Volume 25, Number 4, Winter 1982/83

Oceanus®

The Magazine of Marine Science and Policy

Volume 25, Number 4, Winter 1982/83

Paul R. Ryan, *Editor*
Ben McKelway, *Assistant Editor*
Elizabeth Miller, *Editorial Assistant*
Lexes H. Coates, *Advertising*
William H. MacLeish, *Consultant*

Published by Woods Hole Oceanographic Institution

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

Editorial correspondence: *Oceanus,* Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543. Telephone (617) 548-1400.

Subscription correspondence: All subscriptions, single copy orders, and change-of-address information should be addressed to *Oceanus* Subscription Department, 1440 Main Street, Waltham, MA 02254. Telephone (617) 893-3800, ext. 258. Please make checks payable to Woods Hole Oceanographic Institution. Subscription rate: $20 for one year. Subscribers outside the U.S. add $3 *per year* handling charge; checks accompanying foreign orders must be payable in U.S. currency and drawn on a U.S. bank. Current copy price, $4.75; forty percent discount on current copy orders of five or more. When sending change of address, please include mailing label. Claims for missing numbers will not be honored later than 3 months after publication; foreign claims, 5 months. For information on back issues, see inside back cover.

Postmaster: Please send Form 3579 to *Oceanus,* Woods Hole, Massachusetts 02543.

Marine Policy
and Beyond

:es many problems as well as
number of ocean policy issues

e Sea

patterned after the Stratton
ded to explore the implications
ı Convention.

Marine Science:
ity for the Future
l Michael C. Healey

hers, the legal challenge of
e in foreign waters could
as the scientific challenge. New
operation, though, should open
ties as well.

one Management Program:
-Sharing Save It?

astal Zone Management
l other federal programs,
the fate of the offshore oil and
concept.

agement
o

nt is to avoid repetition of past
fundamental reappraisals are in

ing
n, Judith M. Capuzzo, Thomas
chael A. Champ

possibly the 1990s will be a
ational and international debate
the ocean to receive wastes
.

51 The Call of the Arctic
by Melvin A. Conant
The Arctic is an example of an area where there is a need in the 1980s for a strong federal commitment to develop vast resources in an environmentally responsible way.

58 Ocean Science and Military Use of the Ocean
by Robert S. Winokur and Rene E. Gonzalez, Jr.
Ocean science in the 1980s will continue to play an important part in this country's military use of the ocean.

profile

67 Roger Revelle — Senior Senator of Science
by William H. MacLeish
"He doesn't follow through, I think, by deductive logic. He's more like Conan Doyle. He assimilates a large body of evidence and then eliminates the unlikely."

concerns

71 The Cessation of Commercial Whaling
by Francisco J. Palacio
An end to an anachronistic slaughter is in sight.

75 Women in Oceanography
by Ben McKelway
A look at some of the problems women face in the field of oceanography.

letters

80

book reviews

82

INDEX

88

The Cover:

Photo collage by E. Kevin King.

 Oceanus (ISSN 0029-8182) is published quarterly by Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543. Second-class postage paid at Falmouth, Massachusetts, and additional mailing points.

Oceanus®

The Magazine of Marine Science and Policy
Volume 25, Number 4, Winter 1982/83

Paul R. Ryan, *Editor*
Ben McKelway, *Assistant Editor*
Elizabeth Miller, *Editorial Assistant*
Lexes H. Coates, *Advertising*
William H. MacLeish, *Consultant*

Published by Woods Hole Oceanographic Institution

Editorial correspondence: *Oceanus*, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543. Telephone (617) 548-1400.

Subscription correspondence: All subscriptions, single copy orders, and change-of-address information should be addressed to *Oceanus* Subscription Department, 1440 Main Street, Waltham, MA 02254. Telephone (617) 893-3800, ext. 258. Please make checks payable to Woods Hole Oceanographic Institution. Subscription rate: $20 for one year. Subscribers outside the U.S. add $3 *per year* handling charge; checks accompanying foreign orders must be payable in U.S. currency and drawn on a U.S. bank. Current copy price, $4.75; forty percent discount on current copy orders of five or more. When sending change of address, please include mailing label. Claims for missing numbers will not be honored later than 3 months after publication; foreign claims, 5 months. For information on back issues, see inside back cover.

Postmaster: Please send Form 3579 to *Oceanus*, Woods Hole, Massachusetts 02543.

contents

2 **Comment**

3 **Introduction: Marine Policy for the 1980s and Beyond**
by John A. Knauss
The United States faces many problems as well as opportunities as the number of ocean policy issues continues to grow.

7 **The Law of the Sea**
by Paul M. Fye
A new commission, patterned after the Stratton Commission, is needed to explore the implications of the Law of the Sea Convention.

13 **International Marine Science: An Opportunity for the Future**
by David A. Ross and Michael C. Healey
For U.S. oceanographers, the legal challenge of doing marine science in foreign waters could become as complex as the scientific challenge. New opportunities for cooperation, though, should open up research possibilities as well.

20 **The Coastal Zone Management Program: Will Revenue-Sharing Save It?**
by James P. Walsh
The future of the Coastal Zone Management Program, and several other federal programs, depends heavily on the fate of the offshore oil and gas revenue-sharing concept.

29 **Fisheries Management**
by Spencer Apollonio
If fishery management is to avoid repetition of past mistakes, some very fundamental reappraisals are in order.

39 **Ocean Dumping**
by John W. Farrington, Judith M. Capuzzo, Thomas M. Leschine, and Michael A. Champ
The 1980s and quite possibly the 1990s will be a period of vigorous national and international debate over the capacity of the ocean to receive wastes without undue harm.

51 **The Call of the Arctic**
by Melvin A. Conant
The Arctic is an example of an area where there is a need in the 1980s for a strong federal commitment to develop vast resources in an environmentally responsible way.

58 **Ocean Science and Military Use of the Ocean**
by Robert S. Winokur and Rene E. Gonzalez, Jr.
Ocean science in the 1980s will continue to play an important part in this country's military use of the ocean.

profile

67 **Roger Revelle — Senior Senator of Science**
by William H. MacLeish
"He doesn't follow through, I think, by deductive logic. He's more like Conan Doyle. He assimilates a large body of evidence and then eliminates the unlikely."

concerns

71 **The Cessation of Commercial Whaling**
by Francisco J. Palacio
An end to an anachronistic slaughter is in sight.

75 **Women in Oceanography**
by Ben McKelway
A look at some of the problems women face in the field of oceanography.

letters

80

book reviews

82

INDEX

88

The Cover:

Photo collage by E. Kevin King.

Oceanus (ISSN 0029-8182) is published quarterly by Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543. Second-class postage paid at Falmouth, Massachusetts, and additional mailing points.

comment

In this issue, there is a call for the establishment of a new commission, patterned after the Stratton Commission, to study the implications of the Law of the Sea Convention in view of the United States' refusal to approve the Treaty. We would add that there is also a need today for someone to act as "chief oceanographer" of the marine community — a Mr. or Mrs. Oceans, if you will — to provide the enthusiasm, the knowledge, the vision, and the influence to get things that need to be done, done.

In the past, the Mr. Oceans sobriquet has gone to Senator Warren G. Magnuson, Democrat of Washington, and to Vice President Hubert Humphrey, Democrat of Minnesota. One might argue that, in the latter case at least, the title was applied because of a set of special circumstances, and that the leadership in marine affairs provided by these men is unlikely to be duplicated in the future. Ideally, the candidate for Mr./Mrs. Oceans should have the ear of the President and the eye of a sea-going scientist, much the same as Humphrey had:

> *The Marine Sciences Council under Humphrey demonstrated what can be done, given the statutory authority, the willingness of the President to utilize it, and the personal inclinations of the Vice President. By virtue of these prerequisites, the Vice President assisted the President in identifying unmet needs and in developing programs and policies to serve them; in recommending priorities and matching resources to goals; in clarifying and coordinating responsibilities of various participating agencies where the field crossed departmental lines, coordinating their activities, and resolving differences; in developing long-range evaluation of future developments and conflicts; in assessing the quality of on-going programs to eliminate the marginal; and in integrating diverse technical, economic, and political considerations . . . Humphrey contributed to success of the Council largely from his own qualities of intellect, style, enthusiasm, and leadership. Indeed, the Council revealed qualities of Humphrey unknown to the general public: conciseness in addressing issues, sharpness in phrasing alternatives, impatience with bureaucratic red tape, and breadth of vision in relating government to needs of future generations. In the theater of action associated with marine affairs, Humphrey was an Administration Vice President, and an effective one.*
>
> **Ed Wenk in *The Politics of the Ocean***

Given a Republican President, it would appear that the Mr. or Mrs. Oceans of the moment should be a Republican, although there are several Democrats who have excellent qualifications for the position. One wishes that one of the prime requisites for the post would be a degree in bipartisanship.

Nevertheless, the importance of the need for a Mr./Mrs. Oceans looms larger when one considers the likelihood of the United States recognizing a 200-mile Exclusive Economic Zone in the near future. This would make Mr./Mrs. Oceans the benefactor of a vast territory, an area far greater than any state, but, unfortunately, without a voting constituency. Still, the natural resources within this area are such that the position will become important and powerful.

Where then should this strong leader come from — Capitol Hill, the Executive Branch, academia, or a government agency? After all, he or she must be able to act as a catalyst for the many recommendations coming out of the studies of various committees and boards in such institutions as the National Science Foundation, the National Academy of Sciences, and the National Oceanic and Atmospheric Administration, to name but three.

We have gathered the names of a few candidates who could hold the title of Mr. Oceans, but certainly the list is far from exhaustive. We think of Senator Ted Stevens, Republican of Alaska, a man with a long coastline whose waters are graced with an abundance of natural resources; Senator Bob Packwood, Republican of Oregon; Representative John Breaux, Democrat of Louisiana, a state experiencing the rewards and problems connected with offshore oil and gas exploitation; Senator Ernest F. Hollings, Democrat of South Carolina; Senator Claiborne Pell, Democrat of Rhode Island; Representative Gerry E. Studds, Democrat of Massachusetts; and Senator Lowell P. Weicker, Jr., Republican of Connecticut. This list of contenders is drawn from Capitol Hill and thus all are subject to the time constraints imposed by the voting public.

We also are reminded that Vice President George Bush has some prior involvements with the oceans, involvements that might be capitalized on by leaders of the marine community. We refer to his wartime years as a lieutenant (jg.) in the Navy and his 12-year stint as cofounder and president of Zapata Off-Shore Company.

Wherever he or she may be, though, it is time for another Mr. or Mrs. Oceans to step forward and preside over our marine environment as we advance toward the 21st century.

Paul R. Ryan

Introduction:

Marine Policy for the 1980s and Beyond

by John A. Knauss

"How fully and wisely the United States uses the sea in the decades ahead will affect profoundly its security, its economy, its ability to meet increasing demands for food and raw materials, its position and influence in the world community, and the quality of the environment in which its people live." Thus began *Our Nation and the Sea,* the 1969 report of the Commission on Marine Science, Engineering, and Resources, better known as the Stratton Commission. Subtitled *A Plan for National Action,* this report laid out in some detail its recommendations and its rationale for realizing these goals.

The Stratton Commission was the culmination of a decade of effort, much of it Congressionally driven, to provide focus and momentum to this nation's marine efforts. It began with the 1959 report of the National Academy of Science Committee on Oceanography (NASCO), which was followed by a host of similar efforts including *A National Ocean Program* (1964) for the National Security Industrial Associates; a second NASCO effort, *Oceanography, 1966; Effective Use of the Sea,* a 1966 report of the Panel on Oceanography of the President's Science Advisory Committee (PSAC); and *The Ocean Science Program of the U.S. Navy, Accomplishments and Prospects* (1967), for the Oceanographer of the Navy.

Most important was the passage of the Marine Resources, Engineering, and Development Act of 1966, which established the National Council on Marine Resource Development (the Marine Council), a federal, cabinet-level interagency committee, chaired by the Vice President, and the aforementioned Commission on Marine Science, Engineering, and Resources. The bill was a compromise between the Senate, which pushed for the Marine Council, and the House, which thought recommendations on federal organizations should come from a presidentially appointed commission. While it lasted, the Marine Council, under its enthusiastic chairman, Vice President Hubert Humphrey, and a hard-driving council staff headed by Ed Wenk, did indeed provide focus and momentum. Its annual reports for the years 1967 through 1970, *Marine Science Affairs,* document new initiatives, growing budgets, and general enthusiasm for this nation's marine programs. Wise program managers are always attuned to the new buzzwords of Washington, and a number of existing programs in such agencies as the Coast Guard, Geological Survey, and Army Corps of Engineers suddenly became part of the nation's marine science affairs effort; but at least some of the growth was real, as we saw the start of such programs as Sea Grant and the International Decade of Ocean Exploration.

The two main organizational recommendations of the Stratton Commission were to form an independent agency for the oceans and the atmosphere, the National Oceanic and Atmospheric Administration (NOAA), and a public advisory body to the President and Congress, the National Advisory Committee on Oceans and Atmosphere (NACOA). The Stratton Commission believed that with these organizations in place there would no longer be a need for the Marine Council. President Nixon agreed to establish NOAA, but housed it in the Department of Commerce rather than making it an independent agency, and Congress passed legislation establishing NACOA. The Marine Council was then allowed to officially dissolve, but it already had been killed effectively by administrative indifference. A high-level interagency group is only as effective as its chairman's commitment. Vice President Humphrey was an ocean enthusiast, and under him the Marine Council prospered. Marine Affairs were not high on Vice President Agnew's agenda, and after 1969 the Marine Council rarely met.

Many hoped the Stratton Commission would signal a new beginning in federal ocean interest, but by 1969 this nation had more urgent matters to address. The ghettos were exploding and Vietnam was dividing the country as few issues have in recent memory. "Ocean" was no longer a Washington buzzword. However, those who view the mid-1960s with nostalgia may be missing an important point: this nation's commitment to ocean activities has grown and deepened since the Stratton Commission report. One measure of this deepening involvement is the extent of federal interest. The Stratton Commission reported that ocean activities were located in six departments, four independent agencies, and 17 agencies and subagencies within departments. One of the principal reasons for the establishment of NOAA was to centralize some of these ocean activities. NOAA is now the premier federal civilian ocean agency, but a 1978 Department of Commerce report, *U.S. Ocean Policy in the 1970s, Status and Issues,* notes that ocean programs were by then administered in 10 departments, eight independent agencies, and 38 agencies and subagencies within departments. The oceans' influence on our government and its people is pervasive, and no new organizational plan will ever again purport to centralize this nation's ocean effort.

The growth of ocean activities and their influence on national policy can be measured in a number of ways. Among them are: number and size of programs, diversity of activities, economic growth, opportunities for future growth, and national security implications. This issue of *Oceanus* focuses on many of the important ocean-related issues of the last 15 years. If there is a common thread to these articles, it is that this nation and the world are continuing to increase and diversify the use of the oceans and their resources, and with these opportunities comes a host of problems. These include boundary delimitations between nations, such as the United States and Canada, the rational management of fisheries, and the urgent need to better understand the implications of using the oceans as receptacles for society's ever-growing pile of waste.

A second common thread in these articles is "creeping jurisdiction." As we make more use of the ocean and its resources, we extend our jurisdiction seaward. The Coastal Zone Management Act applies to the breadth of the territorial sea. The Fishery Conservation and Management Act extended U.S. jurisdiction over fisheries to 200 miles from shore. The Law of the Sea (LOS) Treaty provides every coastal nation with a 200-mile Exclusive Economic Zone (EEZ), in which it has sovereignty over all the natural resources and jurisdiction over all marine scientific research. The ocean management and policy issues of the 1980s are more extensive and more complex than those of the 1960s.

It is often easier to develop ocean policy in federal legislation than it is to implement it. As Walsh notes in his article, the Coastal Zone Management Act of 1972 was the result of Stratton Commission recommendations. The concept was simple. The coastal zone was being subjected to increased use and to often-conflicting multiple uses. Often there was a commonality of interest that stretched beyond the perspectives of local town zoning boards. Many times the interests were "national," but the federal government was perceived as too remote to serve as an effective coastal zone manager. Thus the states were given the charge, and with it, as Walsh points out, a series of carrots to induce them to take on the difficult, albeit important, task of rational management and development of the nation's coastal zone. The results have been mixed. At a minimum, the mere act of developing a coastal-zone plan raised the consciousness of many state governments that had never before considered the issue. Coastal zone management today in some states is just a paper tiger, but in many the Act has been a strong and generally positive force that has made significant contributions to wise development and conservation.

Vice President Hubert Humphrey was an ocean science booster. He is shown here observing a demonstration of equipment aboard the research vessel Atlantis II. *The cruise was part of his 1967 visit to Woods Hole, Massachusetts. (WHOI photo)*

The Magnuson Fishery Conservation and Management Act (MFCMA) of 1976 resulted from the widely shared belief within the United States that our fish stocks were being badly depleted because of significant overfishing by foreign fleets. Passage was aided by the Congressional perception that the LOS Treaty, then under negotiation, would provide national jurisdiction over fisheries resources out to 200 miles. There was a conscious attempt by Congress to make the Act consistent with the expected provision of the Treaty. For example, the MFCMA excludes tuna, billfish, and other highly migratory species from its management provisions because in 1976 there was some suggestion that these species would be subject to international management agreements, a position that did not prevail in the Treaty negotiations.

As Apollonio makes clear, it is one thing to pass a law establishing a management framework; it is another to manage wisely. The administrative deficiencies in the MFCMA can be handled, and given the revolutionary character of its management scheme — a series of regional councils manned by public members of adjacent coastal states, whose plans must be approved by the Secretary of Commerce — it is remarkable that the system has needed as few administrative and legislative adjustments as it has. However, the development of management plans that achieve optimum yield, however defined, is quite another matter. Fisheries science has made significant progress in the last 20 years, but many believe that rational management of a complex mixed fishery, as described by Apollonio, is beyond our present capability. More worrisome, some believe that even if we knew how, the cost of the resultant observational system would be a significant fraction of the value of the fishery. Many think it will be difficult enough to achieve the minimum management objective of preventing the collapse of fisheries stocks.

Perhaps the most difficult, complex, and far-reaching policy issues are those addressed by Farrington, Capuzzo, Leschine, and Champ. It now seems clear that the earlier goal of zero ocean dumping is unrealistic and probably unwarranted. The ocean does indeed have a large assimilative capacity. It has accepted enormous amounts of waste in the past; it can undoubtedly accept more in the future. The public health risks of ocean dumping would appear to be significantly less than for many forms of dumping on land. But how much can be dumped? What are the consequences of incineration at sea versus on land? Should we pick a few specific oceanic sites and dump everything there — a sort of underwater landfill — or should we try to disperse the material over as wide an area as possible? There are no simple answers, nor, as Farrington and his colleagues point out, should one ever expect final answers. As we learn more, our solutions are refined and occasionally dramatically altered.

All marine scientists associated with ocean dumping issues are concerned that, to use Farrington's phrase, the present snowball of ocean dumping does not suddenly increase to an avalanche. Unfortunately, there is a real possibility such might occur. As more and more landfills are shut down because of contaminated drinking water, as incinerators are closed because of concern about heavy metals and imperfectly combusted organics escaping from the smokestacks, as we improve our legal and technical surveillance of industrial pollution, we are faced with an ever-increasing amount of waste material and ever-fewer places to put it. To many, the oceans appear to be an increasingly attractive option. Given the very real possibility of an avalanche in ocean dumping, the amount of scientific research in this area is inadequate.

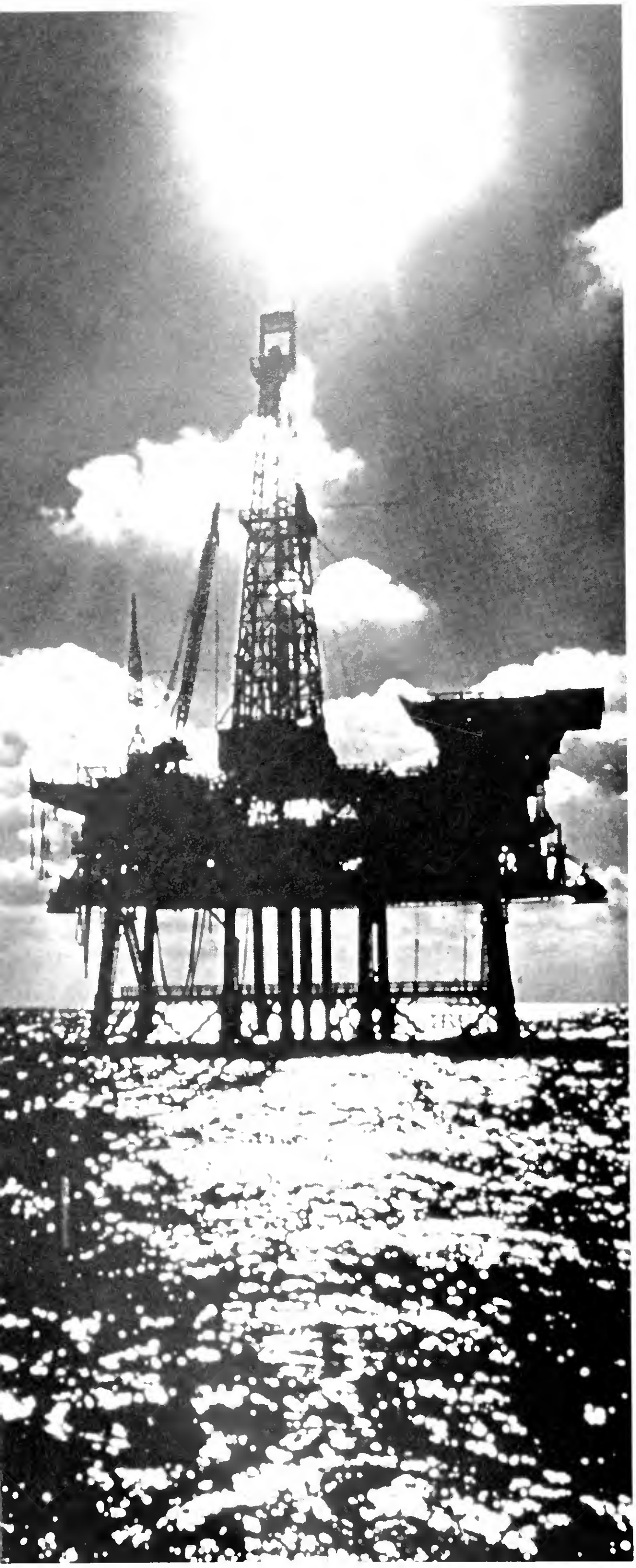
Wise use and development of the oceans depends on scientific understanding. That is clear in coastal zone management, fisheries management, and waste management. It is also true for the use of the ocean by the military, as Winokur and Gonzales point out. World War II re-emphasized for the Navy that the side with the best knowledge of the environment has a distinct advantage. And with the addition of the ballistic-missile-launching submarine, the Navy's traditional mission of projection of power and sea control has taken on an additional dimension. The Navy's interests are worldwide, and the service has adopted a high-technology approach to the development of weapons systems. Although the Navy no longer plays the preeminent role in support of basic marine scientific research that it did 20 years ago (that role is played by the National Science Foundation), the Office of Naval Research maintains a strong and far-ranging interest in most aspects of marine science. In particular, it has provided support for large, complex new techniques, such as underwater mapping (SEABEAM), remote sensing from aircraft and satellites, and acoustic tomography (see *Oceanus*, Vol. 25, No. 2, p. 12). With the decision of the Reagan Administration to modernize the Navy and increase its size, one might assume that Naval support of marine science will at least remain steady, and might grow.

The single most important ocean policy issue of the past decade has been the United Nations Law of the Sea negotiations, recounted in this issue by Paul Fye, who, along with his colleagues, calls for a new commission, patterned after the Stratton Commission, to study the implications of this nation's rejection of the Treaty. A new chapter in U.S. ocean policy has begun; U.S. rejection of the Treaty does not mean that we can ignore it. As Conant notes in his article on the Arctic, in addition to all the other problems resulting from the lack of a clear Arctic policy, the United States needs to reach accommodation with Canada, a strong Treaty advocate, on a number of Arctic ocean issues affecting both nations. Ross points to the problems marine scientists can expect as a result of the Treaty and the particular problems U.S. marine scientists face because the United States will not be party to the Treaty.

One result of the Law of the Sea negotiations has been that nations have had to think through all their ocean interests. For a number of developing nations (and perhaps many developed ones) this may have been the first time anyone at the highest level of the foreign ministry had focused on ocean policy. Apparently, a number of coastal nations were dismayed at what they found. The problem for many coastal nations was that they had little idea of the extent of resources within 200 miles of their shores, and few, if any, had facilities and trained people to determine, let alone exploit, those resources. One consequence, as Ross points out, has been a rapid increase in the budget of the United Nations Educational, Scientific, and Cultural Organization's Division of Marine Sciences, the UN agency whose primary mission is to help develop a nation's marine infrastructure.

Finally, there are policy issues that it was not possible to address in a single issue of *Oceanus*. Despite years of legislative efforts dating back to at least 1936, this nation's merchant fleet continues to shrink. A series of proposals by the Reagan Administration is aimed at increasing the percentage of our trade that is carried in U.S. vessels. With the adoption of the United Nations Conference on Trade and Development's Code of Conduct for Liner Operations, which allows a port state to insist that 40 percent of freighter cargo is carried in ships carrying the flag of the port state, and the possibility of this policy being expanded to tankers and bulk carriers, shipping and port development may become major ocean policy issues of the 1980s.

Although most discussion of fisheries policy in the last five years has centered around the implementation of the MFCMA, there are other fisheries issues that may take on increasing importance. For example, the MFCMA applies only to fisheries between three and 200 miles. Inside our three-mile territorial sea, fisheries are subject to state law only. Finding a means to reconcile state and



A production drilling rig in the Gulf of Mexico. (Photo courtesy of American Petroleum Institute)

federal differences in fisheries management, where they exist, is likely to become an increasingly important and vexing problem. A second issue concerns tuna, billfish, and other highly migratory species. Whether or not these species should remain outside the scope of the MFCMA may be a hotly debated issue once the Law of the Sea Treaty is widely adopted. A third issue is sport fishing. Saltwater recreational fishermen now number more than 15 million and the total is growing rapidly. It is estimated they catch at least 700 million pounds of fish a year, more than 10 percent of the commercial catch. In some fisheries, such as the West Coast salmon fishery, recreational fishermen have a significant impact on the commercial fishery. It is likely that conflicts between commercial and sport fishermen will grow.

And finally, a fourth fishing issue for the 1980s is the role of aquaculture. A major, commercially viable aquaculture industry has been just around the corner for more years than its proponents care to admit. Recent developments, however, have convinced many that a significant number of the critical biological problems have been solved. What may be more difficult to solve are the political and policy issues related to such matters as the assigning of certain rivers for salmon culture, or the leasing of certain grounds for shellfish culture.

There are other ocean policy issues of the 1980s that one can foresee: offshore mineral development (see *Oceanus*, Vol. 25, No. 3); conflicts between fisheries and other ocean uses, such as offshore oil and gas development; the possible extension of the breadth of the territorial sea from three to 12 miles; the possible development of ocean thermal energy conversion (OTEC); and the role of the federal government in providing "services" to the ever-growing number of ocean users. As the uses and users of the ocean continue to grow in number, so do the issues of ocean policy.

John A. Knauss is Dean of the Graduate School of Oceanography and Vice President for Marine Programs at the University of Rhode Island. He was a member of the Stratton Commission and is currently Chairman of the National Advisory Committee on Oceans and Atmosphere (NACOA).

