modifications which will let municipalities discharge less than secondary treated wastes to the marine environment provided they can demonstrate that significant environmental damage will not occur. Reviews of applications for this type of permit modification are currently underway. Conversely, in other cases, technology-based regulatory controls may not provide enough protection, and marine environmental problems may result.

Perhaps even more significant is the question of whether excessively stringent controls on marine waste discharges may impose unnecessary costs or greater burdens on some other sector of the environment. Increasingly, however, we are recognizing the need to examine environmental trade-offs; for example, wastes not discharged at sea may require land disposal or incineration, causing environmental problems elsewhere. As pressures mount on such issues as ultimate disposal of toxic wastes, protection of groundwater from leachates from land disposal sites, the atmospheric effects of waste incineration, the energy costs of waste disposal, and others, decisions based on a more quantifiable relationship between environmental control requirements and environmental response increasingly will be required. The need for better information about the ecological consequences of waste disposal in the ocean will be even greater than it is today.

Efforts to address questions such as those outlined above provide the basis for EPA's current research activities relating to marine pollution. Although EPA's research programs and resources in this area are relatively limited, we are working in close cooperation with other agencies and research institutions. We know that we can never hope to find solutions for all the problems of our impact on the oceans, but we are attempting to provide information which will greatly assist in making more rational and informed management decisions. □

Oil-smeared bird is victim of pollution.

Dr. Hirsch is EPA's Deputy Assistant Administrator for Environmental Processes and Effects Research.

EPA and the Marine Environment

The need for data on ocean pollution is of growing importance to EPA and other agencies responsible for marine protection and management. EPA is especially concerned with the need for regulation to curb ocean pollution and for research to furnish the scientific basis for regulatory decisions.

EPA's marine and coastal activities are carried out under several laws: Clean Water Act; Marine Protection, Research, and Sanctuaries Act; Toxic Substances Control Act; Federal Insecticide, Fungicide, and Rodenticide Act; Deep Sea Hard Mineral Resources Act, and the Ocean Thermal Energy Conversion Act. (For EPA's role in international marine agreements, see article on page 8.)

EPA's research is conducted by the Office of Research and Development at the Agency's laboratories at Gulf Breeze, Fla.; Narragansett, R.I.; Newport, Ore., and Grosse Ile, Mich. Other EPA-supported research is done at universities throughout the U.S. and a Marine Center of Excellence at the University of Rhode Island.

EPA research and regulatory activities related to marine and coastal areas are listed below.

EPA-supported research, which provides the technical basis for regulatory decisions, is focusing on marine waste disposal, energy impacts, toxicity studies, wetlands, the Great Lakes and Chesapeake Bay, and monitoring. Research activities include:

- determining the impact of municipal wastes disposed of through ocean outfalls.
- developing procedures to measure the toxicity of dredged material and to determine levels of pollutants in sediments.
- determining the impact of drilling fluid disposal from oil and gas drilling activities.
- examining the effects of oil in the marine environment.
- developing and testing oil spill prevention, control, and cleanup devices and procedures.
- determining the impact of chlorine in discharges to the marine environment.
- developing procedures to measure the toxicity and impact of pollutants such as pesticides and toxic substances.
- determining the impact of carcinogens on the marine environment.
- investigating the fate and effects of pollutants in simulated marine ecosystems.
- developing procedures to define wetland boundaries for legal purposes.
- studying wetlands to determine their function and value in the environment.
- conducting studies on toxics, submerged aquatic vegetation, and nutrient enrichment in the Chesapeake Bay.
- examining pollutant input, cycling, fate and effects in the Great Lakes.
- assessing the use of mussels and oysters as a technique for monitoring pollutant levels in marine coastal areas.
- developing methods to monitor pollutant exposure at specific sites in marine environments over relatively short periods of time.

In addition to these research efforts, EPA is also involved in regulatory activities affecting the following areas:

- ocean dumping of municipal, industrial and radioactive wastes.
- disposal of dredged material.
- discharge of municipal and industrial effluents from ocean outfalls.
- discharge of wastes from oil and gas drilling operations, deep sea mining activities, and offshore thermal conversion facilities to produce energy.
- oil and hazardous materials spill prevention, cleanup, and damage assessment.
- development of water quality criteria for hazardous materials.
- registration or reregistration of pesticides.
- premarket testing of toxic substances.