The Law of the Sea

by Paul M. Fye

It is now 15 years since November 1, 1967, when Arvid Pardo, then Malta's Ambassador to the United Nations, proposed to the UN General Assembly that the resources of the oceans beyond national jurisdiction should be the "common heritage of mankind." He further pointed out that chaos threatened the seas; nations were claiming the waters and marine resources 200 miles and more beyond their coasts, threatening the free passage of ships and aircraft and provoking conflicts over fish and minerals. He called for a major conference to negotiate a new legal constitution for the oceans.

Three years later, after debating the issues involved, the 25th General Assembly set forth a Declaration of Principles in which the Assembly unanimously agreed that the deep-sea resources are indeed "the common heritage of mankind" and thus belong to everyone. The Assembly also proposed an international conference to draft a comprehensive law for the sea.

Even though the concept had been suggested earlier by others, the phrase "the common heritage of mankind" rang throughout the world with great resonance. UN delegates from some of the newer nations assumed that if this were indeed part of their heritage, then somehow by ways mysterious and unclear, science and technology would provide the means to harvest resources so rich as to supply all their needs. Unhappily, national greed and pride during 15 years of negotiations have bargained away most of the visions of enormous wealth and resources created by Pardo's "common heritage."

Laws controlling the use of the seas date back to the ancient mariners of the Mediterranean. By the 13th Century, city-states were demanding heavy tributes from passing ships. In the 15th Century, Spain and Portugal attempted to divide the oceans between them under the power of a papal grant, and it was generally accepted that the seas could be appropriated by powerful nations.

In 1609, a young Dutch jurist named Hugo Grotius proposed in his treatise *Mare Liberum* that the high seas should be free "for the innocent use and mutual benefit of all." For more than three centuries, nations generally went along with this highly permissive doctrine for the high seas and limited their sovereign jurisdiction to a narrow strip typically three miles from their coast.

The Grotius principle was not seriously challenged until 1945, when President Truman, by proclamation, unilaterally claimed the natural resources of the seabed of the continental shelf for the United States. Although the waters above the seabed, under the Truman doctrine, remained the high seas, many Latin American nations — starting with Chile, Peru, and Ecuador — claimed sovereignty over the ocean out to 200 miles from their coastlines. These unilateral declarations, which followed shortly after the Truman proclamation, have been primarily concerned with fishing rights and, more recently, with oil and gas.

In the six years between Pardo's speech and the first organizational meeting of the Third UN Conference on the Law of the Sea (UNCLOS III) in December 1973, much happened that influenced the conduct of this Conference. Seventeen nations expanded their claims for territorial seas to 12 or more miles. Advances were made in marine technology that would prove to be influential in UN debates. The capability of drilling for oil in waters up to 1,000 meters deep and sampling the ocean bottom to a depth of several miles made the oceans more exploitable than ever before. The engineering

Hugo Grotius (Portrait courtesy of the Rijksmuseum, Amsterdam) capability for mining deep-sea manganese nodules was demonstrated. Mechanization of distant water deep-sea fishing fleets allowed them to become more self-sufficient and to stay at sea for months at a time.

Years of Preparation

Perhaps the most significant event during these years was the formation, in late 1967, of the Ad Hoc Committee to Study the Peaceful Uses of the Seabed and Ocean Floor Beyond the Limits of National Jurisdiction. This Seabed Committee, as it soon became known, had the difficult job of preparing for the formal conference which was to follow. The Committee was initially composed of 34 nations but finally grew to 91 before it passed its work over to the Third UN Conference.

In the interim, while the Seabed Committee was working on the preparation for UNCLOS III, the General Assembly took two related actions of significance. In 1969, it passed the Moratorium Resolution, which stated that "nations are bound to refrain from all activities of exploration of the resources of the area of the seabed and ocean floor, and the subsoil thereof, beyond the limits of jurisdiction." The United States, fearing this resolution would deter technologic development in the deep ocean, voted against it.

Second, the UN adopted the Treaty on the Prohibition of the Emplacement of Nuclear Weapons and other Weapons of Mass Destruction on the Seabed and Ocean Floor and Subsoil Thereof. The United States, Soviet Union, and some 60 other nations signed this treaty in 1971 and thus agreed not to place weapons of mass destruction more than 12 miles from their respective coastlines.

Also in parallel with the meetings of the Seabed Committee, the United States and the Soviet Union undertook bilateral negotiations concurrently with a number of other nations with a view to obtaining international agreement on a territorial sea of 12 miles, freedom of transit through international straits overlapped by such territorial seas, and agreement on fishing rights in the area beyond 12 miles. However, it was not the intention or desire of either the United States or the Soviet Union that these limited negotiations should become a part of an all-inclusive new legal regime for the oceans. Instead, the intent was to handle different ocean problems separately, in manageable pieces. The majority of other members of the United Nations did not agree. Most developing countries, along with a number of others, wanted to deal with the legal problems of control of the oceans in a comprehensive way, including other subjects such as the exploitation of the continental shelf and the deep sea, protection of the marine environment, scientific research, and a variety of others in a single negotiating effort.

The Seabed Committee was given special instructions by the General Assembly to prepare draft articles for a comprehensive regime for the seabed and ocean floor, as well as a list of themes and issues for consideration by the formal Conference. In its six-year lifetime, the Committee held many informal meetings under its Chairman, Ambassador H. Shirley Amerasinghe of Sri Lanka, but was able to reach only one agreement: the adoption of a list of themes and issues that could serve as a framework for the discussion of draft articles. The Declaration of Principles, adopted by the General Assembly in 1970, was formulated only after a great deal of bargaining and negotiation in the course of examining the report of the Seabed Committee.

The General Assembly, in debating the Seabed Committee's report, finally agreed that the Committee had fulfilled its mandate and that the preparatory work was sufficient for a successful Conference. It also agreed that the goal of the Conference would be to produce a single, comprehensive, unified Convention rather than several treaties. The General Assembly adopted a gentlemen's agreement to the effect that the Conference should make every effort to achieve a Convention acceptable to all nations through a consensus approach and that no vote on substance should be taken until all efforts to achieve a general agreement had been exhausted.

Thus the plans were laid to convene a new Conference on the Law of the Sea. The first session, held in New York City in December of 1973, devoted most of its time to procedural questions, election of officers (Ambassador Amerasinghe was elected President of the Conference), the organization of its work, and the composition of different committees. The Conference organized itself into three working committees with the responsibility for drafting articles for a draft convention.

The First Committee was concerned with the international regime and machinery for the seabed beyond the limits of national jurisdiction, usually referred to as the "international area" or the deep seabed. The mandate to construct a new international regime that could give substance to the concept of "the common heritage of mankind" was exciting. Visions of a more perfect international community got tangled up with economic ideology and sometimes obscured the pragmatic purpose of the First Committee — mining manganese nodules on the ocean floor. The Committee Chairman was Ambassador Paul Bamela Engo of Cameroon, with Ambassador Christopher Pinto of Sri Lanka serving as chairman of a negotiating group.

The Second Committee had the broadest and most complex mandate of the three committees, embracing virtually all of the traditional Law of the Sea subjects. These included issues regarding the territorial sea, straits, archipelagos, the high seas, the economic zone (including living and non-living resources), the continental shelf, and access to the sea. This Committee was chaired by Ambassador Andres Aquilar of Venezuela.

The Third Committee was concerned with marine pollution, scientific research, and the transfer of technology. Ambassador A. Yankov of Bulgaria was elected Chairman, with Ambassador José Vallarta of Mexico as chairman of the informal sessions on marine pollution, and Cornel Metternich of West Germany serving as chairman of the informal sessions on scientific research and transfer of technology. It was the work of this committee that was followed most closely by the United States ocean science community. Chief U.S. representatives to the Third Committee over the years included Donald McKernan, Thomas A. Clinghan, Terry Leitzell, and Norman Wulf.

Another working group that evolved informally out of discussions among delegations of at least 30 nations during the 1974 Caracas session was the Informal Group on Settlement of Disputes. This group was chaired initially by Ambassadors Galindo Pohl of El Salvador and Ralph Harry of Australia, with Professor Louis Sohn of the Harvard Law School serving as rapporteur.

Decision By Consensus

Two aspects of the long negotiations in UNCLOS III that will be of great interest to parliamentarians of the future are the mechanism of arriving at decisions through consensus, as mandated by the General Assembly and adopted by the Conference in June 1974, and the unusual delegation of power to the committee chairmen. In a desperate move to speed up the consensus process, President Amerasinghe proposed that the chairmen prepare the negotiating texts. This procedure was adopted by the Conference in April, 1975, at the second substantive session meeting in Geneva.

Reaching decisions by consensus had been tried in a more limited way in previous UN bodies. During the first substantive session of UNCLOS III in Caracas and partway into the second session in Geneva, the Conference tried passive consensus procedures. It was hoped that the high desire for a successful outcome would provide the momentum toward compromise. It became clear to President Amerasinghe that this process was becoming highly protracted. In a sense, this consensus process was a continuation of the procedures used in the Seabed Committee, but even the more intense atmosphere of the full-scale conference did not eliminate the repetitious rhetoric or speed up the negotiating process.

Arvid Pardo in 1965. (UN photo)

President Amerasinghe put to the delegates an inspired proposal, namely that the chairmen of the three main committees be mandated to produce Informal Single Negotiating Texts covering the agendas of their respective committees. The delegations agreed to transfer to the chairmen their collective right and responsibility to draft a text agreed on by consensus. The advantage of this procedure was that it gave the initiative in formulating compromises to the chairmen, and thereby enabled the negotiations to overcome the unwillingness of delegations to abandon their own positions. This innovation became the central procedural mechanism of the Conference, dominating subsequent sessions. It was the heart of the active consensus procedures developed during UNCLOS III. No previous exercise in treaty-making or international law-making has been so extensive, so complex, so ambitious, nor so controversial, and many observers believe that this new way of negotiating compromises will be used in future attempts at complex treaty-making.

And so the process rolled on. The Informal Single Negotiating Text became the Revised Single Negotiating Text, which in turn became the Informal Composite Negotiating Text — each version having many revisions. Finally, in the spring of 1982, after 11 sessions (several of which were in fact double sessions), the Conference produced a Draft Convention on the Law of the Sea, which is in reality a new Law of the Sea Treaty.

The U.S. Pulls Out

This only happened after the United States had effectively called a halt to negotiations in the spring of 1981. It was generally felt that the delegations were close to the end of their long and tedious sessions and that one more "final" session was all that was needed to iron out the few remaining differences. Only days before this, the 10th session, was to begin, President Reagan fired the U.S. delegation that had been appointed originally by President Carter and instructed the new team, headed by James L. Malone, to defer additional negotiations until a comprehensive policy review had been completed. This review was to be conducted by all appropriate government agencies and was to determine how satisfactorily U.S. interests would be served by the draft treaty. It was conducted largely in secret and engendered confusion in both national and international circles.

Ten months later, in January 1982, President Reagan announced the results of this review. After emphasizing the importance of the oceans, which he called "a frontier for expanding scientific research and knowledge" (the only mention of scientific research in his entire statement), he set forth the changes the United States wanted in the deep seabed mining provisions. He concluded by stating that "the United States remains committed to the multilateral treaty process for reaching agreement on law of the sea." The specified changes all related to seabed

James L. Malone, appointed by President Ronald Reagan, was chairman of the United States delegation to the Third United Nations Conference on the Law of the Sea. (Photo by Utaka Nagata — UN)

mining and can be summarized as follows: In order to satisfy the United States, the Treaty should 1) not deter development of any deep seabed mineral resources; 2) assure national access to and promote the economic development of these resources; 3) provide for a fair decision-making role in the new regime; 4) not allow amendments to come into force without approval of participating nations, including in our case the advice and consent of the Senate; 5) not set undesirable precedents for international organizations; and 6) be likely to receive the consent of the Senate. In this regard, the treaty should not contain provisions for the mandatory transfer of private technology nor for participation by and funding for national liberation movements.

Following the President's statement, a serious attempt was made by the new President of the Conference, Ambassador Tommy T. B. Koh of Singapore, and many other delegations to meet the United States demands. A number of important concessions were made, including the provision that the U.S. (if the "largest consumer" of seabed minerals) would have a seat on the Council of the International Seabed Authority, provisions for preparatory investment protection (which gave the U.S. companies that have pioneered deep seabed mining guaranteed access to a specific mine site up to 150,000 square kilometers), and certain other marginally useful improvements. The failure to obtain other compromises, which would have brought the draft treaty closer to the President's goals, was due, according to Leigh S. Ratiner, Deputy Chairman of the U.S. Delegation, to an overly rigid attitude on the part of the U.S. Delegation, together with concurrent attempts on the part of the United States to arrange a separate mini-treaty with our allies outside the framework of the UN Conference. This latter position convinced many developing countries that the United States was not negotiating in good faith and had little interest in the successful outcome of the Law of the Sea Treaty.

Finally, on the last day of the 11th session of UNCLOS III, at the request of the United States, the Conference voted on the acceptance of the Draft Convention as it had developed during almost nine years of extremely hard work by many diplomats. A total of 151 states voted, with 130 voting to accept the Convention, 17 abstaining, and 4 voting against acceptance (Israel, Turkey, the United States, and Venezuela). The group of 17 who abstained included, among others, Belgium, West Germany, Italy, Britain, and the Soviet Union, along with the block of associated East European countries. Most observers believe that many of these abstainors will sign the Treaty when it is open for signing in December and January. The Treaty will go into force, for those nations ratifying it, 12 months after 60 nations have filed ratification papers with the UN. Some believe this could be as early as 1984 or 1985.

The Conference officials and most of the delegations had devoutly wished to adopt the Treaty by consensus, but the U.S. request for a vote blocked this goal. It is significant that in the nine years of negotiations this was the first vote on a substantive issue. It is beyond the scope of this article to detail the accomplishments of this massive and complex constitution for ocean law. The main body of the text consists of 320 articles, with an additional 118 articles

Tommy T. B. Koh of Singapore, President of the Third United Nations Conference on the Law of the Sea. (Photo by Yutaka Nagata — UN) in 8 annexes, and covers all of the subject matter assigned to the four working groups.

Key Features

The Convention on the Law of the Sea lays down rules for all parts and virtually all uses of the oceans. The following are some of its key features:

- Coastal nations have sovereignty over a territorial sea of 12 miles, with foreign vessels allowed "innocent passage" for purposes of peaceful navigation.
- Ships and aircraft of other nations are allowed "transit passage" through straits used for international navigation.
- Archipelagic nations have sovereignty over a sea area enclosed by straight lines drawn between the outermost points of the related islands, with the ships of other nations enjoying the right of passage through sea lanes within these waters.
- Coastal nations have sovereign rights in a 200-mile Exclusive Economic Zone with respect to natural resources and certain economic activities and also have certain types of jurisdiction over scientific research and environmental preservation. All other nations have freedom of navigation and overflight in the zone, with land-locked nations and nations "with special geographical characteristics" having the right, under certain circumstances, to share in the zone's fisheries.
- Coastal nations have sovereign rights over the seabed of the Continental Shelf, extending to at least 200 miles and out to 350 miles or even beyond under specified circumstances, without affecting the legal status of the water or the air space above. There is provision for sharing revenues derived from exploiting the shelf beyond 200 miles with the international community.
- All nations retain the traditional freedoms of navigation, overflight, scientific research, and fishing on the high seas.
- A "parallel system" is established for exploring and exploiting the international seabed area. All activities on the seabed are under the control of the International Seabed Authority, which is authorized to conduct its own mining operations through its Enterprise. The Authority can contract with private and national companies for mining in specific mine sites provided the Enterprise is awarded a site of equal size or value. The resources of the area (primarily manganese nodules) are to be managed as a "common heritage of mankind." Mining concerns having contracts with the Authority must be willing to sell their technical knowledge to the Authority. Production ceilings are set in the treaty to protect land-based producers, and a group of "pioneer operators" is to be guaranteed mining contracts.

Paul Bamela Engo of Cameroon, who chaired the First Committee of the Third United Nations Conference on the Law of the Sea. He prepared negotiating texts for articles dealing with the international seabed regime. (Photo by M. Grant — UN)

- Nations are bound to prevent and control marine pollution by "the best practical means at their disposal."
- All marine scientific research in the Exclusive Economic Zone and on the Continental Shelf is subject to the consent of the coastal nation, which is obligated to grant consent provided certain criteria are met and the research is for peaceful purposes (see page 13).
- Nations are bound to promote the development and transfer of marine technology "on fair and reasonable terms and conditions."
- Nations are obliged to settle differences by peaceful means using arbitration procedures if necessary.

Standing Alone

The refusal to approve the Treaty leaves the United States standing alone in isolation from most of the nations of the world. President Reagan has stated that most provisions of the Convention are consistent with U.S. interests. Included among these are provisions for commercial navigation and overflight, mobility of air and naval forces, fisheries, marine mammals, scientific research, control of marine pollution, dispute settlement, and many more.

The Reagan administration appears to be relying on the development of a mini-treaty with a limited number of nations. This would permit deep-sea mining as a means of protecting our strategic interest in the nickel, copper, cobalt, and manganese available in the nodules on the seafloor. However, many maritime experts doubt that a mini-treaty could provide a regime which would provide the stability and security necessary to entice funding agencies to invest the $1.5 billion that a deep-sea mining project may require.

So it appears that the United States wishes to seek the advantages of those portions of the treaty which it likes while turning its back on the portions it dislikes. Only time will tell whether the majority of the nations of the world will be this tolerant with the nation whose commitment to the rule of law contributed so much to the foundations of the Law of the Sea treaty.

As far as our interests in conducting scientific research are concerned, I believe we would be better off under the treaty than with the United States standing aside. Coastal zones are where most important scientific questions arise. In recent years, a significant portion of our research (perhaps a third to a half) has been conducted in foreign waters within 200 miles of a coastal nation. Now oceanographers are reluctant to plan such research, for fear they will be denied access at the last minute. For those coastal nations who resent the failure of the United States to support the treaty, the easiest way to show this resentment is to deny U.S. research ships access to their waters. The resulting confusion, in both our State Department and foreign ministeries, can only be harmful to the pursuit of oceanography.

Two fellows of the Marine Policy and Ocean Management Program at the Woods Hole Oceanographic Institution, Robert W. Knecht and Robert E. Bowen, have just finished a study entitled the *Implications of the Law of the Sea Convention for U.S. Policy in the 1980s*. I would like to quote briefly from their study, which is scheduled to be published in a forthcoming issue of the *Marine Technology Society Journal:*

"It should be clear to most observers that the Convention on the Law of the Sea will be an important factor in U.S. ocean policy-making in the 1980s. It seems likely that the treaty will serve as an important guiding force in the future development of international legal norms for the oceans. The United States will not be able to isolate itself from the impacts of the significant changes in marine law and practice that the next few years will witness. The likely entry into force of the treaty by the end of the decade and the actions of individual nations leading up to that event, will require a broad range of responses [Table 1] by the United States regardless of the status of the treaty in the U.S. . . .

"We believe that a new commission, patterned along the lines of the earlier Stratton Commission, should be constituted to review existing programs and to explore the general implications of the LOS Convention as well as the specific actions that the Preparatory Commission and other coastal nations may take in the near future. Ideally, such a commission should have a clear congressional mandate and a carefully worded charge and be staffed and funded for a period of at least two years. The staff would receive balanced policy guidance from a high-level group of commissioners, representing important ocean users, government, academia, and the public at large. The report and recommendations of the commission would be transmitted both to the appropriate congressional committees and to the executive branch upon completion of the study."

In conclusion, I would like to quote Ambassador Elliot L. Richardson, who headed the U.S. delegation to UNCLOS III from January 1977 to October 1980:

> *The real importance of the Law of the Sea Treaty cannot be found either in the sum of its parts or in its extraordinarily comprehensive whole. It lies rather in its demonstration of the capacity of 160 sovereign states to work out rational accommodations among vital competing interests. This is an achievement whose significance will loom even larger as the world increasingly finds itself forced to come to grips with its own inseparability.*

Table 1. Conclusions reached by Robert W. Knecht and Robert E. Bowen in their study entitled the *Implications of the Law of the Sea Convention for U.S. Ocean Policy in the 1980s.*

- **Given the magnitude and diversity of U.S. ocean interests, the United States will be significantly affected by the Law of the Sea (LOS) Convention even if it does not become a party to the treaty in the foreseeable future.**
- **Over time, the Convention will have its most important impact on international law (and consequently, on the United States) to the extent that its provisions serve as the authoritative guide to a consistent and uniform practice of coastal states.**
- **Domestic action, probably involving legislation in most cases, will be required to take advantage of parts of the Convention consistent with our interests, for example, establishment of an Exclusive Economic Zone.**
- **The United States also will find it necessary to take action to mitigate the adverse effects of certain other LOS provisions, such as those dealing with marine scientific research and seabed mining.**
- **Reviewing and deciding upon appropriate courses of action in connection with these issues will be a major preoccupation of ocean interests in the 1980s.**
- **Such reviews must take into account the status of the LOS Convention in international law and the possible reaction of other countries to a U.S. refusal to sign and ratify the treaty.**
- **Given that certain of the LOS-triggered issues are politically volatile and co-mingled with existing coastal and ocean management problems (for example, the expansion of the U.S. territorial sea), the creation of a "study commission," is suggested as a means of reaching a national consensus on them.**

Paul M. Fye is President of the Corporation of the Woods Hole Oceanographic Institution. He is also a Senior Advisor in the Marine Policy and Ocean Management program.

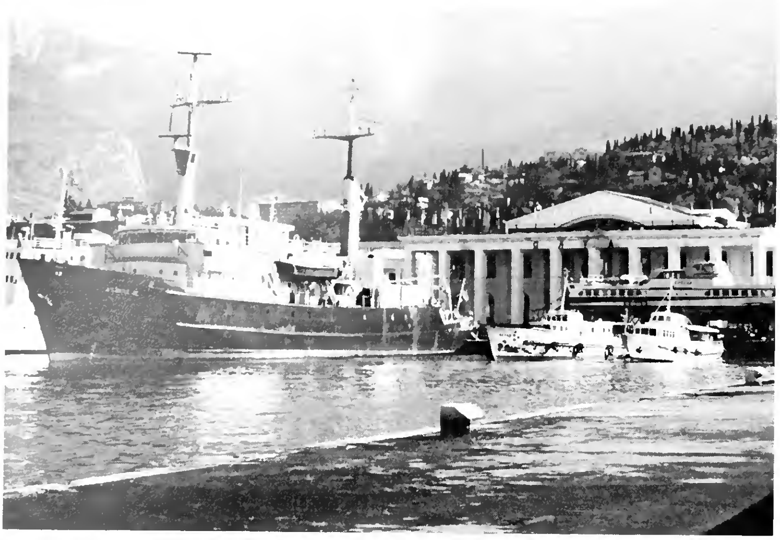
An Indian scientist sorts samples of plankton at the UNESCO-supported Indian Ocean Biological Center in Cochin, India. (Photo by G. Hempel — UNESCO)

International Marine Science: An Opportunity for the Future

by David A. Ross and Michael C. Healey

The style and techniques used by marine scientists to conduct research in foreign waters are clearly entering a period during which major changes will be necessary if many research activities are to continue. In the United States and other developed countries, marine scientists are experiencing decreased funding for research and a reduction in the size of academic oceanographic fleets. Furthermore, since the United States has declined adoption of the Law of the Sea Treaty, uncertainties and complexities for U.S. scientists in the international arena have increased. One technique that could counteract the curtailment of research that these events suggest and also lead to improved international opportunities in marine research is to foster new or improved mechanisms for cooperation among marine scientists, institutions, and governments.

Cooperation in marine science is not a new idea. It has been a valuable and effective technique since the beginning of the field, especially on the individual scientist-to-scientist level. Unfortunately, the individual approach will probably not be as effective in the future because of increased regulation under the Law of the Sea Treaty, especially the requirement that international communications and negotiations concerning research programs "be through official channels" (Article 250 in the treaty). Because of this requirement and other aspects of the treaty, as well as the realities of the modern world, it appears that the more institutionalized approaches to cooperation in marine science will prevail in coming years. Certainly institutionalized cooperation could reduce some of the enthusiasm and spontaneity of scientific interactions, at the same time adding to an already increasing bureaucracy in marine science. The alternative, however, could be either forestalled or lost research opportunities in foreign waters. International cooperation can take several forms and, when the politics are kept to a minimum, should be acceptable to most scientists.



The American research vessel Atlantis II, *anchored at the post office in Yalta during a scientific study of the Black Sea in 1969. (WHOI photo)*

Background

The Third United Nations Conference on the Law of the Sea (UNCLOS III) is entering its second decade of debate, but on April 30, 1982, a Law of the Sea Treaty was approved by a vote of 130 to 4 (the United States, Israel, Turkey, and Venezuela voted no) with 17 abstentions. There are still several hurdles the treaty must clear, including ratification by 60 countries, before it actually takes effect. Many countries, however, already have incorporated parts of the treaty into their national law. The UNCLOS III debates and the resulting treaty cover almost all aspects of ocean use and are considered to be the most complex negotiations ever undertaken. To the average observer, however, these negotiations probably seem to have focused mainly on the conflict over deep-sea mineral resources, in particular manganese nodules, which cover a major portion of the deep ocean floor and contain high concentrations of manganese, copper, cobalt, and nickel (see *Oceanus*, Vol. 25, No. 3).

Perhaps less obvious to the casual observer of UNCLOS III is that a large portion of the ocean will (and in several instances already has) come under coastal-nation jurisdiction. Although it is far from clear how the seaward boundaries ultimately will be drawn, at least 40 percent of the ocean will be involved — a region about equal in size to the present continental area of this planet. In addition, the remaining 60 percent of the ocean will come under an international administrative regime (the International Seabed Authority) for mineral resource development and other activities.

In the summer of 1982, the Reagan Administration announced its decision to withdraw from further UNCLOS III negotiations because of unhappiness with the treaty articles that will cover exploitation of deep-sea resources. In defense of this decision, the points are often made that deep-sea minerals are important to the United States and that American companies have already invested more than $100 million in preliminary mining operations. On the other hand, many knowledgeable individuals doubt that deep-sea mining will occur in this century, in large part because of uncertain economic conditions. Likewise, it is not clear that the United States could legally mine the deep sea if it were to remain outside the regime of the treaty.

Another group, less well publicized than the deep-sea miners, also has made large investments in the ocean and could be affected by expansion of jurisdiction and by the U.S. decision to remain outside of the treaty. We refer to the distant-water oceanographic research community: those institutions and individuals that conduct marine research in the 40 percent of the ocean that is to come under coastal-nation control.

The treaty has a section on marine scientific research that details the requirements and specific conditions for getting consent from foreign countries for work in their waters. Pros and cons of these scientific research provisions have been discussed elsewhere (Ross and Knauss, 1982). Suffice to say that there are many articles that may frustrate and delay oceanographers in the planning and conducting of research in foreign waters. The basic point is that coastal nations will control research in their internal waters, their territorial sea, a 200-mile exclusive economic zone (EEZ), and in some instances even further offshore. More than 80 countries have already established some form of control over these waters. This is an important point, since sufficient national legislation already exists to restrict the distant-water oceanographer, regardless of the ultimate fate of the treaty, and these rules, according to some, are already part of established international law.

Consequences for Oceanography

The conditions for getting permission for marine scientific research within foreign EEZs are not the subject of this article, but these conditions clearly will make the logistics of distant-water research more difficult, more costly, more time-consuming, and, therefore, less likely to occur. Successful projects will have to be developed in close cooperation with foreign countries and scientists. The procedure to develop such cooperative foreign programs often will be hard for individual scientists to ascertain and follow. Indeed it is not even clear how marine science funding organizations and the U.S. State Department will respond to the treaty's articles on marine scientific research. A potentially frustrating "Catch-22" situation can result if permission to conduct research is required from a foreign country before a project can be funded, while at the same time the State Department does not admit that coastal nations possess such authority.