Interagency coordination regarding the marine environment is carried out both formally and informally. Formal planning for and dissemination of information on marine research activities for the Federal Government is coordinated through the interagency Committee on Ocean Pollution Research, Development and Monitoring. □

Heron wading in ocean surf at Padre Island, Tex., with offshore oil well in background.

Underwater Scientists at Gulf Breeze

By Betty Jackson

Marine biologists at EPA's Environmental Research Laboratory in Gulf Breeze, Fla, are taking a leaf from diving techniques to supplement laboratory research on the effects of pollutants on marine life.

Divers there have been conducting biological surveys underwater, collecting organisms and samples for use in laboratory tests, and even transferring portions of the sea floor into the laboratory for experiments that attempt to simulate natural conditions.

Laboratory Director Henry F. Enos foresees an expanded role for the scientific diver in response to increased demands for field validation of laboratory experiments and on-site biological surveys for environmental problem-solving.

"To fulfill this role, divers at our laboratory needed intensive advanced training in the use of sophisticated equipment and in the management of diving accidents," Dr. Enos explained. "Therefore we set up a workshop in advanced diving technology that was conducted by instructors of the National Oceanic and Atmospheric Administration."

The workshop curriculum was designed to help Gulf Breeze scientists expand their research periphery and extend their work from the laboratory bench to the underwater environment. They were also instructed in diving physiology, uses of underwater equipment, and safety procedures.

At the conclusion of the training, laboratory Diving Officer Jim Patrick was certified as a diving supervisor and dive master. Six laboratory staff members were certified as operational divers: Joel Ivey, Dana Morton, Jim Spain, Patrick Borthwick, Norman Rubinstein, and Wiliam P. Davis. Biological Aide Jeff Wheat qualified as a surface support tender.

"Our team is the first within the Environmental Protection Agency to meet diving standards of the National Oceanic and Atmospheric Administration," Dr. Enos said. "Certification of our divers will be a continuing exercise and will be subject to periodic review by their instructors."

As more and more scientists combine laboratory research with underwater investigations, guidelines for their health and safety has become a concern of the Occupational Safety and Health Administration. Jim Patrick, Gulf Breeze's diving supervisor, hopes that the exercise guidelines and procedures used in the certification and training of his team can be useful in developing safe diving requirements for EPA divers.

"We consider ourselves pioneers in the development of a safe diving code for the Agency that will be applicable to scientific divers who monitor pollution or document damage caused by pollutants," Patrick said.

In addition to intensive training in lifesaving procedures, instructors Ed Clark and Richard Rutkowski, assisted by Marc Kiser, and Michael A. Heeb of EPA, taught Gulf Breeze divers the use of sophisticated dry suits designed for cold or contaminated waters. Divers using the dry suits are supplied air from the surface through two types of face masks. Both mask systems are full-face, underwater breathing devices that protect the diver from contaminated water and provide direct two-way communication between the diver and a surface tender.

The dive team also was introduced to an underwater television system that can record behavior of marine life and any changes in biota and the physical environment caused by people. Divers learned how underwater video television technology can aid in communication with topside support personnel who monitor divers for safety and assist in the evaluation of results.

Divers received training in the latest collecting techniques for capturing delicate animals in nets, cages, and devices such as the airlift—a long pipe equipped with an air venturi that transports sediment and organisms to a collecting bag.

These techniques will be applied to, or modified for research projects being conducted by members of the dive team.

Microbiologist Jim Spain, operational diver, relies on other members of the team to assist him in the collection of sediment and water cores for tests to determine the fate of toxic chemicals in the aquatic environment.

The cores are collected carefully to preserve bottom sediment, an area of intensive microbial activity. Divers collect the cores in an apparatus designed to transfer sediments intact to the laboratory for experiments with pesticides. The test system, called the Eco-core, was developed at Gulf Breeze to measure the rate of microbial degradation in contaminated sediments. Results aid in predicting the fate and persistence of toxic organic chemicals in the marine or estuarine environment.

Cores for the tests are collected from various underwater sites in the Gulf of Mexico, Pensacola Bay estuary, and rivers, often under difficult conditions. Spain, like the other scientists at Gulf Breeze Environmental Research Laboratory, believes that scientific training and intimate knowledge of the test procedures and objectives are essential to the performance of such diving tasks.

This view is shared by other members of the team. Jim Patrick, who is currently involved in studies with the belted sandfish, *Serranus subligarius*, has found that diving is the only method of collecting the animals unharmed. Each fish, a type of hermaphrodite, can produce both viable eggs and sperm. Mating pairs are identified by behavioral interaction and by subtle differences in pigmentation. Thus scientific expertise is required to identify and collect the pairs needed for laboratory tests to determine whether the species can be used in reproductive studies.

Joel Ivey, a biological technician, and a member of the dive team, aided in the design of community tests that use benthic or bottom-dwelling communities established in habitats placed underwater and later retrieved by divers. The organisms are lifted to the surface with the aid of air-filled lift bags controlled by the divers.

With the assistance of other divers, Ivey can transfer habitats that contain such communities from the seafloor to the laboratory for tests designed to determine the toxicity of oil-well drilling fluids to bottom-dwelling organisms. The test species, including annelids, arthropods, molluscs, crustaceans, and nematodes, settle in the habitats that contain sand taken from the sea bottom. After eight weeks, the habitats and the developed communities are transferred to the laboratory for toxicity tests with drilling fluid components. Results of such tests are used to validate tests with benthic communities that have been developed in the laboratory.

Research biologist Patrick Borthwick sees diving as a useful tool for locating and collecting new test species for laboratory acute toxicity studies. Under water, the scientific diver can observe and collect live specimens in various stages of development from specific aquatic habitats. In his search for novel test species, he hopes to develop a battery of sensitive organisms representing several types of marine life for screening pollutants.

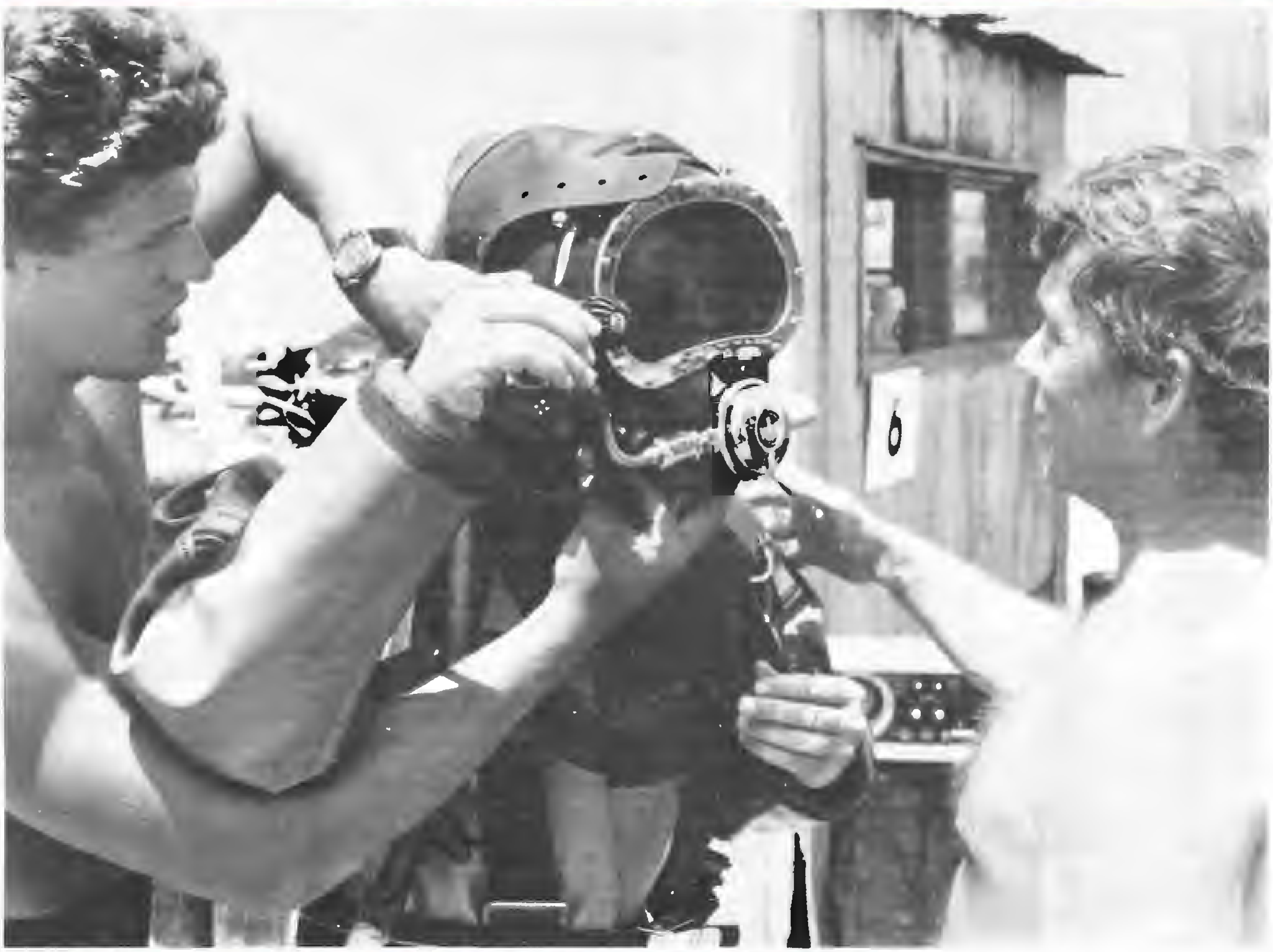
Diving is important in the study of crabs and other shellfish. These commercially important species are oriented to the ocean bottom and are often difficult to sample with conventional traps.