There are other potentially annoying aspects of the treaty, especially since the United States has decided not to participate in future negotiations. One that should be mentioned is the question of what will happen if the State Department requests permission to conduct research within the EEZ of a country and that country responds that permission is dependent on acceptance of the marine science articles in the treaty. Acceptance of such a condition by the State Department could be interpreted as tacit acceptance of the treaty, which is contrary to the present position of the U.S. government. In this situation, the State Department would probably withdraw the request — a political decision resulting in cancellation of a scientific project that scientists in both countries may have spent several years planning and promoting. Such political niceties may be of little interest to the practicing scientist. But the question remains, how do we continue to do our important oceanographic research without being harassed or stymied by the bureaucrats of the world? One approach is to increase and improve our international cooperative oceanographic activities on the scientific as well as the diplomatic front. This approach should lead to significant benefits for the U.S. oceanographic community, but it will not be easy.

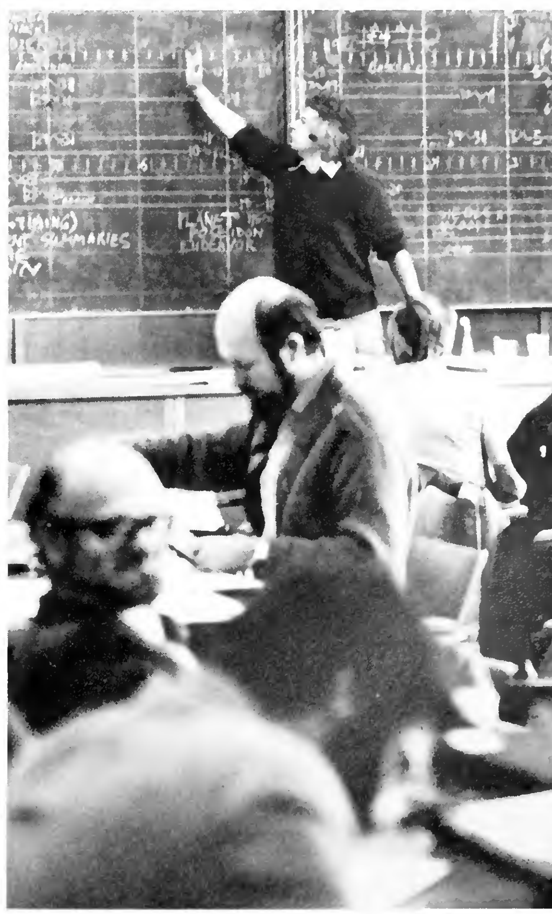
Reasons for Cooperation

There are several very good reasons for having cooperative programs with foreign countries, especially developing ones. Certainly among the most important is the altruistic motive of sharing the knowledge and benefits of research. There also are important scientific consequences of assisting foreign scientists and technicians to reach high levels of competence, in that the work these people conduct in the future will be more professional and of a higher caliber. Most scientists who participate in cooperative foreign programs find them to be very satisfying for scientific as well as personal reasons.

The treaty will create another motivation for cooperative international projects — access to foreign waters — but it will not be a straight *quid pro quo*. To develop a program will require a better understanding of a foreign country's marine scientific research needs and expectations, the latter of which are very often different from ours.

Many foreign countries, especially developing ones, look to the ocean as a source of food, energy, raw materials, and tourism rather than as a place to test scientific hypotheses. Environmental protection may not have a high priority, at least at the present time. Some coastal countries have no tradition of marine scientific research, and it is only because of their newly acquired jurisdiction over a large part of the ocean that they now look seaward. Thus, while foreign countries may be anxious to participate in cooperative marine research, their main interests will be in applied research that will focus on the assessment and exploitation of real, potential, or imagined marine resources. They also may be more interested in research on marine policy, marine economics, or coastal zone management than the more specific and traditional subdisciplines of oceanography. It has been mainly for these reasons that a number of developing countries have taken an active role in some international organizations.

Foreign countries, and their scientists, will expect to take a much more active role in the



The final planning session for the Joint Air-Sea Interaction project (JASIN), a five-year (1977 to 1982) scientific investigation involving 60 scientists from nine countries. At this meeting in Wormley, England, the group coordinated schedules for 14 ships and four aircraft that were used in a two-month expedition northwest of Scotland. (Photo by Mel Briscoe — WHOI) planning and execution of cooperative scientific programs than they have in the past. An important point in effective cooperation is that it should include individuals with compatible skills. Some of the newer countries, especially those which lack backgrounds in marine science, may have few appropriately trained people who could participate in a cooperative project. For this and other reasons, the host country may require as a condition of access that the visiting country offer practical training courses (shipboard training may be especially appealing) and assistance with developing national expertise in assessing marine resources. Most countries also will want samples of all materials collected and copies of all data and reports. None of these potential requirements is unreasonable and, if approached creatively, may actually lead to more interesting and productive projects.

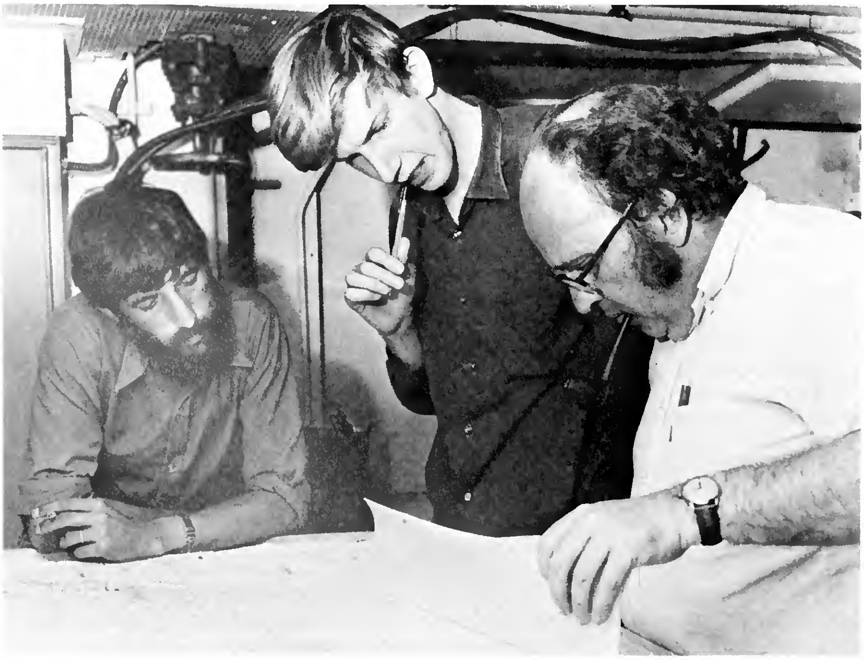
Major Facilitating Organizations

Some official international organizations already exist for coordinating and promoting marine science. Unfortunately some of them have not been very successful, but it is their potential rather than their past performance that we should consider.

International organizations fall into two general categories — governmental and nongovernmental. Either can be organized on a global or regional scale. There are several global and regional oceanographic forums in which the United States participates and which are or could be effective vehicles for developing international marine activities. Among these are the Intergovernmental Oceanographic Commission (IOC), the Scientific Committee on Oceanic Research (SCOR), the International Council for the Exploration of the Sea (ICES), and United Nations organizations such as the United Nations Educational, Scientific and Cultural Organization (UNESCO). In addition, there are other ways that the United States could foster marine science programs in foreign waters. These include bilateral science and technology agreements as well as trade and aid agreements that include access for marine science. Also worthwhile are specific programs like the International Decade of Ocean Exploration (IDOE) program of the 1970s, which stressed international cooperation (see *Oceanus*, Vol. 23, No. 1). It would be exciting to see a new effort such as this develop for the 1980s. International Sea Grant might have fulfilled this role but, unfortunately, has fallen victim to U.S. budget cuts.

Probably the first effective international governmental organization for cooperation in marine science was ICES, formed in 1902. ICES now has 18 member countries, mainly from Europe and North America (including Iceland), and essentially all have considerable expertise in marine science. ICES has focused mainly on living resources and pollution research, and sponsors important annual meetings on these subjects. Although there are national delegates to the Council, most of the scientific deliberations are handled by working committees of scientists so that recommendations of the Council are based mainly on scientific rather than political considerations. This separation of science and politics has been an important reason for the success of ICES. It should be noted, however, that ICES is an organization of developed countries having similar social and economic goals and that its members are fully supported by their governments.

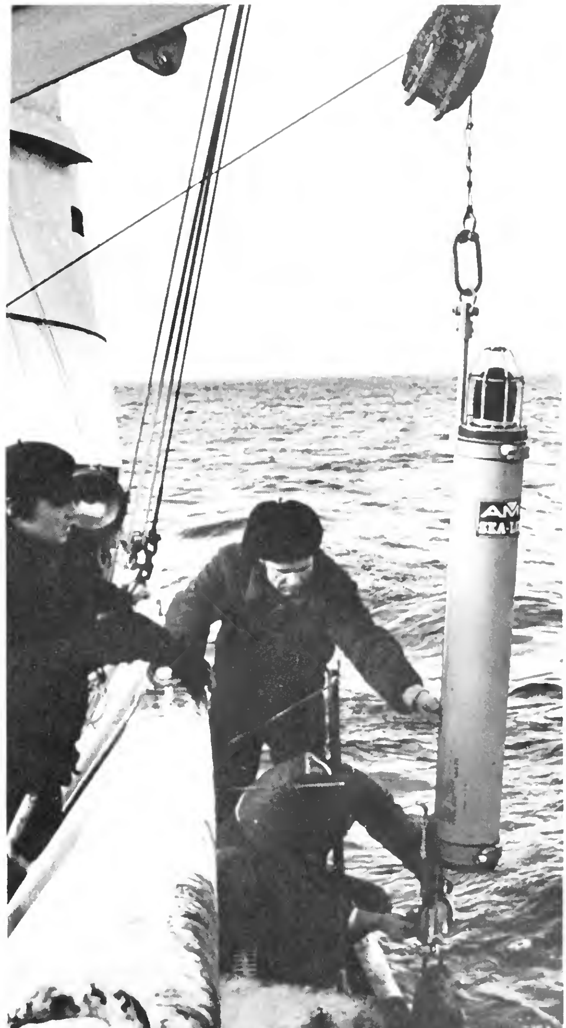
Several nongovernmental international groups, with links to marine science, have developed within the International Council of Scientific Unions, including the International Association for the Physical Science of the Ocean; the International



France, Britain, and the United States are represented here as three scientists look over charts aboard the Woods Hole Oceanographic Institution (WHOI) research vessel Atlantis II *in 1973. They are (left to right) Jean-Marie Auzende of the Centre National pour l'Exploitation des Oceans; Michael Purdy, then a graduate student at Cambridge University and now with WHOI; and Elazar Uchupi of WHOI. As part of the Eastern Atlantic Continental Margin Project of the International Decade of Ocean Exploration (IDOE), the three were working off the coast of Morocco to study the Azores–Gibraltar plate boundary. (WHOI photo)*

Union of Biological Sciences; and the International Union of Geological Sciences. These organizations are known for the scientific symposia they sponsor and for their affiliation with SCOR. This group was formed in 1957 in recognition of the interdisciplinary nature of oceanographic research and the need to bring the disparate and isolated marine disciplines together. The organization has scientific representation from 34 countries and is well known to most of the marine scientific community. SCOR is an active organization. It has working groups looking at specific problems, sponsors scientific meetings, and provides scientific advice to UNESCO. SCOR, like ICES, draws its membership mainly from developed countries.

In 1960, UNESCO sponsored an intergovernmental conference on oceanographic research that led to the formation of the Intergovernmental Oceanographic Commission, and to the recognition of SCOR as the scientific advisory group for UNESCO. IOC was created to coordinate international marine scientific programs, and one of its first activities was to take charge of the International Indian Ocean Expedition, which had been initiated by SCOR. This was ultimately a successful project that involved many countries and demonstrated the considerable potential of IOC. More recently, however, there has developed a general disenchantment with IOC. A 1982 Ocean Policy Committee study suggested that the growing ineffectiveness of IOC was a consequence of two factors. First, the general conflict between developed (North) and less developed (South) countries that has pervaded many United Nations forums (including UNCLOS III) also has affected scientific cooperation. Second, large-scale descriptive studies, such as that done in the Indian Ocean, for which IOC was a suitable coordinating body, are now an uncommon type of research. International projects are more localized, involve only a few countries, and could (before the treaty) be arranged on a more personal basis. Nevertheless, the IOC still has the potential to foster international cooperation. For example, projects approved by a coastal nation within an international forum such as IOC shall also be deemed to have been authorized by that country. To successfully fill such a role, however, the IOC will have to regain the scientific focus it had at its inception.



Russian scientists prepare to test an acoustic release owned by the Woods Hole Oceanographic Institution. Three Woods Hole oceanographers were aboard the Soviet research vessel for a brief cruise in 1975. A cooperative experiment was conducted, comparing Soviet and American current meters. (Photo by Robert Heinmiller — WHOI)

Other U.N. Agencies

There are other specialized agencies within the United Nations that emphasize cooperation in marine science and technology. These include the Ocean Economics and Technology Branch (OETB), the Food and Agriculture Organization (FAO), the International Maritime Organization (IMO), the World Meteorological Organization (WMO), the United Nations Environmental Program (UNEP), and UNESCO's Division of Marine Sciences. FAO is well known to marine scientists, as it has made many contributions to work on fishery-related problems, especially through its field programs in developing countries. OETB has focused on studies relating to ocean energy, deep-sea minerals, and marine technology transfer and application. It has sponsored workshops and published technical analyses on these subjects. The IMO, previously known as the Intergovernmental Maritime Consultative Organization, concerns itself with shipping and related matters, such as pollution from ships. The WMO has been especially successful in developing international cooperation and coordinating marine meteorological projects. It could serve as a valuable model for other marine science organizations.

Chinese scientists prepare to deploy a surface buoy that will mark the location of moored instruments, as part of a recent joint research program involving oceanographers from China and the United States. (WHOI photo)

UNEP was established following the 1972 United Nations Conference on the Human Environment, where the oceans were identified as a priority area. Probably its best known activity is the Regional Seas Program. In this capacity, UNEP has acted as a catalyst for regional efforts involving governments and national institutions. Through meetings, consultations, and other activities UNEP has developed a series of action plans for 10 regional seas, such as the Mediterranean and Red Seas. The action plans attempt to assess the causes of deterioration in environmental quality of the sea and to provide scientific links with management and development of the coastal and marine environment.

UNESCO has an especially visible role in marine science activities, largely through two specific programs: the Division of Marine Sciences and the previously discussed Intergovernmental Oceanographic Commission. Both programs are especially important to developing countries. The Division of Marine Sciences has emphasized research on coastal marine systems and development of trained manpower and technical infrastructure. Efforts of the Division, as with many United Nations activities, are developed in consultation with members of the scientific community and SCOR. The Division also publishes a monograph series on oceanographic methodology, technical papers in marine science, reports on various UNESCO marine activities, and a quarterly newsletter, the *IMS Newsletter,** which details UN efforts in the marine field. The manpower program provides fellowships, expert advisors, and small grants for travel and research, and organizes training courses, specialized curricula, and workshops. The Division's budget has been increasing relatively rapidly. It is presently $6 million, which is distributed among national programs in 17 countries and regional efforts in Asia and Africa.

In general, these UN activities are not well known to the average marine scientist. This is unfortunate, as they can offer opportunities for work in foreign waters or in the development of regional plans through an international infrastructure that is already well established. Although the research opportunities might not be the type most U.S. scientists are familiar with, they still could result in valuable scientific opportunities.

Governmental Agreements

International research cooperation can also be facilitated when governments are willing to develop specific bilateral or multilateral agreements. Bilateral agreements with countries such as Canada and Mexico, within whose waters a large portion of U.S. foreign marine research occurs (usually more than 50 percent of U.S. research clearance requests go to these two countries), or with other parts of the world, could lead to many scientific benefits for both sides. For the United States, one benefit should be improved predictability with regard to clearance and obligations in conducting research. There also can be

---

**IMS Newsletter, Division of Marine Sciences, UNESCO, 7 Place de Fontenoy, 75700 Paris, France.*

Dr. N. M. Ali, left, of Egypt's Ain Shams University, looks over data with Dr. David A. Ross on a joint Egyptian–United States study of the Nile River delta in 1975. They are aboard the U.S. research vessel Chain. *(WHOI photo)* negative aspects, such as increased costs and time taken in negotiations and planning; compromises or additions to scientific objectives that result in extensions or modifications in the cruise track; increased costs associated with providing berthing for foreign scientists; and the broader distribution and analysis of data. One way to minimize these impacts is through active collaboration with institutions in the host countries. Some U.S. institutions already have developed cooperative relations with similar institutions in foreign countries.

These arrangements can lead to valuable cooperative research and educational opportunities, often at modest costs. In any such arrangement, however, it must be understood that permission for research in foreign waters is a prerogative of the government, and that universities and institutions may have little influence in such matters. Nevertheless, such institution-to-institution arrangements can usually provide opportunities for scientists to work on foreign research ships or in foreign institutions and may occasionally lead to more ambitious projects.

The coming years clearly are going to present a challenge to distant-water oceanographers. The legal challenge of doing marine science in foreign waters could become as complex as the scientific challenge. New and established mechanisms for cooperation could reduce the problems and frustrations while opening up new research opportunities.

David A. Ross is Director of the Marine Policy and Ocean Management Program at the Woods Hole Oceanographic Institution, where he is also Sea Grant Coordinator and a Senior Scientist in the Geology and Geophysics Department. Ross is also a member of the U.S. Delegation to the 1982 Intergovernmental Oceanographic Commission. Michael C. Healey is a Research Scientist with the Canadian Department of Fisheries and Oceans, and a Senior Policy Fellow in the Marine Policy and Ocean Management Program at Woods Hole.

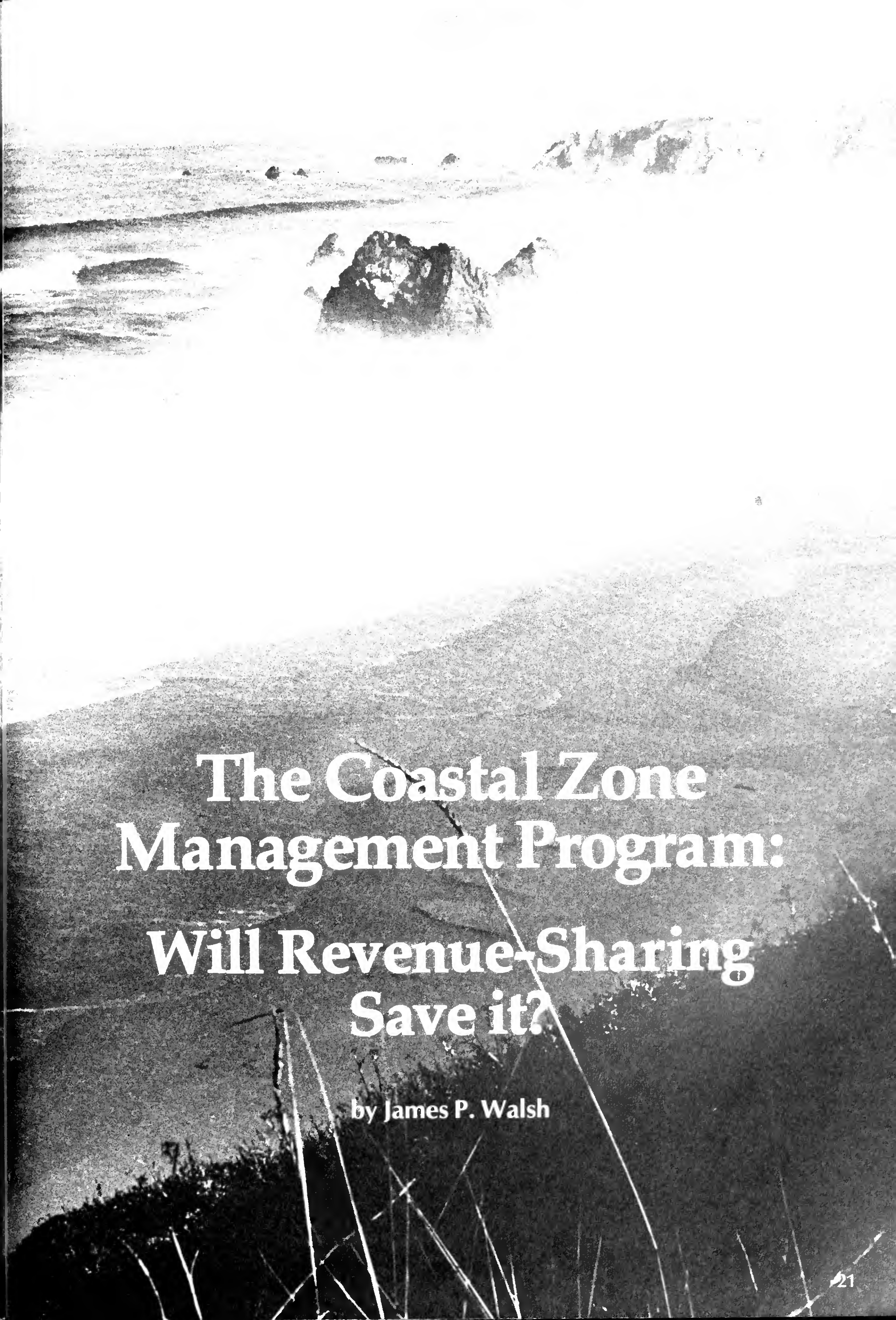
References

Ocean Policy Committee. 1981. Bilateral agreements for marine science by the ad hoc committee of the Freedom of Ocean Science Task Group, 13 pp. Washington, D.C.: National Academy Press.

Ocean Policy Committee. 1982. *United States Interests and Needs in the Coordination of International Oceanographic Research,* 121 pp. Washington, D.C.: National Academy Press.

Ross, D. A., and J. A. Knauss. 1982. How the Law of the Sea Treaty will affect U.S. marine science. *Science* 217 (4564): 1003–1008.

Wooster, W. S. 1980. International cooperation in marine science, pp. 123–136. In *Ocean Yearbook 2,* ed. E. M. Borgese, and N. Ginsburg. Chicago: The University of Chicago Press.



The Coastal Zone Management Program: Will Revenue-Sharing Save it?

by James P. Walsh

Mr. President, today legislation is being introduced in a bi-partisan spirit by myself and 14 of my colleagues on Outer Continental Shelf oil and gas revenue sharing with coastal states. This is an idea which has been discussed for years in the Congress. A number of factors have recently converged that convince me that the time is right to implement the proposal. There is a myriad of coastal and ocean related issues which have been recognized over the years by the Congress, and had previously received generous annual Federal support: fisheries research and management, coastal management effects, sea grant, coastal energy impact mitigation, port development, coastal energy development and research. The list goes on. Budgetary problems and the state of the overall economic health preclude us from continuing this support year in and year out at previous levels. However, these issues will not go away and it would be irresponsible to assume otherwise, merely because Federal funding is withdrawn.

Senator Ted Stevens (R-Alaska)
U.S. Senate Floor
July 27, 1982

Thus began the campaign in the United States Senate to find a more secure funding source for several federal ocean and coastal programs, all threatened with financial termination by the Reagan Administration. Senate Bill 2792, introduced by Senator Stevens and other Senators supportive of these programs, is the counterpart of House Resolution 5543, the Ocean and Coastal Resources Management and Development Block Grant Act, which passed the House of Representatives September 29, 1982. Senator Lowell Weicker (R-Conn.) has introduced his own version of a revenue sharing bill, S. 2794.

The goal of these bills is to tap the royalties paid to the United States from the leasing and sale of publicly owned oil and gas resources located on the U.S. Outer Continental Shelf (OCS), which extends seaward from the edge of coastal state jurisdiction, in order to fund various existing ocean and coastal programs. The programs specifically identified for funding in these revenue-sharing proposals were characterized by the Reagan Administration as being state or local in nature and thus candidates for the phasing out of federal support, like many other "discretionary" civilian federal assistance programs. One such program, or set of activities, is that created by the Coastal Zone Management Act of 1972.

The Beginnings of a National Coastal Program

The 1969 Stratton Commission Report, *Our Nation and the Sea,* identified the need to come to grips with the accelerating and complex problems of growth at the water's edge. That report, among the most perceptive ever done by the federal government, triggered legislative action to implement its recommendation for a comprehensive national system of coastal resource management, with primary reliance on the individual states backed by federal finance assistance and other incentives. The report concluded that poorly managed development in coastal areas was a matter of national, not just local, concern.

On October 27, 1972, after considerable tugging and hauling between the Nixon Administration and the Congress, the Coastal Zone Management Act became law. The essential features of the Act, which have been the source of its resiliency even in the context of today's "New Federalism," are the following:

— a stated purpose of preserving, protecting, developing, and, where possible, restoring or enhancing the resources of the nation's coastal zone for this and succeeding generations;

— financial assistance, on a matching basis, for coastal states that voluntarily engage in the process of developing and implementing management programs to achieve wise use of the land and water resources of the coastal zone, giving full consideration to ecological, cultural, historic, and aesthetic values, as well as to needs for economic development;

— a requirement that all federal agencies cooperate and participate with state and local governments in accomplishing the purposes of the Act, and a mandate that certain federal activities, such as the granting of permits, be "consistent" with a completed and approved state management program (these features are often referred to as the "consistency provisions"); and

— a directive that the public and all levels of government be encouraged to participate in the development of state coastal zone management programs.

The original 1972 Act also contained a provision for funding assistance for the acquisition, development, and operation, by coastal states, of estuarine sanctuaries that would be used as "natural field laboratories" for studying the natural and human processes at work in the coastal zone.

The fight over the CZM Act was intense, due mainly to the lukewarm interest of the Nixon Administration. After passage, bureaucratic obstacles held up the formation of an effective administering office and, of greater consequence, funding for the program was initially refused. Congressional maneuvering finally pressured the Nixon Administration into releasing the funds, and the program began in March of 1974.

Initially, some states did not consider the incentives of the original Act strong enough to overcome traditional local resistance to a government "planning" process. Consequently, Congress began to consider other incentives. The first one enacted was inserted in the Deepwater Port Act. It established, as a condition of licensing a deepwater port, the requirement that the adjacent coastal state to which the port is connected by pipeline either 1) have an approved coastal zone

Overleaf: Beach in northern California. The state government has gone to court to prevent drilling in waters off northern California. (Photo by George Daniell — PR)

A portion of the South Slough Estuarine Sanctuary, near Coos Bay, Oregon. This was the first sanctuary acquired with Coastal Zone Management Act funds as a "natural field laboratory" for the study of natural and human processes in the coastal zone. (Photo courtesy of Oregon Division of State Lands)

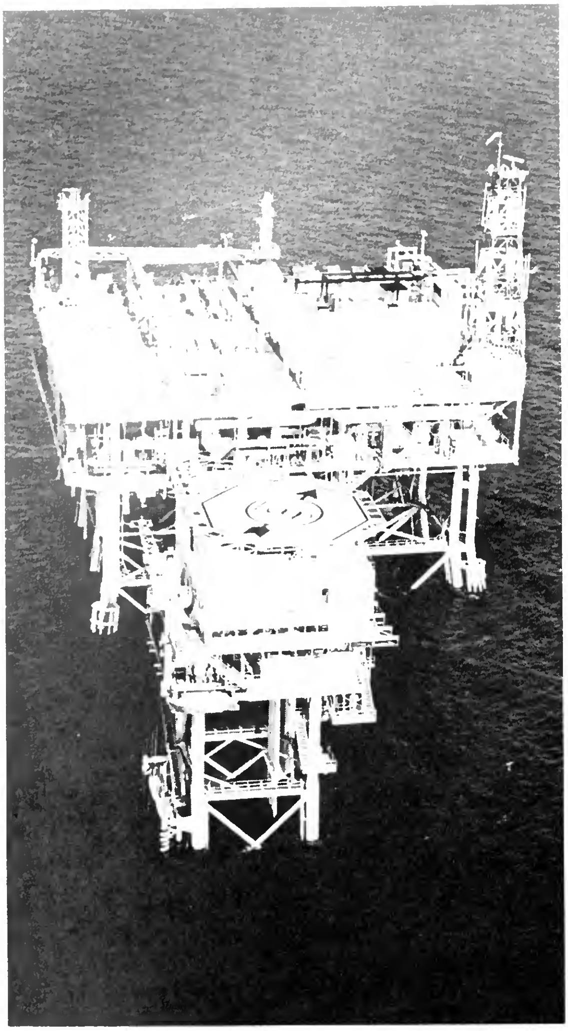
management program or 2) be making reasonable progress toward developing an approvable program. This incentive was among the inducements that brought a coastal zone management program to Louisiana, where this nation's only offshore deepwater port is now located.

In 1976, the first state management program was approved, the one developed by the state of Washington. That same year Congress added further incentives to the Act in response to heightened national concern, following the Arab oil embargo, for secure sources of energy. A large new "Coastal Energy Impact Program," authorized to funding levels in excess of $1 billion, was created to help coastal states cope with expanded energy development efforts in or affecting the coastal zone, such as oil and gas drilling, port development, transportation, refining, and general support activity. To receive the assistance provided by this program, a coastal state had to be receiving funds for developing or implementing a coastal zone management program "consistent with the policies and objectives of the Act."

Federal assistance could be used for: 1) loans to help provide public facilities and services required by coastal energy activity; 2) bond guarantees for new or improved public facilities; 3) grants to pay off coastal state credit assistance if the "boom and bust" cycle left a community unable to pay for expanded public facilities and services; 4) grants to ameliorate environmental losses not attributable to any identifiable source; 5) grants to study and plan for economic, social, and environmental consequences from expanded coastal energy activity; and 6) "formula" grants to coastal states, based on a calculation of acreage leased and oil and gas produced near a particular state, oil and gas landed in that state, and increased employment tied to Outer Continental Shelf energy development.

The new program's sponsors argued that it would build on the Coastal Zone Management Program in dealing with the drive for new energy sources and stave off coastal state demands for untargeted (and therefore potentially wasteful) OCS revenue-sharing. Congress later added authority to use these funds for assisting states wishing to participate in the OCS leasing decision process.

After 1976, momentum behind the Coastal Zone Management Program began to build. By the time Congress conducted the first in-depth program oversight hearings in late 1979 and 1980, more than 20 states and territories had received approval of their coastal management programs from the Office of Coastal Zone Management in the National Oceanic and Atmospheric Administration; the California program approval had been challenged and successfully defended in court (*American Petroleum Institute v. Knecht*, 1979); and the consistency



The Louisiana Offshore Oil Port (LOOP) platform complex, 18 miles off the Louisiana coast. The large pumping platform has two decks measuring 215 feet by 204 feet — about an acre. Crude oil is received through a pipeline from supertankers at moorings further out to sea and then pumped ashore by pumps on the lower deck. The upper deck houses gas-turbine generators to furnish electric power. The smaller control platform, connected to the large platform by a pedestrian bridge, measures 70 feet by 70 feet and contains shops, storage areas, and emergency equipment on its lower deck; a control room and offices on its second deck; and living quarters and recreational facilities for the staff of 35 on its third deck. The third deck roof serves as a heliport, with the arrow pointing north. Congress induced Louisiana to institute an acceptable coastal zone management program by linking the program to the licensing of LOOP. (Photo courtesy of LOOP, Inc.)

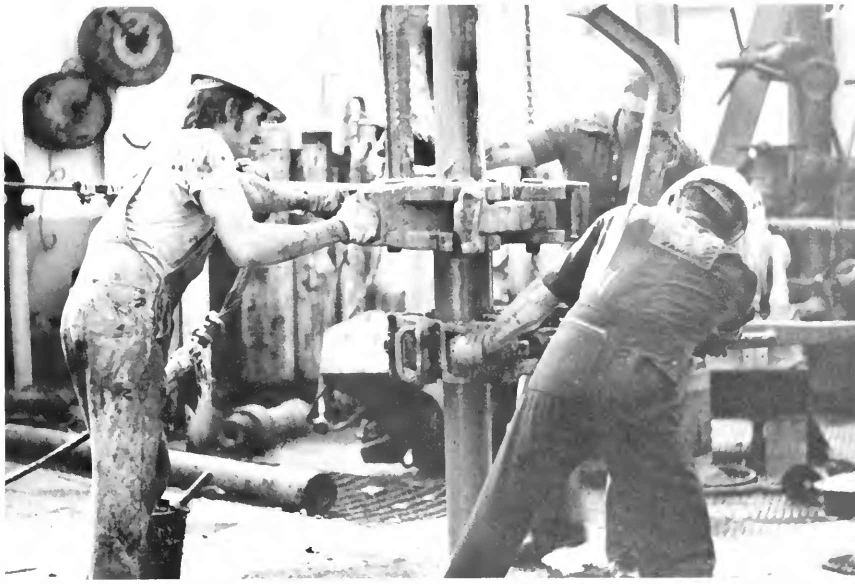
LOOP

The only deepwater port in the United States is 18 miles at sea in the Gulf of Mexico. This is the Louisiana Offshore Oil Port (LOOP), which unloaded its first tanker in May of 1981. Because the United States lacks a developed harbor deep enough to receive supertankers, which can have drafts as deep as 90 feet, a group of oil companies built a facility that can pump 1.4 million barrels a day.

The incoming supertanker is boarded by a specially trained mooring master, who guides the ship to one of three mooring buoys. Here the ship's pumps transfer crude oil through floating hoses to the buoy's base and into a pipeline buried in the seafloor. This pipeline leads to the LOOP pumping platform complex more than a mile away, where oil is "boosted" to shore through another pipeline. After reaching the mainland, the oil continues inland, beneath 28 miles of marshland, to the Clovelly Salt Dome, a complex of mined underground cavities. A network of pipelines delivers the oil from the storage cavities to refineries in Louisiana, Texas, and the Midwest.

Although LOOP is the only system of its kind in North America, there are approximately 200 similar systems in the world; they are used for loading supertankers as well as unloading. If it doesn't use LOOP, a supertanker with U.S.-bound oil can pump its cargo into storage tanks at one of several deep Caribbean harbors or into a series of smaller tankers at sea.

The Hilda Knudsen, *a supertanker of 417,000 deadweight-tons, unloading oil at a LOOP mooring buoy. (Photo courtesy of LOOP, Inc.)*



Disconnecting a length of drillpipe on an offshore rig. (Photo courtesy of Zapata Corporation)

provisions had been invoked by a coastal state (California) in a controversy over an OCS lease sale by the Department of the Interior.

The Coastal Zone Management Act Amendments of 1980 made no major changes in the basic features of the 1972 Act, as it had been amended in 1976. Fine tuning, with an appropriate emphasis on evaluation, was clearly the Congressional intent, as well as a reaffirmation of the Act's inherent partnership between the federal government and state and local governments. Significantly, no alteration of the sensitive consistency provisions was attempted by the legislators.

The Budget Crunch Cometh

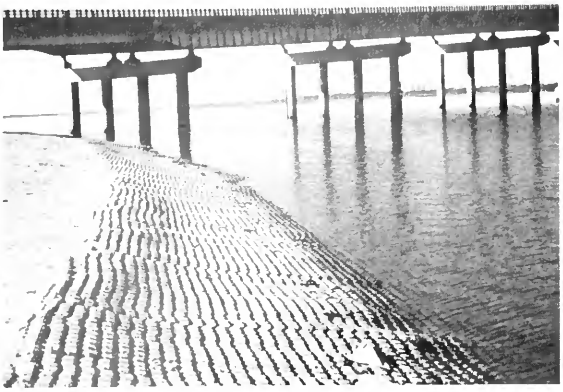
By 1980, however, the size of the federal government and its budget and the bewildering number of national "categorical" assistance programs had become political issues that no politician could ignore; these became major issues in the presidential campaign. The Carter Administration, supportive of the 1980 amendments yet sensitive to the need to reduce federal program costs, wanted much lower authorization levels, increased state matching funds, limits on the number of years a state could receive assistance, and declining federal assistance under the Coastal Zone Management Act. Compromises were reached, and with the election looming large, the 1980 amendments were signed into law. The future of the program seemed secure.

But it was a false security. The Reagan Administration moved quickly to implement the President's proposed New Federalism by significantly altering the executive branch budget request pending before the Congress on Inauguration Day, 1981. The revised Reagan budget request for fiscal year 1982 called for the elimination of funding for nearly all elements of the Coastal Zone Management Program. In the President's message to Congress of February 18, 1981, entitled "America's New Beginning: A Program for Economic Recovery," the termination of the program was described tersely:

> *Funding will be terminated for the Coastal Energy Impact Program (CEIP) and the Coastal Zone Management (CZM) state grant program.*
>
> *The Administration proposes to terminate the CEIP program because the local impacts from oil and gas development have proven to be far less than originally anticipated and well within the capability of states and localities to handle. The overall coastal population is only expected to increase by about 8,000 persons a year as a result of coastal energy development. Louisiana, which has received a large portion of CEIP funds, also received severance taxes from oil and gas — amounting to roughly $500 million in 1979. These funds could be used to assist persons in relocating.*
>
> *The CZM program has largely achieved its purpose. States covering 78 percent of the coastline already have received seven years of federal assistance to develop, implement, and administer their coastal zone management programs. Continuation of the state CZM programs and any additional improvements should be financed by the states.*
>
> *These changes are consistent with the original intent of the coastal programs — to provide federal assistance only when essential and for front-end seed money.*

The real message was simple: let the states pick up funding for the program because the federal government can no longer afford it.

Congressional supporters of the CZM program and the coastal states immediately began to attack the assumptions in the President's budget proposal at Congressional oversight hearings on the



Riprap prevents further erosion at a small park in Calcasieu Parish, Louisiana. Wake from ship traffic in a nearby ship channel had eroded the park's beach. Because the ships were travelling to and from petrochemical plants that were built because of oil rigs offshore, the state of Louisiana applied for and received a federal grant under the Coastal Energy Impact Program. The money was used to restore the beach with sandfill and riprap and to purchase picnic tables. The park is popular with the employees of the nearby oil refineries. (Photo courtesy of Louisiana Department of Natural Resources)

implications of terminating federal assistance for the coastal management effort. The Coastal States Organization (CSO) submitted to the Congress on April 27, 1981, a paper setting forth several arguments against accepting the Reagan proposal:

- *Congress had just reauthorized the Act and recognized the importance of coastal zone management.*
- *States are not yet in a position to assume the full financial burden of coastal management.*
- *Significant national benefits will be lost if the Coastal Zone Management Program is terminated.*
- *The majority of state programs are not yet institutionalized.*
- *The Coastal Zone Management Program is a cost-effective program which complements the Administration's desire to transfer the focus of decision-making to state and local governments.*
- *The termination of funding is unfair and inequitable, and will undoubtedly generate ill will toward energy activities in coastal states.*

A poll taken by the CSO indicated that termination of funding will mean abandonment of the program in 10 states and significant curtailment in 10 others. In only five states will the program remain intact, though reduced in scope. In addition, seven states now in the development process would not be able to proceed further. The CSO claimed that individual states, faced with declining revenues, could not continue all the federal assistance programs shifted to them by the Reagan proposals. Put another way, coastal zone management would be pursued when budgets were not tight, but for most states other public programs take precedence over coastal planning when overall public funds are reduced.

Starting in early 1981, the Congress began to focus all its energies on the broader implications of the federal budget and the threat of unprecedented deficits. The Coastal Zone Management Program is one of many national grant-in-aid programs that were targeted for elimination. Its supporters had, and still have, genuine cause for concern.

Revenue-Sharing to the Rescue?

The Coastal Zone Management Act passed its 10th year on October 28, 1982. As of this writing, 28 states and territories have reached the approved program threshold and one (Virginia) is still seeking approval (Table 1). Six states have opted not to participate at all in the program. The fact that the Office of Coastal Zone Management continues to process and approve coastal state programs (two in 1982) is a sign of continuing interest in the program despite the threat of termination. Furthermore, despite court decisions adverse to the Department of the Interior and the oil and gas industry (requiring consistency between lease sales and approved state coastal management programs), no movement to repeal the Coastal Zone Management Act is evident in Congress.

The resiliency of the Coastal Zone Management Act and the strong interest of the coastal states provided sufficient reason for the Congress to reject the proposed elimination of the basic administrative grant program (section 306). The House and Senate appropriations committees provided $33 million through the end of fiscal year 1982 for state programs. But the source of the money was the Coastal Energy Impact Program, which Congress decided to jettison in favor of section 306. With these funds and with judicious use of unspent money from last year, the Office of Coastal Zone Management was able to financially support all state activities through September, 1982. Now, state programs have begun to wither. Congressional appropriations committees would have to come up with another $33 million to fund another year of assistance at the 1982 level. The Reagan Administration has requested only $4 million for fiscal year 1983, mainly to fund the bureaucratic costs of overseeing and conducting program evaluation, administering outstanding loans, dealing with consistency issues, and running the estuarine sanctuary program (Table 2).

If the coastal program's Congressional supporters are unable to insert the necessary funds in the fiscal year 1983 appropriation bill, the predictions of the CSO will become reality: state programs will be reduced substantially and approximately 50 percent of staff laid off. Funding losses could be greater than 50 percent.

In those states where public sentiment favors coastal management independent of federal assistance and where the consistency provisions are seen as a valuable tool, as in California, the state programs would survive at a minimum level, just adequate for maintaining approvability under the Act. These states would be a decided minority of the coastal states, however.

It is in this context that the revenue-sharing concept has been embraced as a means of providing funds, in the form of block grants to the states, to assure a future for coastal zone management activities. But the success of this move remains uncertain. The outcome will determine the future of the Coastal Zone Management Program as well as Sea Grant and several other federal ocean and coastal assistance programs.

The Prospects

The revenues generated by leasing publicly owned oil and gas resources found beneath the nation's rather substantial Outer Continental Shelf are large, and will increase with the ambitious drilling efforts now under way. Second only to income taxes as a source of revenue, the bonus bids, royalty payments, and rents received are deposited in the General Fund of the U.S. Treasury. The Office of Management and Budget views these revenues as a major offset to other federal expenditures, reaching a level of $15 to $17 billion a year by 1985.

To co-sponsors of H.R. 5543, S. 2792, and similar measures, these funds are an appropriate way to support the national interest in wisely managing and using ocean and coastal resources. The pattern of laws now on the statute books defines a special federal-state relationship that has been carefully constructed since 1947, when the Supreme Court determined that the federal government, and not the states, owned the mineral resources underlying the territorial sea (out to three miles) and beyond. With the Submerged Lands Act of 1953, Congress returned ownership of the land underlying the territorial sea to the states, retaining federal ownership of the Outer Continental Shelf beyond three miles. The sponsors of most of the revenue-sharing proposals want to

Table 1. Status of state coastal zone management programs.

State		
Washington	1976	Approved
Oregon	1977	Approved
California	1978	Approved
Massachusetts	1978	Approved
Wisconsin	1978	Approved
Rhode Island	1978	Approved
Michigan	1978	Approved
North Carolina	1978	Approved
Puerto Rico	1978	Approved
Hawaii	1978	Approved
Maine	1978	Approved
Maryland	1978	Approved
New Jersey (bay and ocean shore segment)	1978	Approved
Virgin Islands	1979	Approved
Alaska	1979	Approved
Guam	1979	Approved
Delaware	1979	Approved
Alabama	1979	Approved
South Carolina	1979	Approved
Louisiana	1980	Approved
Mississippi	1980	Approved
Connecticut	1980	Approved
Pennsylvania	1980	Approved
New Jersey (remaining section)	1980	Approved
Northern Marianas	1980	Approved
American Samoa	1980	Approved
Florida	1981	Approved
New Hampshire (ocean segment)	1982	Approved
New York	1982	Approved
Virginia	?	*
Ohio	Not Participating	
Indiana	Not Participating	
Georgia	Not Participating	
Minnesota	Not Participating	
Illinois	Not Participating	
Texas	Not Participating	

*Governor Robb requested reinitiation of the CZM Program in May 1982; OCZM decision pending
Source: Office of Coastal Zone Management.

Table 2. Ten-year appropriation history of the Coastal Zone Management Program.[1]
(Dollars in Thousands)

	1974	1975	1976[2]	1977	1978	1979	1980	1981	1982	1983[3]	Totals[6]
Section 305 (Program Development)	7,200	12,000	15,000	17,803	11,028	4,535					67,566
Section 306 (Program Administration)		2,100	6,053	6,142	18,212	24,712	27,212	33,962	33,000[4]		118,393
Coastal Energy Impact Program											
Formula Grants				10,000	17,690	27,750	27,750	7,172			90,362
Planning Grants				3,500	3,500		3,500[5]	3,500[5]			7,000
OCS Participation							3,000[5]	3,000[5]			
Environmental Grants				1,500	1,500		1,500[5]				3,000
Loan Guarantees				110,000	110,000						220,000
Program Management						600[5]	420[5]	620[5]	399[5]		2,039
Estuarine Sanctuary Program	4,000			1,500	300	3,000	3,000	3,000	2,000	1,280	18,080
Program Management	800	900	1,447	1,208	3,550	3,343	4,963	5,201	3,165	2,876	27,453

[1] Source: National Oceanic and Atmospheric Administration.
[2] Includes transition quarter.
[3] Administration request. Congress has not yet approved appropriations for FY83.
[4] Transfer from Coastal Energy Impact Program.
[5] Funded by reprogramming.
[6] Includes direct appropriations only.

preserve the vitality of these laws and programs. One proposal, however, introduced by Representative John Breaux (D-La.), would give states OCS money without tying it to ocean and coastal programs.

Yet the economic difficulties of the nation are such that a good number of worthwhile government programs (along with some bad ones) have already lost their funding, and others will expire in the future. It may well be that revenue-sharing will not arrive, or will arrive too late, to provide the funds needed to save the Coastal Zone Management Program, at least at the scope of today's activities.

The first and foremost reason is the size of the forecasted federal deficit ($175 billion in 1984). Because the Congress has generally gone along with the President's budget priorities (more defense spending, fewer social programs), the odds are against coastal management funding.

Second, the President's financial advisors surely will object vehemently to mandatory use of OCS revenues of up to $300 million a year for programs President Reagan has recommended eliminating. Moreover, OCS revenues are already earmarked for general Treasury receipts in the President's economic program through 1985. Can there be any doubt that his advisors will recommend a veto of any revenue-sharing bill similar to H. R. 5543 or S. 2792?

Clam shells on a barge are sprayed by high-pressure hoses into water off the coast of Louisiana. Funded with a federal grant under the Coastal Energy Impact Program, this project provided material on which larval oysters could attach themselves, thus rehabilitating or relocating oyster reefs which were damaged by petroleum industry activities. (Photo courtesy of Louisiana Department of Natural Resources)

Finally, unless the supporters of the revenue-sharing concept are successful in obtaining automatic transfer of OCS revenues to the coastal states without the need for annual appropriation, funding will still be subject to the annual budget process, in which budget-cutting is the present norm. The chances of bypassing the appropriation process are not good. Ironically, the federal Coastal Zone Management Program, though it has been judged successful and has all the elements of the "New Federalism," will probably deteriorate, perhaps irretrievably in some coastal states.

The federal government's role will then be to review continuing eligibility for approval. With approval comes the right to invoke the consistency provisions for federal projects and activities. Once approval is lost, consideration of the "national" interest in certain land and water use decisions will be more haphazard and will depend on factors external to the policies in the Coastal Zone Management Act.

Perhaps the goals of the Coastal Zone Management Act will be embraced in other federal statutes, for example the Clean Water Act or the Fish and Wildlife Coordination Act, or in some other manner. For Senator Stevens is correct — the problems of bad or inefficient management and coordination between government entities will not go away. Either some method of coping with these problems will be invented or all the difficulties identified by the Stratton Commission will come back to haunt the nation, and the progress fostered by the Coastal Zone Management Program will be lost.

James P. Walsh is an attorney in Washington, D.C. He is a former Deputy Administrator of the National Oceanic and Atmospheric Administration.

Selected References

Coastal States Organization. 1981. *Coastal Management — A Sound Investment.* A position paper on funding the Coastal Zone Management Program. Washington, D.C.

Committee on Merchant Marine and Fisheries, U.S. House of Representatives. 1982. Report to accompany H. R. 5543, the Ocean and Coastal Resources Management and Development Block Grant Act.

Galloway, T. D., and D. Nixon. 1982. The newest federalism and coastal areas. *Oceanus,* Vol. 25, No. 2

Office of Coastal Zone Management, National Oceanic and Atmospheric Administration, U.S. Department of Commerce. 1979. *The First Five Years of Coastal Zone Management: An Initial Assessment.*

————. 1982. Managing the nation's coast. Biennial report to the Congress covering fiscal years 1980 and 1981.

Fisheries Management

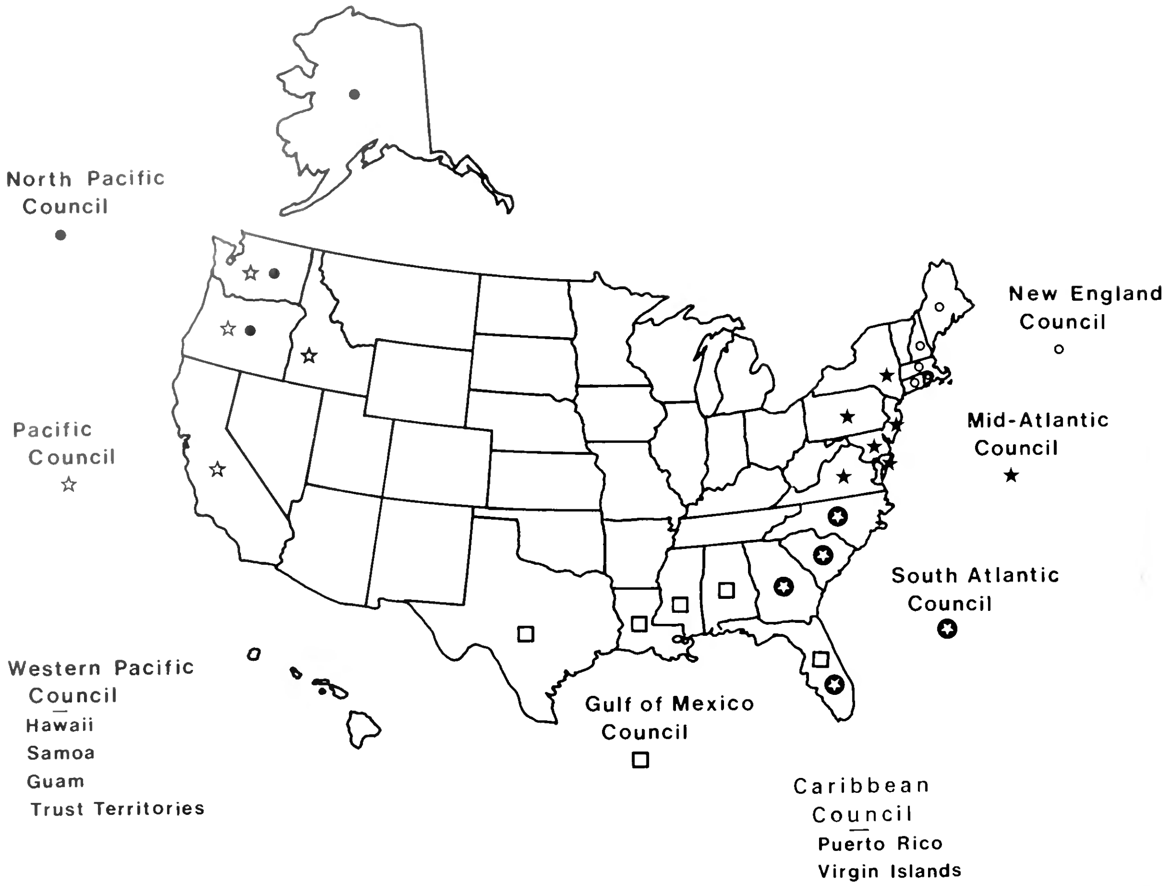
by Spencer Apollonio

Marine fisheries management entered the 1980s carrying with it, in the United States at least, the mandate of law and a considerable burden of mythology and tunnel vision. The mythology centers on the assumption that commercial species exist in isolation from each other and their environment, and that fishing is the dominant variable affecting abundance. The tunnel vision is centered on a limited range of perceived fisheries policies or management objectives, all implicitly assuming that maximum sustainable yield (MSY) is the proper and possibly the only objective.

Fisheries management has already encountered, in the New England Groundfish Management Plan, for example, some of the unpleasant circumstances that are inevitable when wishful or conventional thinking encounters the real world. At the moment, however, the full appreciation of the discrepancy between hypothesis and actuality does not appear to be widespread. If fishery management is to avoid repetition of painful experiences and is to manage fish in any rational and beneficial manner, some very fundamental reappraisals are in order.

Limited Experience

The United States had very little formal and practical management experience prior to the mid-1970s. There were some success stories, such as Pacific halibut and Pacific salmon. These were successfully managed fisheries. They also were very special, even unique, cases; indeed, how special they were became obvious in the 1960s when Pacific halibut were subjected to the bottom-trawl fishery for pollock by Japan. At that point, the successful management of halibut faded remarkably. The



There are eight Regional Fishery Management Councils. The majority of voting members on each council are selected by the Secretary of Commerce from lists submitted by the governors of the states in that region. Other mandatory members include the regional director of the National Marine Fisheries Service and the official from each state who has principal responsibility for marine fisheries management. Nonvoting members include the regional director of the U.S. Fish and Wildlife Service, the commander of the Coast Guard district, the executive director of the Marine Fisheries Commission for the geographical area concerned, and a representative of the Department of State.

mixed-species, bottom-trawl fisheries are where we seem to be unable to respond to ever-increasing fishing pressure.

In addition to the relatively few examples of successful single-species management, the U.S. experience included multi-species management within the International Commission for the Northwest Atlantic Fisheries (ICNAF). In a sense, this also was a special case, in that the common denominator of maximum sustainable yield — a purely biological management objective allowing the maximum yearly harvest that will not seriously reduce a fish population — was generally accepted by 17 nations and underlay ICNAF policies. In other words, ICNAF functioned with a commonly-agreed-upon, though quasi-quantifiable, management objective. In these several cases of national fisheries management experience, the decisions were largely in the hands of full-time professional managers, who generally understood the nature and limitations of scientific advice offered to them as well as the need for commonly perceived and commonly accepted management policies.

A revolution in fish management was mandated in 1976 by the Magnuson Fishery Conservation and Management Act (MFCMA), which required that all stocks be managed as units throughout their ranges to achieve "optimum yield," an ill-defined and, as it turned out, elusive concept that allows social and economic considerations. Incidentally, Canada and the European Economic Community also adopted optimum yield as their management goal, but apparently they have not extended the idea much beyond traditional MSY.

The MFCMA created eight regional management councils consisting of persons serving on a part-time basis for staggered three-year terms, charged with setting fisheries policy and making management decisions. Few members came to the councils with any previous scientific or fisheries management experience or much familiarity with the volume, limitations, and subtleties of fisheries science and management literature. Many come, even if unconsciously, with the notion that MSY is the proper and possibly the only legitimate goal of management, despite its rejection by most fisheries scientists, and are unaware of "Larkin's epitaph."* Further, the council structure and process are not conducive to close scrutiny of particular fisheries problems, nor to the thoughtful development of any other long-term management objectives. The infrequent meetings are often dominated by bureaucratic busywork and discussions of procedure.