As in recent years, divers from the Gulf Breeze Laboratory this summer collected arrow crabs (*Stenorhynchus seticornis*), at Stage I, a Navy research platform in the Gulf of Mexico 12 miles south of Panama City, Fla. The animals will be used for field and laboratory studies of the effects of drilling fluids on the offshore environment. The research effort, supported by grants, contracts, and interagency agreements, focuses on the effects of drilling fluids on animals and plants normally found near offshore oil and gas rigs. It also seeks to determine the impact of drilling near areas of high biological activity, such as coral reefs and the communities they shelter.

The divers frequently are consulted by fellow scientists on design and procedures for sub-sea experiments. Their underwater observations are useful in evaluating the effectiveness of sampling devices and determining whether the sampling site is unusual or representative of a larger sampling area. Field validation by divers is important in verifying results of laboratory tests and demonstrating that test conditions reflect those existing in nature.

Divers at the Gulf Breeze Laboratory predict that diving technology will be useful in future attempts to monitor changes in aquatic ecosystems at dumping sites or at ocean outfalls. The need for basic data about the environmental health of the nation's water resources holds the promise of a bright future for scientific diving. □

Betty Jackson is a technical writer for the Gulf Breeze Laboratory.



Scientist at EPA's Gulf Breeze, Fla., laboratory prepares to dive in marine pollution research project.

Burning Wastes at Sea

By Charlotte Garvey

The hazardous waste incinerator ship Vulcanus at sea.

Burning chemicals at sea may be a key part of the answer in disposing of some kinds of hazardous and toxic wastes.

Incineration at sea is environmentally safe, economical, and should be encouraged, concluded the recent report of an interagency task force.

The Interagency Ad Hoc Work Group, composed of members of EPA, the Commerce Department's Maritime Administration, the U.S. Coast Guard, and the National Bureau of Standards, has been studying expansion of technology in the area and has issued a report on the topic, "Report of the Interagency Ad Hoc Work Group for the Chemical Waste Incinerator Ship Program."

The group recommended amending the Merchant Marine Act of 1936 to permit substantial Federal assistance and funding to build and operate privately-owned U.S. flag waste incinerator ships.

"This country has an enormous hazardous waste problem and Americans have to face up to it," said former EPA Administrator Douglas M. Costle. "Everybody wants hazardous wastes picked up, but no one wants them put down. Incineration, both on land and at sea, gives us a major option for effectively dealing with hazardous waste. We need to be as supportive of these new technologies as we can."

The government has two options, depending on how many private firms apply for Federal assistance to build incinerator vessels over the next year, said Russel Wyer, EPA's co-chairman of the interagency task force. One option is to stimulate private industry to build ships themselves through financial incentives including subsidies and Federally-guaranteed loans. In return, industry would allow EPA to set up research stations on the vessels themselves to advance the state of the art.

If few applications for Federal assistance are received, another alternative the government will consider is building and operating its own vessel for possible later sale or charter to private industry.

Wyer said that the at-sea program would supplement incineration operations on land, with an estimated capability to handle only a fraction of total hazardous and toxic wastes, even at maximum capacity.

The report recommends giving top priority to setting up "funding mechanisms which encourage private entrepreneurs to build and operate incinerator ships" in the United States and to "place the cost of constructing a vessel in the United States on a parity with foreign construction costs" either through proposed subsidies or tax incentives.

The Vulcanus, a Dutch incinerator ship used extensively throughout Europe, in 1977 successfully destroyed three shiploads of Herbicide Orange, a toxic defoliant used by the United States in the Vietnam War. The average destruction efficiency of this process for dioxin, a highly toxic substance in the herbicide, was greater than 99.9 percent. The burn took place about 1,000 miles southwest of Hawaii.

Burns take place on the high seas at least 100 miles from shore. Under EPA regulations, an Environmental Impact Statement (EIS) must be issued for each incineration site to assess in detail what effect the operation could have on the environment.

The Vulcanus is the only vessel capable of at-sea incineration now available for commercial use that can travel from continent to continent. It was converted from a cargo ship to incinerator capability.

Waste Management, Inc., of Oakbrook, Ill., has since purchased the Vulcanus from its German owners, Hansa Lines. Ocean Combustion Services, a subsidiary of Waste Management, operates the vessel.

EPA has plans for the Vulcanus this year. The Agency wants to destroy one and a half shiploads of Silvex, which has shown the potential to cause miscarriages, birth defects, and have other adverse reproductive effects. EPA also plans to destroy half a shipload of DDT at the same time and is considering use of the Vulcanus for destruction of PCB's.

The interagency group has also drawn up a prototype model incinerator ship which, unlike the Vulcanus and other at-sea incinerator vessels, would have the capacity to destroy solid as well as liquid wastes. Wyer said equipment now on the vessels is limited to liquid waste and the addition of a rotary kiln incinerator to destroy solid waste needs to be tested.

The model ship would have an 8,000 metric ton capacity compared to the Vulcanus' 4,000 metric ton capacity. Wyer says an alternative to building new ships is to convert existing ships to incineration capability, but the vessels would be much smaller than the prototype.

A single prototype ship at full capacity could destroy up to 200,000 metric tons of waste a year.

Costs for constructing a single vessel are estimated at $75 million in 1980 dollars, plus $25 million for incineration equipment.

EPA estimates in 1978 indicated the U.S. generates almost 350 million metric tons of industrial waste a year, and projected at least 57 million metric tons of hazardous waste would be produced nationally in 1980.

Wyer said that incineration at sea offers an attractive addition to the range of methods now used to dispose of chemical wastes. The other methods are landfill disposal, chemical detoxification, and land-based incineration.

An EPA comparative study in 1978 showed at-sea incineration to be the least costly means of disposal. Incineration at sea also is as effective as land-based incineration, often destroying 99.99 percent of hazardous materials contained in waste.

Wyer said there are a number of other advantages to burning at sea, explaining:

"Because the ship destroys wastes away from populated areas, you avoid any risk to nearby communities."

He also indicated at-sea incineration has minimal impact on the environment. "Acid emissions from the incinerator ships can be directly dispersed into the ocean without the 'scrubbing' process needed for land-base incinerators. The ocean water neutralizes most of the acids so the emissions mix harmlessly with the water," he declared.

A gap could soon develop in incinerator ship operations around the world when the Vulcanus' certificate of fitness, approving the vessel's condition for use, runs out in 1982, possibly before any other vessel has been constructed or retrofitted with similar capabilities.

Wyer said that Waste Management hasn't indicated plans for the Vulcanus in the future, but it is possible to rebuild the existing ship.

"It's getting tight," he said. Retrofitting a vessel could take up to a year and half, according to Wyer, and to build a ship from scratch, at least two years. He said that so far, the government hasn't received many applications for assistance.

To get things moving, the interagency group held a meeting on the project in December attended by members of the private sector. The purpose of the meeting was to exchange ideas, suggest possible directions for the program, and help the board estimate the potential number of applicants for Federal financial assistance.

Wyer said that the government's preferred option is for private industry to construct and operate the vessels, because it would keep management of the operation in the private sector and stimulate job opportunities as well. □

Charlotte Garvey is an editorial assistant with EPA Journal.

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