Probably the council members are reinforced in their implicit loyalty to MSY by the scientific advice available to them. Fisheries scientists have few working models for management, and the objective of most models is something closely akin to maximum sustainable yield or to maximum yield per year-class. Any professional advice they can offer must focus rather narrowly — for lack of scientific options — on only one or a few of a wide variety of possible management objectives. Thus scientific advice to managers may be slanted strongly toward a preconceived management objective.

To many new managers it may be unclear that MSY has little to do with conservation or restoration of a stock. And if one ventures to break from MSY as the management objective, science suddenly has little to offer for guidance, and the managers sometimes find themselves adrift in a turbulent ocean of subjective judgments and arbitrary social decisions — all highly controversial and difficult to define, explain, or defend, however valid they may be. It is an uncomfortable position.

There is a wide variety of valid fisheries management purposes. It is useful to recognize, for example, that often-condemned "pulse-fishing" is a perfectly legitimate management technique if it serves an agreed-upon public policy for a particular fishery. The objective of this method is to accumulate maximum protein as rapidly and cheaply as possible by catching most of the fish in one area and then moving on to another.

Undefined Objectives

Despite the wide range of available options, experience has shown that it is difficult for councils to define their management objectives. For more than a year, the New England Fishery Management Council (NEFMC) has been struggling to define both herring and groundfish management goals without success. Casual examination of fisheries management plans (the 14 implemented to date) shows, in many cases, very generally stated objectives. For example: "promote the growth of the U.S. commercial fishery, including fish for export"; "provide the greatest degree of freedom and flexibility to all harvestors of these resources consistent with the attainment of the other objectives of this plan"; "to promote conservation of stocks throughout their range." Many of these objectives are so general that they amount, one suspects, to no clear objective at all. Why this is so is not clear. I have argued elsewhere that this crucial problem may result from structural weakness of the councils — their part-time nature and their high turnover rates. Whatever the cause, the difficulty of identifying practical objectives is a serious hindrance to beneficial management: it can lead to ambiguous, ill-conceived, unenforceable, or inappropriate regulations; to lack of consensus on the progress or accomplishments of management; and, eventually, to dissatisfaction with the management program.

Managers are not in any real way constrained in their choice of management policies. The MFCMA, by setting undefined "optimum yield"* as the goal of fisheries management, in effect has given extraordinary latitude to the regional councils in setting policy. In practice, optimum yield is whatever the regional managers say it is. Delegation of authority for such broad policy determination to the regional councils is undoubtedly appropriate; fisheries by their nature are regional, not national, so regional authorities should be best qualified to set practical policies. Indeed, some regional fisheries were managed prior to MFCMA by some kind of *de facto* policy which, to some degree at least, conformed to economic, biological, or social realities of the region. For example, the Maine clam fishery has traditionally been managed with an implicitly social goal — that of providing at least part-time employment to as many people as possible. Such policies may be criticized, but the fact that they may not correspond to preconceived biological or economic models does not alter the fact of some sort of management for legitimate, regionally-devised ends.

In any case, the councils have a very wide choice of management options. But it may be that the formality of the structure of the procedures of the councils in some way constrains the managers'

---

*In 1977, fisheries scientist Peter Larkin of the University of British Columbia wrote:

Here lies the concept, MSY
It advocated yields too high
And didn't spell out how to slice the pie,
We bury it with the best of wishes,
Especially on behalf of fishes.
We don't know yet what will take its place,
But we hope it's as good for the human race.

*The MFCMA contains the following definition:

(18) The term "optimum" with respect to the yield from a fishery, means the amount of fish –

(A) which will provide the greatest overall benefit to the Nation, with particular reference to food production and recreational opportunties; and

(B) which is prescribed as such on the basis of the maximum sustainable yield from such fishery, as modified by any relevant economic, social, or ecological factor.

Five years experience suggests that this definition is so general as to amount to no definition, because it leaves unanswered the question of how "optimum" is to be defined and measured.

Japanese businessmen at a meeting of the North Pacific Fishery Management Council in Anchorage, Alaska. Representatives of the Japanese fishing industry attend the meetings regularly, as Japan is the major nation fishing the Bering Sea. (Photo by Alfred Chandler — National Fisherman*)*

perceptions of options to a much narrower range of possibilities than had evolved informally prior to MFCMA. And what is now slowly being learned is that the imposition of more conventional management objectives, which often lie within that narrow range, may be very difficult on certain regional fisheries. In some cases, the attainment of such objectives may be politically impossible or not worth the cost.

Another long-recognized problem in fisheries management is the need for knowledge of the relative abundance and trends of fish stocks, for it is of course useful under any policy to have some idea of the quantity of fish with which one is concerned. By relating the quantity, average age, and sex ratio of fish caught commercially and in scientific sampling to the historical performance of a given fish population, it is relatively easy to assess present stock abundance with accuracy sufficient for most practical purposes. But these assessments do not have great predictive value. Thus managers have neither the means of anticipating natural trends in stock abundance nor the means of foreseeing the consequences of their actions or inaction.

Much of the difficulty stems from the current focus on single-species management by both scientists and managers. Scientists by necessity concentrate on single-species models, recognizing their shortcomings, for lack of a usable multi-species model. Similarly, managers traditionally think in terms of single-species regulations because of the obvious complexities of dealing with several species simultaneously, as one must deal with mixed-species trawl fisheries and often should with other fisheries. This difficulty is magnified by the mandate of MFCMA, which prescribes optimum yield as the proper goal. A moment's thought convinces most people that optimum yield (however defined) cannot be obtained simultaneously from several species taken together, and thus fisheries managers are presented with a serious dilemma: how to accomplish that which may not be possible.

Managers are further hindered by an inability to assess the possible consequences of their decisions within the ecosystem. It is routinely acknowledged in an abstract sense that fish are part of a larger system, but currently there is no apparent predisposition by managers to think of multi-species or systems management, nor are there practical models available to predict the impact of perturbations on other fish components of the system, even though such impacts are likely under the heavy fishing pressures that are common in many of our regional fisheries. Neither can we distinguish those man-induced impacts from disturbances that are the result of natural forces within the system.

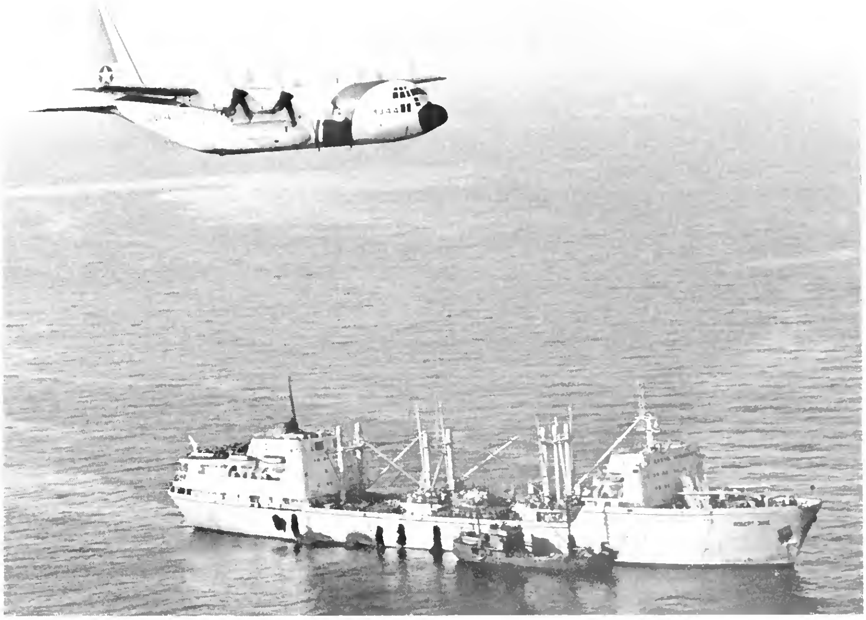
Several problems of serious magnitude thus converge on the regional councils: 1) the problem of articulating a clear management objective; 2) the problem, if the managers choose nonbiological objectives for their policy, of defending subjective judgments; and 3) the problem of understanding what the *system* of fish is likely to do under a particular management plan, given the range of possible environmental fluctuations. To put these concerns into a specific context, it is useful to review the history of groundfish management by the NEFMC in 1977–1978. The review shows an interesting, if unintended, evolution of management goals as well as some of the unanticipated consequences, resulting finally in the overthrow of an entire management approach.

Fiasco in New England

In the fall of 1976, the NEFMC was advised that it must deal immediately with stocks on the edge of collapse, particularly haddock and yellowtail flounder. Therefore the council set very restrictive annual quotas for haddock and yellowtail flounder. The quota for haddock, in fact, was intended only to make legal the unavoidable bycatch of haddock in the cod fishery, the scientific advice being that no haddock at all should be caught if a collapse were to be avoided. At that time the council did not realize how restrictive the annual quotas actually were; it was even anticipated that the annual quotas would not be reached. However, the reported catch (undoubtedly less than the actual catch) approached the quotas less than six months after implementation of the plan because of an unanticipated abundance of haddock. So abundant was the haddock that fishermen reportedly were throwing away large quantities of small haddock in order to land larger, more valuable fish within the quotas.

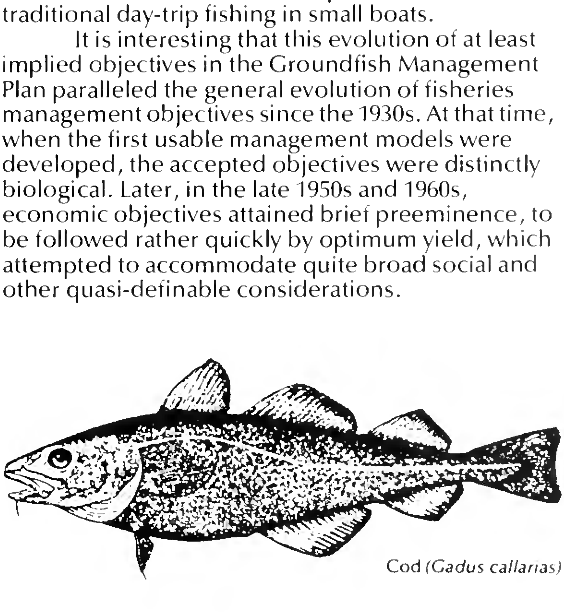
Thus the industry faced a total cod closure for up to six months — an intolerable prospect — because of the mixed bycatch nature of haddock in the otter trawl cod fishery. The council quickly

A Coast Guard HC130 flies over a foreign "mother ship" and one of her trawlers within the United States 200-mile Fisheries Conservation Zone. At sea for five to nine months at a time, the large ship has a crew of several hundred, including a medical staff. Trawlers tie up alongside to unload their catch, which is then processed and frozen. The Coast Guard identifies such ships and later checks to see if they are properly licensed to operate where they were sighted. The arrangement of a trawler's nets and other equipment is often enough to tell an airborne observer what species are being caught. (Photo courtesy of the U.S. Coast Guard)



implemented quarterly catch allocations within the annual quotas, in order to spread the catch throughout the year and thus avoid closures of several months duration. The plan objective thereby shifted significantly from a purely biological objective, that of stock restoration, to a partly economic objective, that of insuring at least some income to the fleet throughout the year. Even so, industry argued quickly and loudly that vessel-class allocations also were necessary to insure that large vessels, capable of year-round, all-weather operations, did not usurp entire quarterly allocations before the smaller inshore vessels had a chance. Vessel-class catch allocations were then adopted, shifting management objectives once again to include social considerations: preservation of traditional day-trip fishing in small boats.

It is interesting that this evolution of at least implied objectives in the Groundfish Management Plan paralleled the general evolution of fisheries management objectives since the 1930s. At that time, when the first usable management models were developed, the accepted objectives were distinctly biological. Later, in the late 1950s and 1960s, economic objectives attained brief preeminence, to be followed rather quickly by optimum yield, which attempted to accommodate quite broad social and other quasi-definable considerations.



Cod *(Gadus callarias)*

And so it went in New England in 1977: soon after adopting a purely biological objective, with its very restrictive catch quotas, the NEFMC inevitably was forced to deal with economic and social considerations. Whereas the original biological objective was comprehensible and enforceable (even if at great cost), the subsequent modifications, forced by political, economic, and social considerations, were so vague and arbitrary, had so many unforeseen and undesirable consequences, and carried so little public understanding and support as to be virtually unenforceable. This problem of credibility was strained even more by the unanticipated appearance of strong year-classes of regulated species concurrent with the imposition of uniquely restrictive regulations on the New England groundfishing fleet, consisting of more than 1,000 vessels. Further, the rather subjective, implicit, and arbitrary nature of the evolving objectives left the NEFMC uncertain as to its own purposes and thus vulnerable to political pressures of all kinds. Without clear objectives, there is no way to measure the success or failure of a plan.

The result of this unsatisfactory and counterproductive situation was that in April, 1982, upon council recommendation and urging, the Secretary of Commerce scrapped the entire groundfish plan, replacing it with a much simpler plan of the council's devising. The new plan essentially involves only mesh regulations to allow juvenile escapement and closed areas to protect concentrations of spawning fish, principally haddock. This plan is a "fall-back" position, recognizing that the more ambitious effort failed and that in the process of failing, created many serious difficulties. These difficulties included the mislabeling and misreporting of catches; the discarding of excess catches at sea; the landing of excess catches at more than one port to avoid trip

New England fishermen prepare to sort the various species of groundfish trapped at the end of a conical net called a trawl. (Photo by Richard Allen)

limits; the setting of dual prices for legal and illegal catches (legal-catch prices being pulled down by the market impact of lower "illegal" prices); and the serious deterioration of the quality of landings data in general, upon which scientific stock assessments are heavily dependent.

The new system, which is partly intended to avoid such problems, is generally recognized as providing acceptable, if minimal, stock protection. It does not attempt to avert a stock collapse, nor does it attempt to attain "optimum yield" in any positive sense, except insofar as optimum yield is considered to be that catch actually taken under the prevailing minimal rules.

Unloading pollock at the Boston Fish Pier. (Photo by Susan Peterson — WHOI)

A lesson from the New England experience is that fisheries management is not as easy as it looks. Granted that stocks are to be "restored and maintained," that "overfishing" is to be prevented, and that "optimum yield" is the goal, the practical difficulties of complying with these rather vague and general directives, particularly in mixed-species fisheries, are clear only to those who have tried. The first difficulty is to attain common agreement on what these terms mean, with sufficient precision so as to provide a base for regulatory action. To what *level* of abundance shall stocks be restored? And at what *rate*? With what *degree* of stability shall stocks be maintained? At what *point* are stocks "overfished"? And what are the regulatory costs associated with the answers to these questions? The answers to these quantitative questions are of practical importance because they govern the nature of regulations necessary to implement a plan, and thus determine how the plan will be received by the fishing industry. It was the failure to ask or even to recognize the importance of these questions that, in great degree, led to the failure of the New England groundfish plan.

Soul-Searching

Fisheries policymakers are at the moment in a state of soul-searching, or should be. Now that fishery management is mandated by law and the nation spends hundreds of millions of dollars annually on management-related activities, the managers are faced with the key question — management for what end? Or — more difficult — management for whom? Frequently the issue becomes one of allocation among competing users, and managers must be prepared to answer these questions with sufficient specificity to satisfy the concerns of those who will be directly affected by the necessary regulations.

The task of identifying and acting upon positive management policies, in the spirit of attaining a form of optimum yield as put forth in the MFCMA, will be a very substantial challenge for the regional fishery management councils. I suspect that it will be a long time before this issue is adequately addressed, and even longer before it is adequately mastered. Until it is, there will be continuing acrimony and dissatisfaction.

In the meantime, there remains the acute need to understand what the stocks and the fishery system are likely to do given environmental changes, increasing fishing pressure, and the probable absence of effective restraint on effort. Managers need assessments of current stock sizes and early-warning devices to apprise them of probable future stock variations, for use both before and after the implementation of management programs. The facts that fish species have characteristically different responses to fishing effort and are characteristically more or less amenable to conventional management methods should strongly influence management policies for several reasons: to avoid excessive management restraints and costs that may be inappropriate for some species; to insure that management efforts are directed to those species particularly vulnerable to fishing effort; and, most important, to understand the probable impacts of cumulative fishing pressures throughout the system of which the fish are part. Such impacts include the possibilities of "species-switches," the replacement of high-value commercial species with low-value "weed" species; increased frequencies and amplitudes of abundance variations of some species; and prolonged reduction of those species particularly sensitive to fishing effort.

The need for such an ecosystem approach was summarized by the National Academy of Sciences in 1980, but recognition of the probable fact of systems interactions and systems responses to fishing pressure is slow in coming to those who set fisheries policy. The fact seems to be that in fully developed fisheries and under intense fishing pressures there can be unforeseen and undesirable consequences of management actions taken in isolation and without regard to systems interactions. For example, the current management regime in New England — an area of fully developed or overdeveloped fisheries — may be contributing to destabilization of the stocks and to exacerbation of stock fluctuations.

This viewpoint arises from the fact that groundfish are now essentially unregulated, or minimally so. This is a potentially destabilizing arrangement because of certain energy-hierarchy concepts articulated by Howard Odum of the University of Florida (see below). Assuming, in accord with those concepts, that herring represent a lower quality of embodied energy than do groundfish (individually or collectively), such concepts predict that unrestrained power input from the higher-quality energy end of the spectrum (the fishing effort) imparts oscillations of increasing amplitude through the progressively lower-order energy components of the system. The apparent

Odum's Energy-Hierarchy Concept

The energy-hierarchy concept is an extension of familiar predator-prey or, more formally, trophic-dynamic ideas. It includes the idea that fish, and indeed all marine organisms, exist at different energy levels in the ecosystem; that species "embody" energy from their prey at underlying levels and thereby acquire higher value.

Haddock, for example, being a carnivore high on the food chain, embodies the energy of its many prey species and of their prey species. As a high-value species, it attracts intense fishing effort. Because of differing levels of "embodied" energy, the organisms at various levels in the hierarchy exhibit differing degrees of predictability or stability, with characteristic responses to natural environmental variations or to fishing pressure.

Oscillations within the system thus may be caused either by natural environmental perturbations or by fishing effort. Natural perturbations, as a rule, enter the system at the "lower" end of the hierarchy via those species especially vulnerable to such disturbances, such as plankton. The oscillations tend to be damped as they progress upward through the hierarchy toward those species of higher embodied energy.

Fishing effort, by contrast, typically introduces perturbations at the "higher" end of the hierarchy — on the high-value species, such as haddock. The energy-hierarchy concept predicts that such effort may cause disturbances that travel toward the lower levels, in a direction opposite to that of natural perturbations. And the concept predicts — most importantly — that these perturbations are not damped as they progress through the various levels of the energy hierarchy, but, in fact, are amplified, thus tending to destabilize the system.

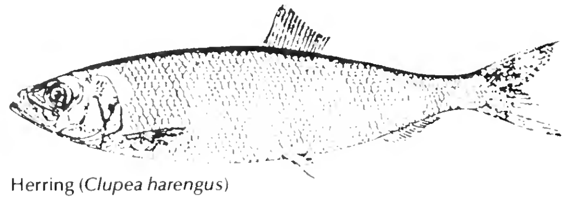
Thus unrestrained fishing effort on high-value species may destabilize other fisheries within the system, leading to greater uncertainty and increasingly difficult management problems. An understanding of how the system works as a whole can suggest critical pressure points, where management could be applied to minimize problems elsewhere in the system.

irony of applying this concept is that those species that are most attractive and vulnerable to fishing (and therefore most appropriate for management constraints) are the most difficult to manage in conventional ways because they typically occur in mixed-species trawl fisheries and multi-species aggregations. In contrast, those species that are most amenable to conventional management because they occur as pelagic schooling fish in single-species aggregations (herring, mackerel, or squid, for example) are in less need of management because they are inherently more variable and have less impact on other components of the system. Thus, largely from consideration of expedience, conventional management restraints may be applied in counterproductive ways that tend to destabilize the system. If this is correct, the current management arrangement in New England, encompassing the principal landed species, clearly holds the potential for inducing species oscillations of a surprising and destabilizing character.

The Aggregate Approach

From the inevitable, though long-overdue, serious study of the fisheries systems, there may emerge useful clues to guide the future development of effective fisheries policy. As Lloyd Dickie of the Marine Ecology Laboratory in Dartmouth, Nova Scotia, has noted, systems tend to have more stable output than do their individual components. Given the apparent inseparability of various components of, for example, the mixed-species trawl fishery system (not forgetting that fishermen are a part of the system), more attention is being given to the possibility of aggregate "biomass" management. The

Estimating fish populations the hard way.



Herring (*Clupea harengus*)

feasibility of realizing stable aggregate biomass output appears to be much greater than that of managing any single component species for MSY, as perhaps is reflected in the highly-adaptive harvesting strategies of fishermen, shifting from species to species as they are available. Dickie maintains, " . . . . the ability of fishermen to choose among alternative activities may be the dominant force translating variable individual species catches into stable overall output."

Probably, regardless of whatever other ends are desired from fisheries management, all would agree that stable aggregate production is desirable; thus any management policy should maintain the maximum flexibility in fishermen's ability to harvest fish. Unfortunately, most conventional management techniques reduce flexibility. An unsolved problem is that of insuring that the harvesting shall not focus on the high-value-species components of the system — yellowtail flounder, for example — thus leaving lower-valued species (Odum's species of lower-embodied energy) to dominate the ecosystem.

As these issues of effective fisheries management are examined under the imperatives of MFCMA and the increasing exploitation of finite resources, some fundamental principles assume great practical significance for policy determinations. As experience accumulates under the mandate of fisheries management, and as more careful thought is given to the purposes and methods of constructive management, several seemingly inherent contradictions emerge. These are both implicit and explicit in the foregoing discussion. They include the following:

> *1) While the legally mandated public hearing process of implementing fisheries policy forces managers to be rather precise in their statement of management objectives, there is a serious question whether such precision in fact works against successful management. John Gulland of the United Nations Food and Agricultural Organization observed that " . . . hope to define in this way [precisely] the Holy Grail of fishery conservation is in vain, and . . . it is impossible to define a 'best' fishery policy because what is 'best' will vary from time to time. . . . the stricter the definition made at the present, the more likely it is this definition will make it difficult to pursue some objective that later becomes apparent . . . . " The paradox is obvious: an enforceable regulation requires considerable precision in the statement of objectives or policy, but such precision precludes options for the future and adjustment for those options in a timely fashion.*

Restacking a seine aboard the Independence, *a tuna seiner based in San Diego, California. (Photo by William High — NOAA)*

2) Though we wish to preserve fishermen's harvesting options and fishing flexibility, most conventional management techniques are essentially restrictive. A closed season for haddock, for example, is unavoidably a closed season for all other species in the area of closure.

3) The other problem with a policy of flexibility is the implication that fishing effort will then be directed at the high-value species, those that are inherently difficult to manage but which are priority candidates for management because of their vulnerability to fishing and because of the consequences for destabilization through the rest of the system in the absence of management.

4) Finally, there is the contradiction of trying to reconcile the positive, upbeat note conveyed by the idea of "optimum yield" as the mandated objective of fisheries management with the probably more realistic, though negative-sounding, management objectives of preventing stock collapse and excess catching capacity (Gulland, 1978).

Whether a particular fishery is carried on by a homogenous group of fishermen concentrating on a single species or shows the diversity of species and harvestors that most do, it is part of a larger system and thus contributes to and is affected by perturbations that ripple through that system. A large, seemingly unmanageable, number of questions appeared in this article. That is partly because we have been in the habit of approaching each species as a separate management issue, each complicated by the diversity of fishermen dependent upon it.

Prescription for Progress

Real progress in effective management will come when several things happen. First is the recognition that a focus on single species is inadequate; that striving solely for MSY is unproductive. Second is the realization that not all fish are created equal; that fish behave differently and react differently to the pressures in the system. Third is that different objectives, or at least different management techniques, are appropriate for different species.

There will be the possibility of real progress when managers recognize that fisheries exist as part of a comprehensible system and make the commitment to *systems* management based on the workings of the system as a whole. Science at the moment probably cannot supply us with a full understanding of the workings of any fisheries system. This is primarily for lack of attention to the problem; the scientists will undoubtedly deliver when the managers ask systematic, rather than species-specific, questions. But there probably are a number of useful suggestions that are now available from our present partial understanding of how systems work. We already know, for instance, that certain species like ocean perch, cusk, and dogfish (no longer "trash fish" in today's society) are highly vulnerable to fishing pressure and are prime

Small boats rigged for longline salmon fishing, moored at Shelter Cove, in northern California. (Photo by Jack White — California Department of Fish and Game)

candidates for careful management. Likewise, we know that other species like menhaden or herring are inherently variable and therefore not logical candidates for the sort of management suitable for ocean perch or cusk or dogfish.

It is safe to predict in a qualitative way, based on existing understanding, that as heavy fishing pressure continues across a large number of species, as on Georges Bank off the coast of New England, surprising and disturbing fluctuations in fish abundance will occur. Managers should expect increasing uncertainty in the systems under their jurisdictions as long as single species management prevails. The managers must take these probabilities into account, and can do so if they avail themselves of existing information. Progress can be made, without waiting for full understanding, if we allow ourselves to be guided by useful, if incomplete, information on how systems work. But the first step is acknowledgment that a fish cannot be managed in isolation.

Spencer Apollonio is Commissioner of Maine's Department of Marine Resources and as such is an ex officio member of the New England Fishery Management Council. He was the council's first Executive Director (1976–1978).

References

ACMRR Working Party on the Scientific Basis of Determining Management Measures. 1979. Interim report of the ACMRR working party on the scientific basis of determining management measures. *FAO Fish. Circ.*, 718, 112 pp. Rome: United Nations Food and Agriculture Organization.

Adams, P. B. 1980. Life history patterns in marine fishes and their consequences for fisheries management. Fish. Bull. 78: 1–12.

Bevan, D., and D. L. Alverson. 1980. The function of optimum yield under the Fishery Conservation and Management Act of 1976. Office of Technical Assessment Workshop.

Dickie, C. M. 1979. Perspective on fisheries biology and implications for management. *J. Fish. Res. Bd. Canada* 36: 838–844.

Gulland, J. A. 1977. Goals and objectives of fishery management. FAO Fisheries Technical Paper No. 166, FIRS/T166, 14 pp. Rome: United Nations Food and Agricultural Organization.

———. 1978. Fishery management: new strategies for new conditions. Trans. Amer. Fish. Soc. 107: 1–11.

Larkin, P. A. 1977. An epitaph for the concept of maximum sustainable yield. Trans. Amer. Fish. Soc. 106: 1–11.

———. 1980. Objectives of management. Chapter 11, pp. 245–262. In *Fisheries Management*, ed. R. I. Lackey and L. A. Nelson. New York, N.Y.: John Wiley and Sons.

Nielsen, L. A. 1976. The evolution of fisheries management philosophy. Mar. Fish Dev. 38(12): 15–23.

Ocean Sciences Board (ad hoc group). 1980. Fisheries ecology — some constraints that impede advances in our understanding, 16 pp. Washington, D.C.: National Research Council, National Academy of Sciences.

Odum, H. T. 1982. Pulsing, power and hierarchy. Chapter 3, pp. 33–59. In *Energetics and Systems*, ed. W. J. Mitsch, *et al*. Ann Arbor, Mich.: Ann Arbor Science Publications.

Ocean Dumping

by John W. Farrington, Judith M. Capuzzo, Thomas M. Leschine, and Michael A. Champ

Simplicity is the most deceitful mistress that ever betrayed man.

Henry Brooks Adams
[1838-1918]

This statement summarizes the past situation in regard to ocean dumping. The oceans have immense volume. They are dynamic and have powerful dispersal forces. A simple extrapolation of these facts has appealed historically to those segments of society searching for a means of waste disposal. The dilution and dispersal forces at work in the oceans, coupled with a capacity to degrade or deteriorate many materials, seems to point to the ocean for waste disposal with few accompanying adverse effects. The attractiveness of this idea is illustrated by recent compilations of major ocean dumping locations and total amounts dumped over the period 1976-1979 (Figures 1 and 2).

The contentious issues of ocean dumping revolve around the question: what is the capacity of the ocean for receiving wastes without adverse effects? Logically, the answer to that question depends on the composition of the waste, the proposed disposal site, the duration of the disposal, and the definition of an adverse effect. Within that context, we seek to review briefly the history of ocean dumping in the United States and make some recommendations for the future.

EDITOR'S NOTE: This article was originally scheduled to be written by Buck Ketchum, an authority on coastal processes and ocean dumping. He was at mid-point in writing a first draft when he died this past summer. It is some measure of the man that it took four colleagues to fill his wading boots.

Why Was Ocean Dumping Restricted?

In the decade of the 1960s and into the early 1970s, research clearly demonstrated that man-made toxic

Nine sewerage authorities in the New York City area have been dumping sewage sludge into the Atlantic Ocean since the 1920s at a site 12 miles equidistant from New York and New Jersey beaches. Here a tug guides a barge full of sludge out to the site. The tug and barge keep moving during the discharge in order to disperse the waste. Some authorities use self-propelled tankers. (EPA photo)

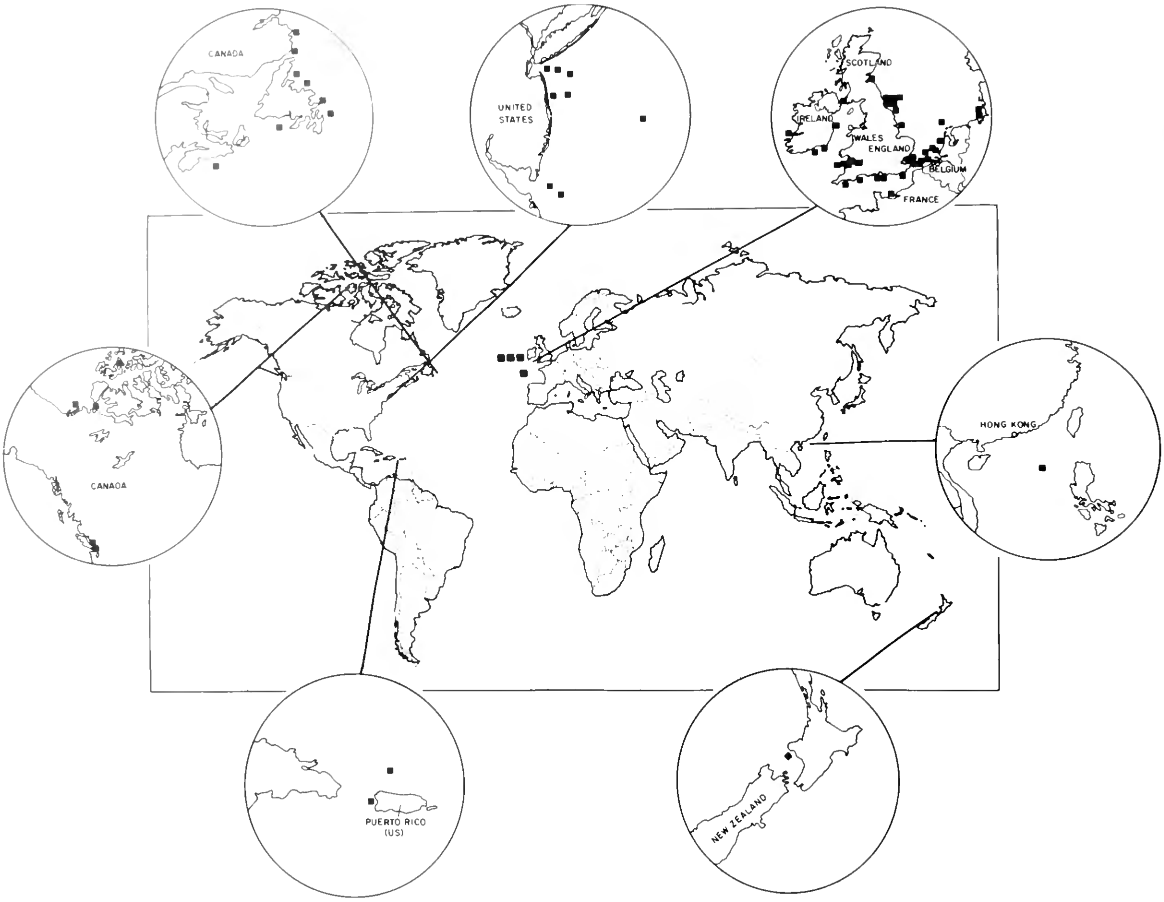


Figure 1. Ocean dumpsites in 1979 used by parties to the London Dumping Convention. (Courtesy of I. W. Duedall, et al., 1983 in press)

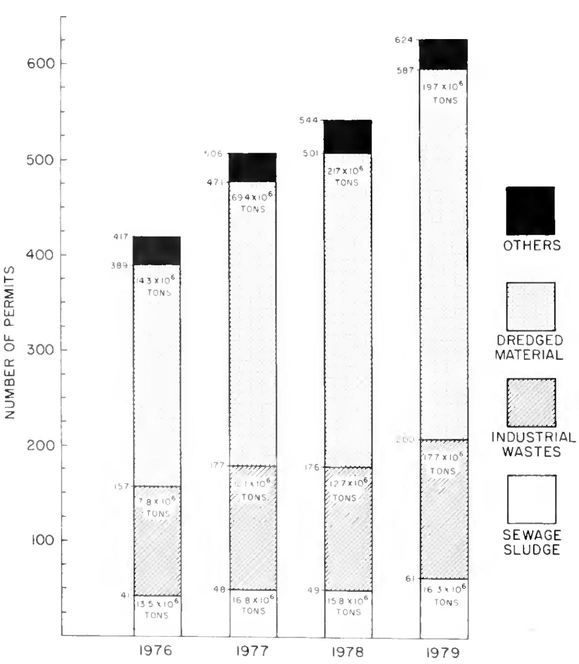


Figure 2. The total number of permits issued and estimated tonnages (in metric tons), on a global basis, for the disposal of wastes in the sea. The tonnages for the "others" category are not given because of insufficient data. (Courtesy of I. W. Duedall, et al., 1983 in press)

wastes could be detected in the farthest and deepest reaches of the oceans. The quantities detected were very small: 10^{-6} to 10^{-12} grams per gram of marine organism tissue or oceanic sediment. However, the chemicals detected, such as DDT, PCB, and the radioactive fallout from nuclear weapons tests, had been in use only 10 to 40 years. Given the vastness of the oceans, the rapid invasion by even trace quantities of these chemicals was viewed with concern by several scientists, because laboratory experiments and field observations in near-shore areas had demonstrated real or potential toxic effects across a wide variety of marine biota. The pathways of entry and movement of wastes through oceanic ecosystems are illustrated in Figure 3.

Concurrently, there were a few incidents of toxic chemicals entering the coastal areas of the oceans and becoming a health hazard to man. For example, in Minamata Bay, Japan, mercury in a chemical plant's effluent entered the bay in sufficient

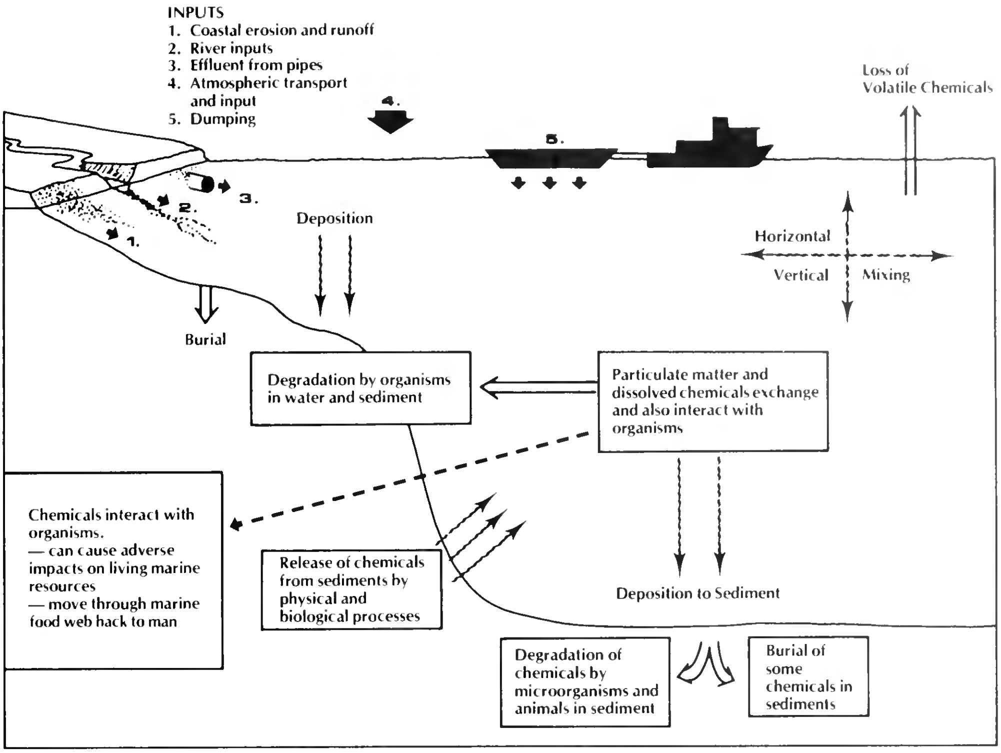


Figure 3. The pathways of entry and movement for wastes in oceanic ecosystems.

quantities to pollute shellfish and fish to the extent that many people who ate these organisms became seriously ill, or died. (See *Oceanus,* Vol. 24, No. 1, p. 34).

A second example, not as tragic, involved contamination of fish by polychlorinated biphenyls (PCBs). These organic chemicals, whose production and distribution was banned in the 1970s, were used in electronic components, such as capacitors and transformers, mainly since the 1950s. They leaked into the environment in a variety of ways and eventually entered the oceans. Fish caught in some coastal areas contained high enough concentrations of PCBs, in a few cases, to cause a significant number of reproductive failures when fed to minks over a period of time. Although obviously there are wide differences between minks and people, the fact that both species are mammals understandably caused concern about the release of PCBs to the environment and subsequent adverse effects on humans. Other more extensive evidence eventually led to a ban on production of PCBs in several countries and restrictions on PCB use in others.

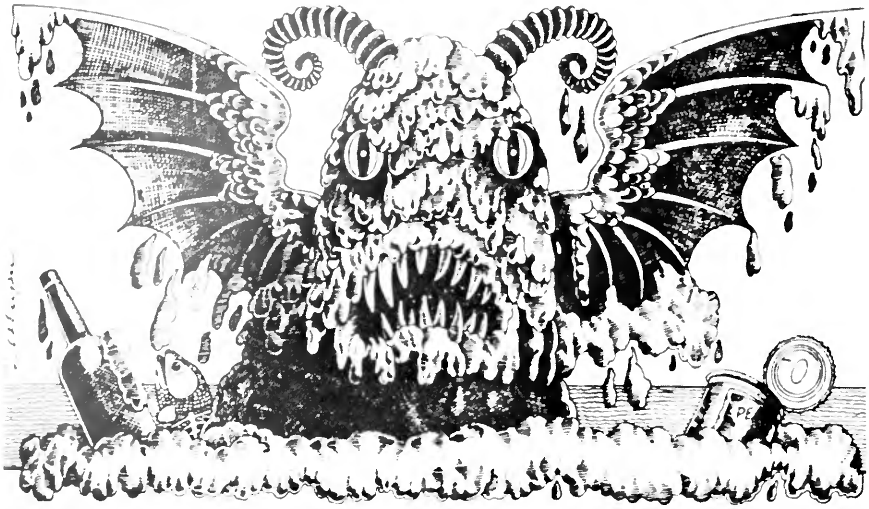
There were several additional incidents that led to increased concern about ocean pollution. Of course, there also were numerous examples of disposal of wastes in the ocean for which no threat to man nor overt adverse impacts were noted; however, the few documented adverse impacts served as warnings of problems in the future. The fact that some bodies of water smaller than oceans had serious problems (the Thames River in Britain, the Houston Ship Channel, and Lake Erie, to name a few) bolstered the arguments for caution against waste disposal in the ocean. For some, the cries of "polluted lakes today, the North Atlantic tomorrow" or "the oceans are dying" were simple extrapolations. The combination of a few concerned scientists and environmentalists, a larger body of concerned citizens, and concerned elected and appointed officials was sufficient to begin the process of regulating and limiting waste discharge in the oceans.

New laws were passed by the U.S. Congress, and rules and regulations were promulgated and implemented. These laws built upon earlier marine pollution control laws dating back to the Rivers and Harbors Act of 1899.

Retreat from a Ban on Ocean Dumping?

In the 1976 to 1978 period, a few engineers and scientists began to realize that, while marine scientists were pointing to the real and potential effects of ocean disposal of urban sewage sludge, among other materials, other engineers and scientists dealing with the pollution of rivers, lakes, and groundwater were successfully advocating construction of advanced sewage treatment facilities. However, no one had planned adequately for the disposal of the new sludge.

In 1977, Congress adopted a 1981 statutory phase-out deadline for sewage sludge that might cause unreasonable degradation of the marine environment. This placed New York City, in particular, on the horns of a dilemma. Where could New Yorkers dispose of the sludge they had been



This cartoon of a "sludge monster" coming ashore is one expression of public concern over the dumping of sewage sludge in the New York Bight. It appeared in a Long Island, New York, newspaper in the mid-1970s. (Gary Viskupic — Newsday*)*

dumping in the New York Bight? As the 1981 deadline approached and economically reasonable alternatives for New York's sludge disposal were not at hand, there was considerable socio-economic and political pressure to re-examine the ban on ocean dumping. Several court cases evolved in regard to New York City's sewage sludge disposal in the New York Bight and the criteria by which sludge could be judged as acceptable or not acceptable for disposal at a given site in the ocean.

During this same period, the United States citizenry was awakened to the seemingly more immediate problem of festering hazardous waste disposal sites on land. We cannot recount here the many examples, such as Love Canal. It suffices to state that the problems with land disposal made it seem ludicrous to ban unequivocably ocean dumping.

In July of 1979, a group of scientists, engineers, and a few observers met at Crystal Mountain, Washington, to re-examine the issue of waste disposal in the oceans. After lively debate and agonizing writing and rewriting, a report, "Proceedings of a Workshop on Assimilative Capacity of U.S. Coastal Waters for Pollutants," was issued. Although there were many important cautionary statements and caveats in the report, the principal message was that in certain circumstances the oceans probably could be used as receivers of waste without undue harm to the oceans or to man. At the very least, said the group, the issue should be examined in context with the other alternatives for waste disposal. The National Advisory Committee on Oceans and Atmospheres (NACOA) reached a similar conclusion two years later after again examining the issues.

Testimony during May, June, September, and November of 1981, and in March of 1982 before the House Subcommittee on Oceanography, the Subcommittee on Fisheries and Wildlife Conservation and the Environment, and the Committee on Merchant Marine and Fisheries addressed the contentious issue of waste dumping. John A. Knauss, Acting Chairman of NACOA, summarized the problem in his testimony, which identified a legislative crisis in regulating the disposal of wastes:

> *Five federal statutes affect the management of society's waste material. They are: Federal Water Pollution Control Act (FWPCA, often referred to as the Clean Water Act); Marine Protection Research and Sanctuaries Act (MPRSA, often referred to as the Ocean Dumping Act); Safe Drinking Water Act (SDWA); Resource Conservation and Recovery Act (RCRA); and the Clean Air Act. It was impossible to implement all five statutes simultaneously and as a result the implementation of each shifted the burden of receiving society's waste products to the medium that was least regulated at the moment. An industry or municipality faced with the problems of what to do with its waste may well find that the Clean Air Act effectively prohibits incineration, the FWPCA and the Ocean Dumping Act similarly limit disposal at sea, and the RCRA and the SDWA effectively prohibit land disposal or deep-well injection. Based on our review of this history and the statutes, NACOA is concerned that this medium-by-medium approach has produced groups of regulations whose primary objective is to protect a particular medium from its use as a waste disposal medium without any regard for the impact of these regulations on other media.*

The problem to which Knauss referred is illustrated in Figure 4, taken from a NACOA report to the President and the Congress.

The Present Situation

Most of the concern about ocean dumping and ocean sewer outfalls is derived from the presence of toxic chemicals, viruses, and pathogenic bacteria in much of the waste discharged to the ocean. Viruses and pathogenic bacteria enter sludge in sewage treatment plants as a result of processing human and animal wastes. Known or potentially toxic, mutagenic, or carcinogenic chemicals, such as PCBs and

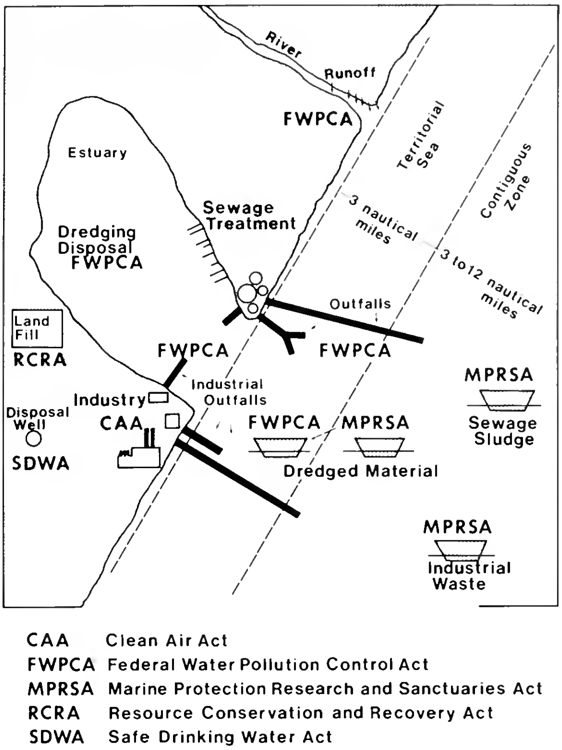


Figure 4. The jurisdictional boundaries of key environmental laws. (From NACOA, 1981)

chlorinated pesticides (DDT and chlordane, for example) can enter sludge as a result of rain washing material from the atmosphere or by dust falling from the atmosphere to city streets. The chemicals are then transported to and through sewers by rainwater runoff. Factories add still more toxic chemicals directly into municipal sewer systems. In older East Coast cities, such as New York, the problem is compounded by combined storm and sanitary sewer systems which convey normal rainfall to sewage treatment plants and also flush some untreated sewage directly into nearby ocean waters when there is an overflow.

Sewage sludge is mostly the remains of solid wastes and a mass of bacteria that has been degrading some organic products from human and industrial wastes. In simple terms, the sludge sewage treatment process is a larger, more sophisticated version of a backyard septic system. As with septic systems, bacteria in the plant periodically need refurbishing. The old bacterial mass is removed. Along with this mass of bacteria, there are recalcitrant chemicals, such as PCBs, many chlorinated pesticides, and some petrochemicals, that are difficult to break apart or degrade biologically. Many of these chemicals are not very soluble in water and are adsorbed onto the surfaces of bacteria during the treatment processes. Other chemicals interact with the sludge in chemical reactions, which results in their removal from the sewage as it passes through the treatment plant. The net result is sludge containing elevated concentrations of toxic chemicals.

Environmental concern with sludge disposal is focused on 1) the accumulation and transfer of these toxic chemicals in marine food chains, 2) the toxic effects of such chemicals on survival and reproduction of marine organisms, and 3) the uptake and accumulation of pathogenic bacteria and viruses in commercially harvested species destined for human consumption.

Dredging spoils from urban harbors, rivers, and estuarine areas often contain elevated concentrations of pollutant chemicals because of industrial and municipal sewer discharges to these areas and runoff from land carrying the fallout from urban air pollution. The pollutant chemicals are present in elevated concentrations in both sludge and dredged harbor sediments as the result of the initial attempt to release the chemicals to the environment for dilution to innocuous concentrations.

Chemical wastes from industrial chemical operations also are dumped at sea and are candidates for increased ocean dumping in the future. Again, the problems revolve around the toxic portion of the waste, which is often a very small part of the total mass of material.

Aside from the greater concern about toxic chemicals and pathogens, there are still concerns about arbitrarily releasing degradable organic matter and nutrients to the ocean. If these substances are discharged in high enough amounts to some oceanic areas of poor dispersion and mixing energy, then depletion of oxygen in the area as a result of so much microbial degradation of organic matter may become a threat to some species of commercial importance. Eutrophication of coastal areas from nutrient enrichment may result in changes, both in the types

To determine the environmental effects of sludge dumping, biological samples from the New York Bight are analyzed by the National Marine Fisheries Service in Sandy Hook, N.J. (Photo courtesy of NOAA) of species that live in a given area and in the dynamics of marine food chains, with consequent loss of commercial resources. For example, during the summer of 1976, poor water circulation and high nutrient inputs to the inner continental shelf off northern New Jersey resulted in a bloom of the dinoflagellate *Ceratium tripos* off the New Jersey coast. This species of algae is rarely used as a food source by zooplankton; thus, a great deal of organic matter not utilized by marine food webs was left to decompose. This resulted in a high rate of oxygen consumption by bacteria decomposing this organic matter (the dead algae), creating hypoxic, or low-oxygen, conditions in near-bottom waters and on the ocean floor. These adverse conditions caused mass mortality of fish and shellfish and commercial losses.

On the other hand, it may be possible, under certain controlled-release conditions, to stimulate the biological productivity of an area and increase the yield of valuable seafood. For the majority of the cases, we suspect that the disposal process itself will be of sufficient social or economic benefit so as not to warrant the extra effort required to demonstrably increase a yield of seafood. The emphasis is now (and will be for several years) on preventing adverse effects, which carry with them social and economic costs.

Waste Management Strategies

The give and take of the Congressional hearings on ocean dumping during 1981 and early 1982 illustrates that we are in a critical period of transition from a regulatory stance that was approaching a ban on ocean dumping to . . . what? The scientific, engineering, and political debates are intense (see *Oceanus*, Vol. 24, No. 1). Policy-makers who govern regulatory actions may be about to embark on a more rational course, toward multi-media (air, land, sea) assessment prior to decisions about where to dump or discharge wastes in the future, though many important issues remain and may require a decade to be resolved.

There are five general waste management strategies, with several options within each category. The costs and benefits of each option should be evaluated and should enter into the decision on how each type of waste is managed. This appears to be a rational and straightforward approach. It *is* rational. However, it is *not* straightforward, because much of the knowledge required to make meaningful cost-benefit comparisons is not available.

Reducing and Recycling Waste

The Global 2000 Report prepared for President Jimmy Carter provided a sobering look to the future. A growing shortage of materials of various types will occur as we proceed toward the year 2000. Thus, we expect that incentives to conserve will increase. There is a growing movement already in the United States toward recycling in local neighborhoods and communities, encouraged nationwide by some manufacturers. The recent documentation of reduced energy utilization, and thereby reduced fossil fuel consumption, may be a further indication of such a trend. We think these are indications that society can adjust its life-style in a relatively short time.

During the 1970s, the production of several toxic chemicals was reduced. The restricted use of DDT and a few other chlorinated pesticides, and the ban on PCB production in the United States, followed a few decades or less after scientific evidence emerged suggesting these chemicals caused environmental damage. Perhaps the alternatives were less effective and more costly, but the important point is that adjustments have been made. Thus, if the evidence is compelling and if the environmental damage is extensive enough or potentially extensive or, more importantly, if human health is at risk, then action can be taken and generation of toxic wastes can be reduced.

Glass at a neighborhood recycling center. Could the awareness that recycling is necessary be expanded someday to prevent the fouling of the oceans? (Photo by Elinor S. Beckwith — PR)

Ideally, the removal of many toxic chemicals from sewage sludge could be achieved by keeping the material out of sewers in the first place. Controls on industrial effluent releases to municipal systems have been in force or proposed for several years. The 1977 amendments to the Clean Water Act require that communities seeking waivers from wastewater secondary treatment requirements develop programs by which their most toxic industrial wastes are removed from municipal wastewater. There is debate about the application and expense of new technologies to reduce industrial chemical releases. Some people argue that the costs to consumers or loss of jobs in a given region make the application of effluent controls untenable. Certain toxic chemical inputs to sewers will be decreased in the 1980s, but there will still be enough industrial effluent input to significantly contaminate many urban sludges.

Another problem of equal or greater significance is the fact that many chemicals of concern enter sewers via dispersive release to the environment or because they are already used extensively by society. Two examples illustrate this. Some polynuclear aromatic hydrocarbons are known mutagens and carcinogens. These compounds enter sewers as a result of chronic dribbling of oil from industrial operations and automobile crankcases. They also are released to the atmosphere during combustion of fossil fuels and deposited on the ground by dry fallout or by rain, and then washed into sewers.

The second example concerns PCBs. Even though they are no longer produced in the United States, a significant amount of PCBs are still in use. Burning of PCB-containing electrical components in municipal incinerators or leakage from electrical components in use releases PCBs to the environment. A portion of this release is collected in sewers via atmosphere deposition and runoff. Thus we cannot look to controls on effluent releases from industrial plants to completely solve the problem of toxic chemicals in sludge.

Furthermore, a significant problem with waste disposal in the oceans is related to contaminated sediments from dredging operations near urban areas. This is a problem of relocating toxic chemicals already released to the environment. As indicated in Figure 2, dredged material is a major ocean dumping input to the ocean. The 7 to 10 million cubic yards of material dredged annually from New York Harbor is sufficient to cover the borough of Manhattan six inches deep. At present, the proportion of dredged material worldwide that contains concentrations of chemicals of concern is not known, but most dredge spoils from industrialized harbors are heavily contaminated.

Incineration of Waste

There is a growing conviction among scientists, engineers, and officials of regulatory agencies that high-temperature, high-efficiency combustion offers the best means of disposing of certain very hazardous chemical wastes. The Environmental Protection Agency (EPA) has allowed several test burnings of chlorinated organic chemical wastes at sea where the basic chemical nature of seawater rapidly neutralizes the hydrochloric acid that is the main combustion product of concern. Burning such wastes on land requires difficult and potentially expensive controls on the release of this acid to prevent adverse effects on nearby structures, plants, animals, and people.

Incineration at sea. Here the Vulcanus, *a specially designed disposal tanker, burns polychlorinated biphenyls (PCBs) in the Gulf of Mexico. With the incinerators set at 1,350 degrees Celsius, PCBs break down into hydrochloric acid and water, which forms a vapor that precipitates into the water behind the ship. The PCBs were drained from spent or recalled transformers and other electrical components. (Photo courtesy of Waste Management, Inc.)*

It appears that the incineration method could be extended to sediments polluted with high concentrations of toxic organic chemicals, using specially designed rotary kilns on ships. However, this technology is only in the early prototype stage.

The main concerns about adverse effects associated with this treatment strategy are 1) ensuring continued high efficiency of operation; 2) preventing accidental spills of material during collection, storage, loading, and transit at sea; and 3) the cost of the fuel necessary to achieve the required temperatures. Current forecasts indicate that this strategy will be economical and of best use to society when applied to low volumes of highly toxic materials.

Disposal on Land

Most of the sewage sludge currently generated for disposal in the United States is disposed of on land. Less than 15 percent is released in the oceans by ocean dumping or by ocean outfalls. Nevertheless, the difficulty of allocating sufficient land for landfill disposal operations, spray irrigation, or land spreading of composted sludge material is a major obstacle to the land disposal option, especially near urban areas where land is more expensive and more wastes are generated. The second problem with land disposal is the protection of public health. Contaminated groundwater and polluted air plague some land disposal sites, and thus are of potential concern for all sites.

Spreading of composted sewage sludge on agricultural lands or spraying treated sewage in forests has been researched and is in use in several inland locations, particularly in the Midwest. However, public health concerns related to the presence of pollutant chemicals and pathogens have prevented more widespread use. Also, suitable agricultural lands and forests are not always within easy reach of urban areas, where the bulk of waste is generated, especially in coastal areas. Thus the costs of transportation and land discourage the use of this option.

In the United States, many cities are near the ocean. A recent EPA study estimated that 25 percent of all sludge generated for disposal comes from counties that border the ocean. The costs of using an area of ocean for disposal are not appreciable at present, compared to the costs of land near urban areas. Thus, ocean disposal has continued appeal; it releases land for other uses.

Disposal in the Ocean

There are two basic man-made modes for delivery of wastes to the oceans: pipes and ships (or barges). The engineering aspects of each are not germane to this discussion. However, there are some fundamental decisions that need to be made as to the mode used and the location of the release.

The two most prevalent scenarios (simplified here) of ocean disposal are near-shore disposal and deep ocean (far away from land) disposal.

Near-shore disposal. The arguments in favor of this disposal scenario are:

Recoverability. If a mistake is made in estimating the severity of adverse effects, then it should be technologically easier to recover the wastes for alternate treatment or disposal than if the material had been disposed in the deep ocean. This argument presumes that the disposal area is a low-energy environment — an area where mixing and turbulence by waves, currents, and storms will not significantly disperse the material.

Impact could be restricted in area. Again, if a low-energy environment is used, then it might be possible to sacrifice a small area of extreme adverse impact in order to minimize effects elsewhere. This is the near-shore equivalent of the landfill disposal option.

Impact could be minimized by dispersal in a high-energy mixing area. The argument here is that tidal and wind-driven currents, storms, and wave-induced turbulence, prevalent in some coastal areas, provide the extensive mixing needed for initial dispersion and dilution.

Research monitoring and management of waste. It is easier and less expensive to conduct research and monitoring to verify predicted adverse effects and discover whether unsuspected, unwanted adverse impacts are about to occur, or have occurred. This presumes our knowledge about coastal and estuarine processes is more advanced than for the open ocean and that it is easier to monitor and conduct research in coastal areas.

Economic. Near-shore disposal is cheaper, often by a factor of three or more, than deep ocean disposal. More importantly, at a time when costs for all types of disposal are increasing rapidly, near-shore disposal is frequently much less expensive than any other disposal alternative for coastal communities. According to one wastewater treatment estimate, sludge handling, transportation, and disposal now account for 35 percent of capital costs and 55 percent of annual operation and maintenance costs. Table 1 compares some current cost estimates of sludge disposal by various means.

The disadvantages of near-shore disposal are:

Proximity to people. Disposal sites are close to land and population centers. If an adverse impact is discovered, there will be less time to protect human health.

Proximity to valuable living resources in coastal areas. The reasoning of the preceding point applies here as well.

Neither high-energy mixing areas nor quiescent areas are always near the activities generating the wastes.

Deep-ocean disposal. The proponents of deep-ocean disposal generally cite the following:

Extensive dilution and dispersion. Concentrations of toxic materials can be diluted in a large volume, thereby minimizing effects on marine ecosystems. Such extensive dilution also makes it less likely that the material will return to man in harmful amounts. Similarly, the exposure to contaminants is reduced for the living resources of near-shore coastal areas.

The disadvantages are:

Recoverability may be impossible. If it is determined that unwanted adverse effects are in progress, then there will be a serious problem. Despite the resolve and great technological ingenuity of society for solving difficult problems, recovering dispersed wastes from the open ocean will be a nearly impossible task and certainly disruptive to the economic well-being of the nation.

Research and monitoring are difficult. The volume of oceanic areas involved and the limitations of our present knowledge make it difficult to check on what is actually happening.

Economics. The transportation of wastes to the open ocean is more expensive than for the coastal option.

International complications. While inputs to coastal areas can eventually reach open ocean areas, the direct dumping of pollutant chemicals in open ocean waters beyond the limits of the contiguous zone could affect the waters of neighboring countries and contaminate living resources fished by nonadjacent countries. For example, ocean dumping at the 106-mile site off New York could seriously

Table 1. Estimated current costs of sludge disposal by various means.

Municipality	Sludge generated for disposal (dry tons per day)	Disposal method	Estimated cost (dollars per dry ton)
Orange County, Calif., Sanitation Districts	150	a) ocean discharge via pipe b) landfill via truck	13-21 82-92
New York City	330	a) near-shore ocean dumping* b) deep-ocean dumping	34 222
Philadelphia	190	a) near-shore ocean dumping** b) composting and land application*	120 200
Nassau County, New York	40	a) near-shore ocean dumping*	43

*Actual cost estimate of current practice.

**Philadelphia terminated its ocean dumping activities in 1980. The cost figure reported is the actual cost per dry ton at that time, when production for ocean disposal was about 15 dry tons per day.

Source: 1981 Congressional Hearings on waste dumping, and information supplied by representatives of municipal sewerage authorties.

contaminate squid, which are fished near that area by Japanese fishermen and marketed for human consumption in Japan. Ocean dumping also is regulated by the London Dumping Convention. The U.S. is a contracting party to that convention and should adhere to the ban on ocean dumping of certain toxic materials.

Focus for the 1980s.

We need to contend with the following essential problems if we are to proceed on a rational course with respect to ocean dumping:

Time and Space Scales of Extrapolation. We need to better understand how to extrapolate from experiments and field observations of short duration (weeks to months) and small spatial scale (meters to kilometers) to the fate and effects of waste disposed for decades in areas the size of the entire northeastern United States coastal area or the Southern California Bight and nearby continental slope.

Unreasonable Degradation. We need further knowledge of the long-term effects of individual chemicals, bacteria, and viruses in various wastes in the marine environment. What constitutes unreasonable degradation of the marine environment and how do we predict such damage? From a scientific viewpoint, assessing the effects of pollutants on the marine environment is a difficult task. It requires an understanding of the adaptive and disruptive responses of each level of biological organization, from cellular to population responses, and how those responses may affect responses at the next level of organization. Only when the compensatory or adaptive responses of the cell or whole organism begin to fail, do deleterious effects on the population become apparent. For predictive purposes, one must be aware of the early warning signs of stress before compensatory mechanisms are surpassed.

From a socio-political viewpoint, the level of environmental degradation acceptable to the public may be quite different than that accepted by some of the scientific community. For example, filling in of the Hackensack Meadowlands in New Jersey to build a sports complex resulted in irreversible damage to a salt marsh in the view of an ecologist but the creation of a valuable recreational facility in the view of a New York Giants fan. Future decisions on the effects of ocean dumping will require an integration of scientific, social, and political viewpoints.

Comparisons of Land and Sea Options. What is the common scientific language by which we can compare effects on a forest ecosystem subjected to decades of waste disposal with effects on a fishery subjected to the same waste input for the same period of time? How can these comparisons be communicated in a meaningful way to those engaged in policy and regulation, and to the public? The degree of damage, the recovery time necessary to restore a natural community, and the resiliency to further damage must be considered in any comparison of ecological systems subjected to waste disposal.

How can the proper comparative studies of specific disposal options for specific materials be

The New York Giants football stadium, part of the Meadowlands Sports Complex in northern New Jersey. Construction of the complex resulted in irreversible damage to a salt marsh. (Photo courtesy of Meadowlands Sports Complex)

The Question of Radwastes

The disposal of radioactive wastes fits a special category in the question of ocean dumping. Congress is presently re-examining the ban on the dumping of radioactive waste in the oceans. In September of 1982, the House of Representatives passed an additional two-year moratorium on such dumping, except for research purposes. The bill also requires the monitoring of radioactive waste dumpsites and an environmental/economic impact analysis with each application for a dumping permit and gives Congress the power to review such permits issued by the Environmental Protection Agency (EPA).

Until 1970, the United States dumped low-level radioactive waste in drums such as this 55-gallon one some 200 miles off the Maryland coast at 3,800 meters depth. The rat-tail fish, Nematonurus armatus, *is seen swimming near the drum. Leakage of some radioactivity has been detected in the immediate vicinity of some drums. (Photo courtesy of Robert S. Dyer — Office of Radiation Programs, EPA)*

The U.S. Navy is seriously investigating the option of sinking hulls of decommissioned nuclear submarines in deep water after removing the fuel rods from the power reactors (see *Oceanus,* Vol. 25, No. 3, p. 52). The Department of Energy (DOE) is expected to request permission to dump radioactive soil at sea. The soil, now kept under plastic tarps in New Jersey, was contaminated during development of the atomic bomb in World War II. The Navy and DOE proposals are both covered by the proposed moratorium. There is also an active research program investigating the feasibility of emplacement of high-level nuclear wastes under deep ocean sediments as a long-term, safe disposal option (see *Oceanus,* Vol. 25, No. 2, p. 42).

Separation of the high-radiation-level and long-lived radioactive waste from short-lived, or low-level, radioactive waste has been and continues to be a wise practice in order to increase options for disposal of the much more voluminous low-level radioactive waste.

Some radioactive chemicals decay rapidly with half-lives of a few hours or days. However, a few of the toxic radioactive wastes, such as plutonium isotopes, have half-lives of more than 10,000 years. This places constraints on disposal options. Because of the longevity and highly toxic nature of some components, disposal of radioactive chemical waste becomes a special case.

conducted when government responsibility is fragmented among several agencies and spread over several levels of government? Most studies to date have focused on single disposal options or the effects of disposal on a single disposal medium.

Flexible Policy. A major misconception about ocean dumping is the expectation among the regulators and the public that a decision is forthcoming, based on solid scientific evidence. They also think that, once the decision is made, we can get on with investigating society's other problems. Such thinking minimizes the complexity of the issues and exaggerates the ability of science to provide predictions that will stand the test of time. We recognize that there has been important and exciting progress on local, regional, and global scales in understanding environmental processes. However, there is still much research that needs to be undertaken and completed.

Of equal importance is the fact that decisions on the future of ocean dumping cannot be made on the basis of scientific and technical information alone. Regulators must be prepared to make important decisions on questions of appropriate societal values: how much pollution of land or water is to be tolerated for the sake of economic, health, or other social benefits that accrue because alternative disposal options are not taken? Given the uncertainties about scientific and technical facts, and the changing nature of societal values, can a policy be implemented that is flexible enough to incorporate changes as a result of value shifts or new scientific information? If a marginally tolerable level of ocean pollution is to be accepted for the sake of economic or other considerations, does the policy selected include sufficient incentives for ocean disposal users to generate better waste management methods in the future?

We are concerned that, once the decision to continue or increase ocean dumping is made, there will not be the follow-up in continued research and monitoring which is required to assess the accuracy of estimates made about the fate and effects of the wastes. We caution that such estimates and predictions are often no better than predictions of the behavior of the economy of the United States. Economists are allowed to continue to collect data to revise and update their predictions and assessments because society recognizes that there are many uncertainties in economic predictions. Scientific assessments of many aspects of waste disposal in the oceans are of a similar nature, and society should accept that, too.

Research and Monitoring

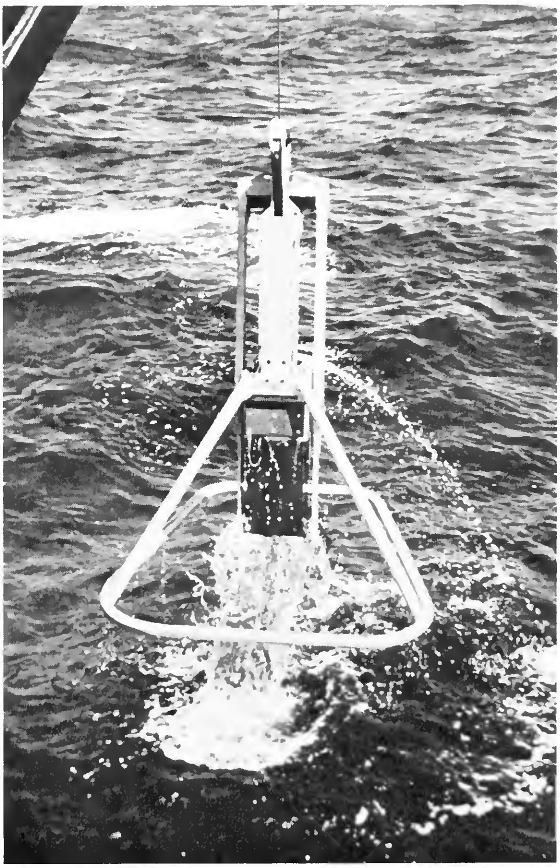
Much of the required information for making decisions can only come from fundamental research. The remaining information comes from monitoring what happens at a given site. Ideally, there should be a five-to-ten-year period of study at a few dumpsites and disposal areas with the various characteristics previously described. In fact, studies of some of the options have been under way for several years in the New York Bight, the Southern California area, and Deep Water Dumpsite 106 off the northeastern U.S. coast. A few more studies like these, incorporating revisions based on lessons gleaned from earlier work, are essential.

There is a very great danger of the "snowball made into an avalanche" effect with respect to ocean dumping, which should be avoided at all costs until reasonable assessment of the options is completed. The problem is that if one municipality or industry is allowed to use the oceans for waste disposal, then many others may cite the precedent and follow. One recent estimate is that municipal sludge dumping could increase by as much as 150 percent if all municipalities that could exercise the dumping option actually did. The situation then could get out of hand before the required data and assessment supportive of extensive dumping is available.

Understanding the fate and effects of materials discharged to the oceans depends on our fundamental knowledge of oceanic processes. At a time when society is poised for a massive experiment with the oceans — continued and possibly substantially increased ocean dumping — fundamental ocean research, and even research and monitoring applied to marine pollution studies, is being severely curtailed. Oceangoing research vessels are being decommissioned and tied up at docks. Even many near-shore research projects require an understanding of open-ocean processes. For example, waves that provide mixing energy in coastal areas are often generated in the open ocean. Many research and monitoring projects on the continental shelf and in areas such as the New York Bight and the Southern California Bight require the larger research vessels to safely handle gear and carry enough scientists to study efficiently and synoptically several facets of the problems. Furthermore, we cannot rely too much on studies of coastal organisms when considering effects on open-ocean organisms. Sensitivities to pollutants are known to vary by as much as factors of 10 or more when comparing organisms for these two different oceanic regimes.

Certainly, remote sensing from aircraft and satellites is a tool of growing significance in ocean research. However, this is no substitute for most ship-based work. Our warning is explicit. If ocean dumping is to be a viable option for waste disposal, then United States ocean scientists have to be able to get to sea to make certain that estimates (many times "guesstimates") of adverse impacts (or no adverse impacts) are correct. There also has to be a concomitant increase in stable research funding in order to understand such important topics as what governs natural fluctuations in marine ecosystems, and to recognize the early indications of changes induced by man's activities.

United States activities in ocean waste disposal will be increasingly watched by other nations and could become part of foreign policy interactions. Wastes discharged to the oceans are not contained by political boundaries. The failure of the United States to support the Law of the Sea Treaty could have repercussions if the U.S. ocean disposal policy in its Exclusive Economic Zone differs from standards agreed upon by other nations. Some nations may well protest United States activities, while others may adopt policies leading to less rigorous standards for disposal of wastes in the ocean. We should be cognizant of the ocean disposal plans of our nearest neighbors in Canada and Mexico, and evaluate the total input to our contiguous oceanic areas. Likewise, if the United



A box corer, used to sample sediment, is brought up from the seafloor in the New York Bight, as part of a monitoring effort by the National Oceanic and Atmospheric Administration. (Photo by George Kelez — NOAA)

States engages in disposal of wastes in open ocean areas, an evaluation of potential long-term impact *must* take into account the activities of other countries that may release wastes into the same or contiguous areas.

For these reasons, we anticipate the 1980s will be a period of vigorous national and international debate about ocean dumping. The debate could extend well into the 1990s.

Summary

We agree with those who argue that the oceans have a capacity to receive some wastes without undue harm to valuable living resources or to public health. We also agree with those who are concerned that a mad dash toward using the oceans as a less expensive, quick fix for waste disposal will occur without due consideration of the relative risks and benefits of all options for waste management.

There are encouraging indications that those who formulate policy and promulgate regulations are evaluating all options. However, we are discouraged that this policy evaluation will probably acknowledge the essential role of continued research and monitoring activities in the rational evaluation and implementation of the various options, while not providing the means for those activities to be effectively carried out. We do not advocate unnecessary delays in decisions about where to put waste today. Rather, we advocate a flexible policy which explicitly recognizes that today's decision can be re-evaluated, modified, or even abandoned as new knowledge is acquired.

One of the most serious mistakes that could be made about disposal of wastes in the oceans is to decide now that we have sufficient knowledge to establish regulations for 20 years or even 10 years. We do not. Our present knowledge of the oceans teaches us how complicated oceanic processes can be; it is rudimentary compared to the questions asked. In the lexicon of computer buffs, "garbage in, garbage out" is not a good way to decide where to put the garbage.

John W. Farrington is Director of the Coastal Research Center at the Woods Hole Oceanographic Institution, and a Senior Scientist in the Chemistry Department. Judith M. Capuzzo is an Associate Scientist in the Institution's Biology Department. Thomas M. Leschine is a Policy Associate in the Marine Policy and Ocean Management Program at the Institution. Michael A. Champ is a Professor at The American University in Washington, D.C., and the Resident Scholar in the Ocean Dumping Program of the National Oceanic and Atmospheric Administration in Rockville, Maryland.

References and Suggested Readings

Duedall, I. W., B. H. Ketchum, P. K. Park, and D. R. Kester, eds. 1983 (in press). Global inputs, characteristics, and fates of ocean-dumped industrial and sewage wastes: an overview. In *Wastes in the Ocean, Vol. 1: Industrial and Sewage Wastes in the Ocean*. pp. 3–45. New York: John Wiley and Sons.

Ketchum, B.H., D.R. Kester, and P.K. Park, eds. 1981. *Ocean Dumping of Industrial Wastes. Marine Science* 12. New York: Plenum Press

Lahey, W.L. 1982. Ocean dumping of sewage sludge: the tide turns from protection to management. *Harvard Environmental Law Review* 6 (2): 395–431.

MacLeish, W. H., ed. 1981. The oceans as waste space. *Oceanus*, 24(1).

Marine Pollution Papers of the Oceans '82 Conference and Exposition. 1982. Organized by The Marine Technological Society and the Institute of Electrical and Electronic Engineers Council on Oceanic Engineering. Reprint by: Office of Marine Pollution Assessment: N.O.A.A., Rockville, Maryland

National Academy of Sciences. 1978. *Multi-medium Management of Municipal Sludge*. Washington, D.C.

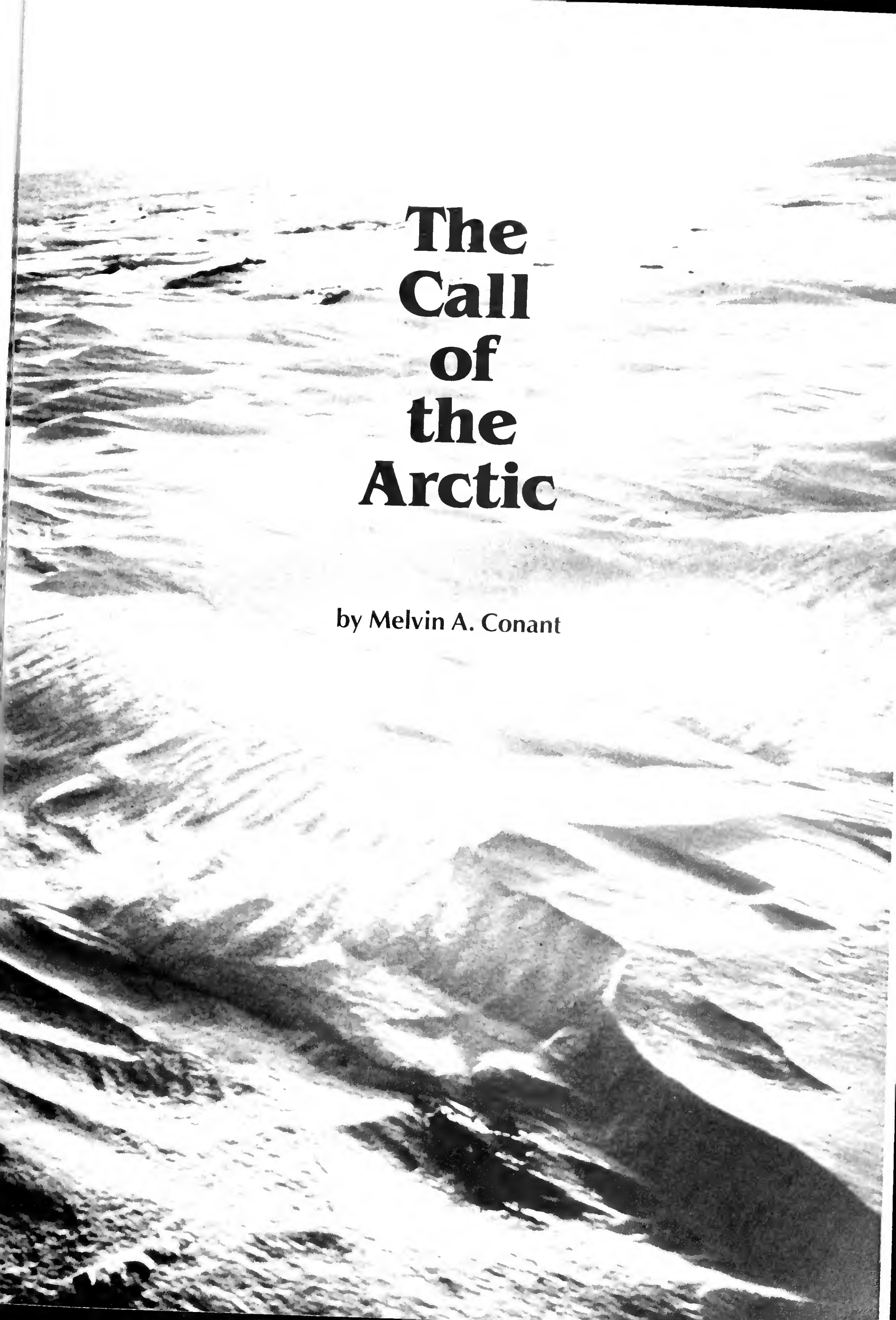
National Advisory Committee on Oceans and Atmosphere. 1981. *The Role of the Ocean in a Waste Management Strategy*. A Special Report to the President and the Congress. Washington, D.C.: U.S. Government Printing Office.

Swanson, R.L. and M. Devine. 1982. Ocean dumping policy, the pendulum swings again. *Environment* 24(5): 15-20.

U.S. Department of Commerce, N.O.A.A. 1979. *Assimilative Capacity of U.S. Coastal Waters for Pollutants*.

The Call of the Arctic

by Melvin A. Conant



The National Petroleum Council, in its important study of petroleum potential in the U.S. Arctic region, suggested that as much as 40 percent of our undiscovered recoverable petroleum resources may yet be found in that forbidding environment. There are no reliable estimates of what volumes of oil and gas could be recovered, apart from those generated through a heady brew of speculation. But it is unlikely that an offshore field of much less than a billion barrels could be economic for many years to come. It is possible that the Navarin Basin, far off the coast of western Alaska, will be more promising.

The stakes are staggering. If present accelerated lease plans are implemented, by June 1987 all of the Outer Continental Shelf areas of the Alaskan Arctic may have been offered for lease to industry. The bids alone for tracts in the Beaufort and Bering seas eventually could total more than $10 billion, or so say the more optimistic analysts. In October, 1982, a number of oil companies (23) bid $2.1 billion dollars for tracts covering 1.8 million acres in the Diapir field in Prudhoe Bay. The cost of exploration wells is very large, in the range of $25 million to more than $60 million each, depending on location (factors include depth of water and problems of protection against ice). Man-made islands surrounding rigs are a general requirement, to withstand the enormous pressures of ice that would otherwise demolish them. These "islands" represent in themselves a staggering logistic challenge involving the mining and transport of hundreds of thousands of tons of gravel for the construction of bases and ramparts. Each of these costs about $2 million per foot of water depth. The average depth of the initial series of wells is in the range of 20 to 60 feet.

Yet it seems as if no physical problems encountered in the Arctic environment are insurmountable. A new generation of technology, engineering, and ship design has emerged in the pursuit of Arctic riches. Assuming vast oil deposits are found and determined to be retrievable on favorable commercial terms, we are on the verge of a mammoth effort to exploit Alaskan resources. Never before has the depth of interest in operating in the U.S. Arctic been so great. Nor have the sums committed been so large — they are already nearly $20 billion, with far more to come. Exxon USA estimates more than $300 billion may be spent on Alaskan petroleum resources. The Canadian Arctic prospects, which may be as large, have involved commitments in the range of $5 billion to $10 billion, with more anticipated.

Issungnak Island in the Canadian section of the Beaufort Sea in September. This is a "sacrificial beach" island; the outer rim breaks storm waves in summer and causes ice sheets to break up and form a protective rubble field around the island. Sandbags and filter cloth reduce erosion. The island is made of 4.9 million cubic meters of sand, dredged from the seabed and delivered to the site through a floating pipeline. It is 26 kilometers offshore in water 19 meters deep. From November through June, there is no open water around the island. In the winter, the sun does not appear on the horizon. (Photo courtesy of Esso Resources Canada, Ltd.)

Immense Riches

Thus the prospects and the investments in the U.S. Arctic have their parallel eastward, with very large Canadian undertakings in Canada's portion of the Beaufort Sea, and further eastward to the Arctic Islands, where the existence of substantial deposits of natural gas is already established. Moreover, in the U.S. Arctic, immense riches of coal (perhaps 130 billion tons) and other hard minerals (gold, silver, iron ore) reinforce the long-held conviction that the resources of these lands — including timber — are great untapped assets; the Canadian Arctic is thought to be one of the largest and richest of geological regions. The effort to create extractive and logistical infrastructures for these other resources is under way, but efforts to obtain gas and oil now dwarf all others.

In both the United States and the Canadian Arctic zones, the greatest gamble today is probably not in the actual hunt for recoverable resources, nor with what most people think is a fragile environment, but in the troubled economies and reduced energy needs of both countries. It is entirely possible that Arctic developers will never quite realize their great expectations for lack of a large enough commercial incentive. If we could know how soon economic recovery will come, what increased energy supply will be required, and how competitive Arctic resources will be on the market, then the scope and pace of Arctic exploration could be made commensurate to those expectations. But without some evidence of a return to economic health and progress, it is doubtful that companies will continue to commit huge investments to enterprises whose return on capital will be neither generous nor soon.

Nevertheless, enough has happened already to bring the historic dream of exploiting the Arctic far beyond its living resources closer to reality; of the goal of making passages east and west through ice and heavy seas; of finding ways to work year-round; of the fashioning of special means to penetrate the frozen earth to great depths and then to recover the resource; of learning much more about the Arctic environment, its weather, its capability to recover from pollution.

Government Presence Required

It also is becoming clear that the Arctic will be a different undertaking economically, in that a federal government presence is an essential component in almost everything to be attempted. This presence is required under law and in policy, as is the case elsewhere in which multiple uses of the oceans and coastal zones call for the weighing of interests, their compromise, and oversight of performance.

Only the federal government has the authority to exercise these responsibilities. The conflicting interests — such as fishing, energy needs, territorial claims, pollution regimes, and considerations affecting defense — are nowhere more complicated than in the Arctic, and only government can sort these out, attach priorities, and aid in the drafting of a broad range of objectives. These objectives must relate to the responsibilities of the state of Alaska as well as to those of the federal government, as to the manner and timing of resource exploitation and the revenues obtained from it. While the federal government holds the bulk of Alaskan lands in trust for all Americans, there are substantial Alaskan interests that also have to be met.

Both federally sponsored research and outlays by the private sector have given us greater knowledge of the means of exploitation and the necessary precautions. Neither funding source can be abandoned. More recently, private-sector outlays for research and technology have dwarfed those of the government on the order of perhaps 20 to 1, but the federal role is still essential, especially in consideration of those requirements not directly germane to a single private investment or a commercial enterprise. Nevertheless, the debate has begun as to what the extent of the federal role should be and what it should cost. It is somewhat ironic that, at a time when great achievements in the Arctic are emerging, the United States has an administration which is convinced that the national interests are best served by a lower federal presence in the defining of policies and regulations to guide Arctic developments. It is more than ironic; it is paradoxical. It may even prove self-defeating as the private sector finds it cannot persevere alone. There are too many unresolved issues with the potential to frustrate and prevent resource development.

The federal government has sole jurisdiction and control over the Outer Continental Shelf (and the overwhelming bulk of Alaskan lands). Its definition of the circumstances in which resources are exploitable, its responsibilities for safeguarding the interests of those people most directly (and possibly adversely) affected, and its duty to protect the environment are all consequential enough, but there are other issues involving relationships to Canada and other Arctic nations that can only be worked out by the sovereign states involved.

For example, boundary disputes in the Navarin Basin (United States and Soviet Union) and Beaufort Sea (United States and Canada) could come to delay exploitation of resources that overlap. The governments of Canada and the United States will both have to be involved in planning for and responding to an oil spill. And industry needs to know how pollution controls over logistical systems will be dealt with by both countries.

The mix of national and international complexities in Arctic operations cannot be sorted out on lower political and administrative levels unless and until the federal interests are defined and then agreed to between Ottawa and Washington. Canadian and United States interests are entirely comparable, but that does not mean that different institutional processes, competing claims of sovereignty, and differences in laws and policies will be quickly resolved. We know very well they will not be. It is thus all the more important that we begin bilateral negotiations. Until the two governments resolve their differences, there is a great chance that the discovery of exploitable resources will not be followed by their exploitation.

The Defense Factor

After World War II, the United States undertook, with Canadian cooperation, the construction of early

Unresolved Arctic Issues

- *Precise outer limits of the continental shelf, for coastal-nation resource purposes.*
- *United States–Canadian boundary in the Beaufort Sea.*
- *The uncertain location of the United States–Russian Convention Line of 1867 in the Navarin Basin.*
- *The character (whether national or international) of passages through the Arctic islands (the Northwest Passage).*
- *Dispute between the U.S. government and the state of Alaska over ownership of coastline areas in the Beaufort Sea:*
    - *a) the area offshore of the National Petroleum Reserve in Alaska (NPRA)*
    - *b) the coastline eastward of the NPRA, including the Prudhoe Bay area.*
    - *c) the area offshore of the Arctic National Wildlife Refuge (ANWR)*
- *The varying status with respect to oil and gas leasing of onshore federal lands in Alaska.*
- *The as yet unclear federal role as a supporter and participant in Arctic development.*
- *The need or lack of a need for a special Arctic science policy.*
- *United States response to the Canadian Arctic Waters Pollution Prevention Act.*
- *The appropriate balance between development activities and environmental protection.*

warning systems against manned air attack. The advent of the intercontinental ballistic missile reduced the need for these expensive, far-flung air defense undertakings and at the same time amplified the need for closer surveillance of limited-range missile-bearing submarines whose targets in the United States and Canada required their approach to the North American Arctic, especially to the Canadian islands of the extreme north. New facilities to detect a missile attack also were emplaced in the northern region. By the late 1960s increased missile ranges had reduced the need for the Soviet submarines (and their United States counterparts) to exploit the proximity of the Arctic regions to industrial targets; the standoff of missile submarines could be far more distant, and the difficulty of tracking these submarines and their missiles' possible trajectories was made much more problematical.

Now, with the introduction of the latest long-range missiles, submarines may elect to remain in their own closely protected seas or move through vast reaches of the oceans, approaching targets from a multitude of vantage points. Thus the special significance of the Arctic in the strategic balance of the superpowers has faded from its earlier importance.

Still unresolved, however, are the contemporary and future requirements for ordinary surveillance of the movements of aircraft, ships, and persons throughout a vast region where detection and tracking present enormous difficulties. The objective of such movements may be to test alertness and the capacity to observe, either to test assertions of sovereignty or for purposes of sabotage. The North American Arctic — more than ever — must be "policed"; facilities for rescue on a large scale also

The Northwest Passage through the North American Arctic.

must be provided. All of these matters can be better dealt with through explicit agreements between the United States and Canada.

Issues of Sovereignty

There are several unresolved differences between the United States and Canada over questions of sovereignty. Especially important is the legal status of the passageways between the Arctic islands. Are they, as Canada asserts, passages within the territory of Canada and thus of its jurisdiction or, as the United States claims, of an international character to which international law is applicable? The United States view limits control of the passageways to internationally agreed-upon conditions, among which is the general principle of unimpeded passage. And we shall have to look again at the territorial division of the Bering Straits between the Soviet Union and the United States — a generally dormant issue, but one which is likely to be involved when the Navarin Basin is explored and tanker traffic begins to move through the Bering Sea.

The *Manhattan* voyage of 1969 brought these matters into sharp focus, and the repercussions from that ice-breaking experiment have not faded from memory. There were disputes over legal control of the passageways and over the Canadian claim that data was withheld by the United States, to name only

The Voyage of the Manhattan

The tanker Manhattan *(left) cuts its way through Arctic ice in 1969, accompanied by the Canadian icebreaker* John A. Macdonald. *(Photo courtesy of Exxon Corporation)*

In 1969, four U.S. oil companies put up $40 million to test the feasibility of tanker transportation through the ice channels above North America. The 500-year-old dream of a Northwest Passage was thus revived, and the Manhattan *set out from Chester, Pennsylvania, on August 24 of that year.*

The largest U.S. oil tanker at 115,000 deadweight tons, the Manhattan *had been cut apart, reinforced, and reassembled with an icebreaking bow. The ship was equipped with strain gauges, torquemeters, accelerometers, and powerful radio gear. Closed circuit television monitored ice under bow and stern.*

The Canadian government provided meteorologists, airplane reconnaissance, and the icebreaker John A. Macdonald. *Again and again the icebreaker was called upon to free the tanker from the ice, but the* Manhattan *eventually made it through to Point Barrow, Alaska.*

Stanley Haas, Humble Oil and Refining Company's project manager for the voyage, said the Manhattan *made the trip "to gather scientific and engineering data for guidance in building a fleet of supertanker-icebreakers that may turn these desert wastes into teeming sea lanes."*

two. It was a classic example of that mix of insensitivity and obduracy that makes United States–Canadian cooperation difficult and time-consuming when it comes to disentangling important issues from those of lesser consequence. So much more could have and should have been done by the Americans to turn this exceedingly important experiment into a cause for bilateral congratulations instead of the raucous affair it became. Anyone involved in an Arctic enterprise involving issues of Canadian sovereignty should make a special study of the *S.S. Manhattan* episode — it contains all the lessons.

The question of sovereignty will become even more pressing if Japanese intentions to purchase some Arctic oil and gas from Canada and/or the United States are realized. Tankers moving from one national jurisdiction to another ought not to have to meet significantly different environmental, construction, and operational standards. The Canadian Arctic Waters Pollution Act of 1970 (an immediate consequence of the *Manhattan*'s passage) and parallel United States legislation have to be reconciled.

The present stance of the Reagan Administration, which removes the United States from participation in the United Nations Law of the Sea negotiations for a set of definitions governing multiple uses of the oceans (and dispute settlement), puts this nation immediately at odds with Canada, which has been a leading advocate of the Law of the Sea treaty (as was the United States until 1980). In the text of the treaty, there is specific provision made for national control over icy waters. This provision in effect acknowledges the extension of Canadian control, but the United States, which once accepted the argument, has voted against the whole text. This is an issue of great importance to the logistics of Arctic supply, for the Administration's unwillingness to persevere in the Law of the Sea negotiations guarantees legal and political conflict over Arctic developments.

Icy Waters Provision

Coastal states have the right to adopt and enforce non-discriminatory laws and regulations for the prevention, reduction, and control of marine pollution from vessels in ice-covered areas within the limits of the exclusive economic zone, where particularly severe climatic conditions and the presence of ice covering such areas for most of the year create obstructions or exceptional hazards to navigation, and pollution of the marine environment could cause major harm to or irreversible disturbance of the ecological balance. Such laws and regulations shall have due regard to navigation and the protection and preservation of the marine environment based on the best available scientific evidence.

— Article 234 of the United Nations Law of the Sea Convention, adopted April 30, 1982.

There is also the United States–Canadian boundary question affecting the resources underlying the Beaufort Sea. Eventually, incidents, claims, and counterclaims will have to be dealt with by an accord between the two countries. In the meantime, 600,000 acres offshore are of uncertain jurisdiction.

Environmental Consideration

As the number of activities in the Arctic multiply and become more capable of wreaking heavy damage — especially from oil facilities and tankers — every effort should be made to minimize the prospect of large and long-term catastrophes. Neither the United States nor Canada will be immune to accidents occurring in the other's territory. Arrangements between private interests for emergency procedures in the event of an oil spill, for example, must include a government presence to help insure their adequacy. The Joint Canada–United States Marine Pollution Contingency Plan, which operated first in the Great Lakes, set an excellent example.

An additional environmental factor, and a fascinating one, is that the Arctic is the climate-maker for much of the rest of the world. We do not know the extent to which North American Arctic enterprises might come to affect that function, but we cannot assume that Arctic operations will have little or no effect. A Soviet plan to divert three large Siberian rivers now flowing into the Arctic might someday lead to a major change affecting the region's climate-making role. Assumptions made by either Canada or the United States should be reached through joint scientific efforts to insure that a total view is obtained.

The Support of Science

Not enough is known of the resilience of the Arctic environment to the pollution and exploitation of its living and nonliving resources. United States and Canadian experiments have never been substantial enough to provide answers. Yet commercial enterprises proliferate. The United States Senate attempted recently to correct this situation with its consideration of Senate Bill 1562, the Arctic Research and Policy Act. The bill, which would promote and coordinate Arctic research, also has been introduced in the House of Representatives, but its fate is uncertain.

There has been a profound change in the nature and scale of scientific efforts in the Arctic. The economic potential of Arctic resources has attracted very large and far-reaching efforts by industrial laboratories — efforts that eclipse the much more modest federal efforts. The Administration's reluctance to continue, much less expand upon, past efforts, which until 1976 centered on the Naval Arctic Research Laboratory (Point Barrow) and other defense-related undertakings, is partly the result of other spending priorities and partly the consequence of an ideological belief that government's role should be reduced.

Sooner or later the force of circumstances will propel the government into sustaining and probably enlarging its scientific role, largely because there are questions about the impact of resource development on other uses, such as fishing, and the public has a stake in seeing that the best means are available to cope with environmental damage. Such matters can never be left to private interests alone, however extensive the latter's research may be in these and other matters. But the Senate Government Affairs Committee hearings on S. 1562 make it clear that an enlarged federal scientific role is not likely in the near future.

Economic Development

Last but far from least of the federal government's concerns in the Arctic is the promotion and support of industrial enterprises there, under appropriate safeguards. Washington could perform a catalytic role, linking the many United States interests into a comprehensive unit for Arctic undertakings. It is an inescapable responsibility, given the federal ownership of the land and the federal jurisdiction over the Outer Continental Shelf. The state of Alaska's own reach over these matters is comparatively limited, as is any state's.

In sum, the federal role as a supporter and participant in Arctic development is far-reaching, consequential, and inescapable. It needs to be defined for the long term. We know enough of the whole Arctic context to be certain there are no simple, inexpensive, and readily available solutions to the host of technical, environmental, and, possibly, meteorological issues. In some cases, these issues are of equal interest to government and industry, as in ship design and operations, where there is a long tradition of pursuing common goals.

The U.S. Interagency Arctic Policy Group (IAPG), from which recommendations for government objectives and roles in the Arctic should emanate, has not yet been able to reach agreement as to the proper scope and direction of the government's presence in Arctic affairs. The original mandate of the National Security Council's Decision Memorandum (December 11, 1971) gave only the most general guidance: to promote sound and rational development of the Arctic, minimizing adverse environmental effects, and to promote international cooperation while protecting security interests such as freedom of the seas and the air space above them. The effort of IAPG to give meaning to these broad strictures has been largely unsuccessful, owing for the most part to the reluctance of the Department of the Interior, which has traditionally emphasized its leading role in determining the pace and means whereby Alaskan resources are developed. The Department of the Interior rarely welcomes the involvement of other government agencies in the exercise of its responsibilities.

One thing seems certain: the Reagan Administration would like the federal presence in Arctic development to be minimal. It is thus all the more crucial that such a presence be concentrated on three vital requirements: agreement on boundaries; the defining and melding of environmental safeguards; and accommodation of different regimes for the control of ships and shipping.

No other responsibility, for the long term, is of comparable importance. Industry's economic performance and return on capital lie beyond the government's purview; defense, it may be assumed, will be adequately looked after; and most scientific work will be financed by industry, whose need to know will transcend government's willingness to pay. A special effort will be required of research institutions to make certain that important scientific inquiries which may not be of sufficient interest to industry are nevertheless supported in an adequate and timely manner. A study of the role of the Arctic as a climate-maker for much of the world would be on a list of such needs.

The Arctic is being opened up as never before; it is an irreversible process with the potential consequence of great good or great harm. This calls for a National Arctic Policy; a governmental commitment that allows the goals of both the private and the public sector to be advanced, but with the oversight which the public interest requires.

Melvin A. Conant, formerly a Senior Government Relations Advisor for the Exxon Corporation, is President of Conant and Associates, a consulting firm that deals with world energy and resources problems in Washington, D.C. He is also Chairman of the Senior Advisors Committee of the Marine Policy and Ocean Management Program at the Woods Hole Oceanographic Institution.

References

Gustafson, T. 1981. *Reform in Soviet Politics*. Cambridge, England: Cambridge University Press.

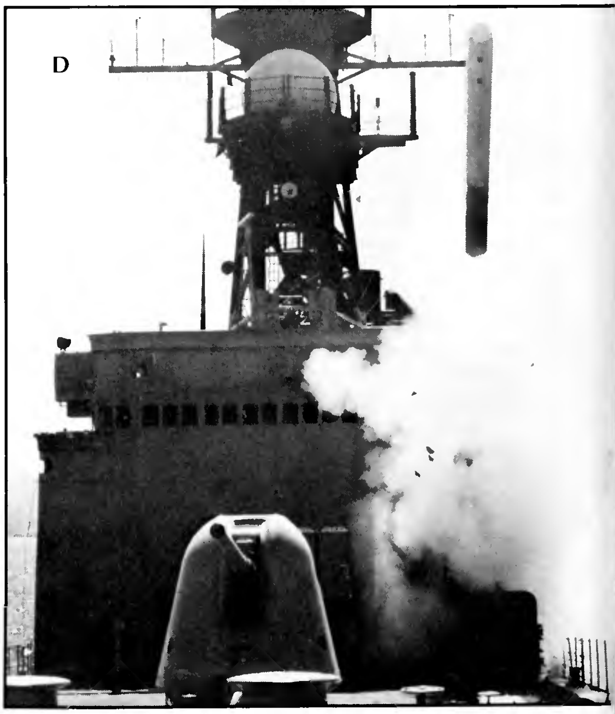
House Committee on Science and Technology, U.S. House of Representatives. 1976. *Polar Energy Resources and Potential.* Washington, D.C.

Interagency Arctic Policy Group, U.S. Department of State. 1982. *Arctic Policy Evaluation.* Washington, D.C.

Johnston, D. M., ed. 1982. *Arctic Ocean Issues in the 1980's.* University of Hawaii.

National Petroleum Council. 1981. *U.S. Arctic Oil and Gas*. Washington, D.C.

Ocean Science and Military Use of the Ocean



by Robert S. Winokur
and Rene E. Gonzalez, Jr.

Seapower is a cornerstone of this nation's long maritime heritage. Today, as in the past, seapower is a vital element of United States defense strategy, which stresses the principles of deterrence, flexible response, and forward deployment. Accordingly, the U.S. maintains a navy of multi-ocean dimension, with plans to restore maritime superiority over the Soviet Union within the decade. The Navy of today represents the results of past technological innovations and efforts, and its future will depend on continued research and development. Thus a long and abiding commitment to ocean science reflects the Navy's requirement for knowledge of its operating environment.

Modern naval oceanography has its origins in World War II, when advances in underwater acoustics and other branches of blue water research contributed significantly to U.S. anti-submarine warfare (ASW) efforts. Future advances in oceanography will be similarly important. As Secretary of the Navy John Lehman recently stated, "we are becoming more aware that a favorable

B

outcome in future conflicts grows daily more dependent on new knowledge from the seas."

As weapons, sensors, platforms, and tactics beome more sophisticated, knowledge of environmental factors becomes more important in system design and performance, and in force deployment. Requirements for new knowledge are thus greater than ever before, and will continue to increase as naval operations span the world ocean from complex shallow regions to the deep basins. In the 1980s, the Navy's research and development program faces opportunities as well as challenges.

Military Use of the Ocean

The Navy's mission is to conduct combat operations at sea in support of national interests. This mission includes two basic functions: projection of power and sea control. Power projection means being able to bring strong forces to bear in remote regions of the world, and keeping them on station as long as necessary. Controlling the sea means being able to counter all kinds of offensive threats, whether from the air, surface, or subsurface.

By performing these functions, the Navy makes critical contributions to each of the three major elements of U.S. defense strategy: sea control makes possible a forward deployment posture; strategic nuclear forces in the form of fleet ballistic missile submarines contribute to deterrence; and the capability of showing force without actually using

C

A U.S. task group (A), consisting of the carriers Kitty Hawk, Midway, *and* Nimitz, *steams through the Arabian Sea. (B) The Navy's Tomahawk cruise missile, launched from a submarine. (C) The USS Ohio, the first of the Navy's new Trident submarines. Larger than any U.S. submarine before it, the vessel carries 24 Trident missiles, each with multiple warheads and a range of 4,000 nautical miles. (Photo courtesy of General Dynamics Corporation). (D) A cruise missile launched vertically from a surface ship. Turning once clear of the launcher, such missiles are aimed electronically. (Photos A, B, and D courtesy of U.S. Navy)* it, for which seapower is inherently well suited, is essential to the strategy of flexible response. Superimposed on these basic functions are a variety of naval tasks. Included among these are ASW, mine warfare, amphibious warfare, special warfare, electronics warfare, and support activities such as search, rescue and salvage, construction, and oceanographic research. The great scope and challenge of this mission, then, has shaped the Navy's force structure, a diverse array of sophisticated systems and more than 500 ships. The plan is to expand the fleet to more than 600 ships by the early 1990s — a "600-ship" Navy.

Since World War II, the United States has chosen a high-technology approach to military systems. Today's weapons perform at faster speeds and over greater distances than ever before. The modern naval arsenal includes new "smart" weapons — quiet and fast submarines, antiship missiles, over-the-horizon sensors and targeting systems, semi-autonomous weapons, and improved undersea weapons and surveillance sensors.

The development of new capabilities, and even survival at sea, often depend upon knowledge of and sensitivity to environmental parameters in the ocean and lower atmosphere. Provision of this knowledge and a superior technology base is the focus of the Navy's ocean science program. And, as Secretary Lehman has pointed out, "there is little separation between that which is militarily useful and that which serves fundamental human enterprise." Some examples of warfare mission areas will illustrate the applicability of ocean science to the problems of modern naval warfare.

For the last 30 years, the Navy has aggressively developed its ASW capabilities. Since sound is the only practical means of detecting targets or communicating underwater at long ranges, acoustics has long been the backbone of ASW. Surface ships, submarines, maritime patrol aircraft, and advanced weapons all employ acoustic systems in their ASW roles. Strengthening tactical and surveillance ASW capabilities is a continuing goal for the years ahead. Mobile surveillance systems will augment fixed systems, providing flexibility of response to changes in Soviet submarine deployment patterns and extending coverage to remote areas. Future capabilities will also be enhanced by new tactical towed acoustic arrays, and sensor and weapons control systems.

The Soviet Union has recently begun to develop capabilities in open-ocean ASW and is investing heavily in advanced systems. This represents a major challenge to U.S. undersea system planners. The vital role of the all-nuclear submarine force in the Navy mission demands that we not overlook any possible means of detection and protection in the future.

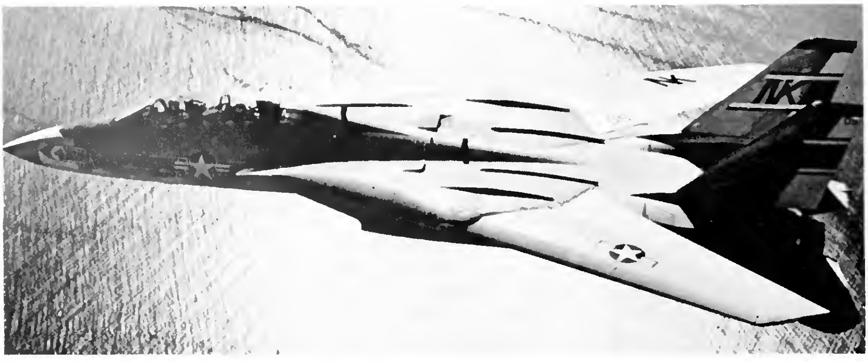
The development of ballistic missiles created a new role for submarines in strategic deterrence. The Poseidon ballistic missile submarines will see service into the 1990s and the Trident submarines, starting with the recently launched *USS Ohio* and *USS Michigan,* will provide a sea-based deterrent well into the 21st century.

Cruise missiles also have important application in naval warfare, greatly increasing the striking power of submarines and surface ships. The deployment of such missiles has heightened the demands for environmental data to enhance submarine force protection, navigation, and missile guidance.

The surface component of the modern Navy also produces demands for better understanding of the environment. For example, problems of safe navigation, weapon and sensor operation, detection, deception, communication, and weapon countermeasures, to name a few, are often compounded by our limited knowledge and ability to predict the weather and ocean conditions. Surface ships serve as operating platforms for a complex array of new missiles, guns, radars, and torpedoes, each with its own environmental design constraints.

Amphibious operations face many problems common to standard surface forces, but with the added complexities of shoreline topography, inshore wave and current actions, tides, and coastal weather effects. Weapons and radars usually used in open waters may be hindered by the noisy thermal and electromagnetic background of the coast, especially a defended coast. The environmental conditions encountered by the British forces in the Falkland Islands provide a vivid illustration.

Mine warfare has proved highly effective in 20th century wars from World War II to Vietnam, and could be important in the future. A modern mine incorporates a high level of technical sophistication, no longer fitting the stereotype of a moored giant sphere waiting for a ship to run into it. Mines can respond to the sound and magnetic signatures of



A Navy F-14 "Tomcat" fighter flies over open water with wings swept back. Such technically advanced aircraft typify the modern systems and weapons of the U.S. Navy. (U.S. Navy photo) passing targets, detonating when something passes nearby, or they may release acoustic homing torpedoes toward submerged targets. The sensitivity, accuracy, reliability, and safety of such mines depend, as does submarine warfare, upon a variety of acoustic, oceanographic, and geological factors. As a consequence, the Navy wants to learn more about the environments in which mines may be deployed, especially shallow waters, straits, and coastal regions. Mine countermeasures are likewise dependent on knowledge of environmental factors.

Military use of the ocean is not limited to warfare and deterrence functions. The Navy also performs important auxiliary tasks, such as general fleet support; search, rescue, and salvage; construction; and even arms control monitoring.

In the case of search, rescue, and salvage, the Navy must maintain a capability, even if it is needed infrequently. The search for a nuclear bomb lost off Palomares, Spain, and the tragic loss of the submarines *Thresher* and *Scorpion* showed the necessity for state-of-the-art manned and unmanned submersibles and deep-sea search capability, and illustrated the difficulty of such operations in the complex and relatively unknown environment of the deep sea. Several sophisticated systems have been developed or are under development for search and salvage. These include new vessel types, such as SWATH (small waterplane area twin hull) ships and catamaran hulls, complex manipulator systems for submersibles and towed vehicles, and deep-towed camera and sonar systems.

Environmental factors also play an important role in design, construction, and maintenance. The effects of near-shore sediment dynamics and marine fouling are but two examples of costly problems that must be dealt with regularly.

Daily support to the operating Navy, in the form of weather data and predictions, is critical to fleet operations and wartime readiness. Advances in computer technology, modeling, and remote sensing (by satellite) present exciting opportunities to enhance existing support capabilities in the 1980s.

Geographic Interests

As mentioned earlier, the United States employs a forward strategy in which the ocean serves as a barrier for defense and a means for projecting power. Naval forces therefore are deployed worldwide, protecting sea lanes and serving critical U.S. interests in many distant areas.

To support military operations on a global scale, ocean science activities must take into account the Navy's interests in distant strategic areas where the environment is poorly known, or in special regions which are environmentally complex or unique. Such regions include the Arctic, shallow waters, sea straits, and the southern ocean.

The Arctic is strategic, separating the Eurasian land mass from North America. ASW is critical in controlling the Pacific and Atlantic approaches to the Arctic. This underscores the importance of Navy Arctic research efforts to better understand the physical processes of this complex region, especially those affecting acoustic systems, and to improve

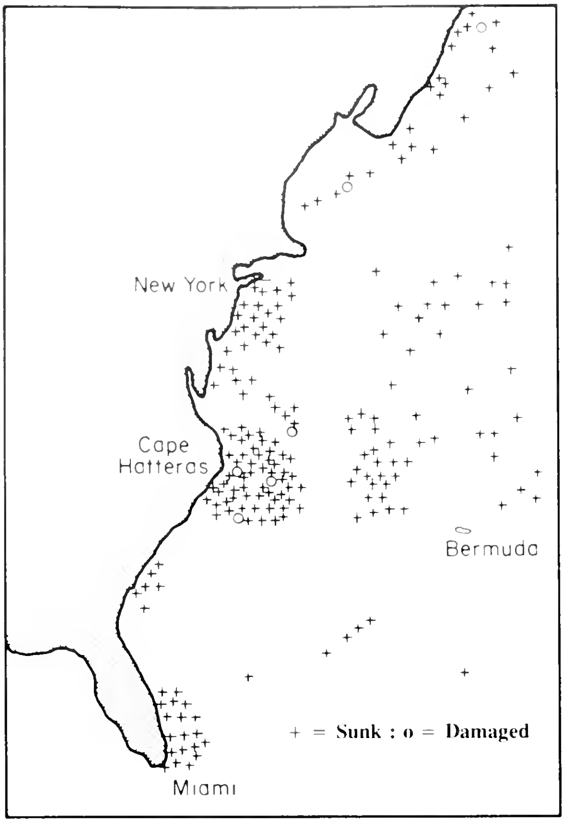
Springtime in the Bering Sea. At left is a field of ice chunks, each up to 4 meters wide, in the process of melting. The streaks extending to the right are concentrations of ice which may be formed by currents converging along sharp lines. Ice edge dynamics, now poorly understood, will be a subject of Navy research in the 1980s. (Photo by S. Martin)

naval operations in ice-covered waters. Research in the 1980s will emphasize the eastern Arctic and the complex transitional area referred to as the marginal ice zone, extending from the perennial ice pack to the open ocean.

Present U.S. policy toward the Arctic was established in the early 1970s by National Security Decision Memorandum 144, which provided a broad framework for international cooperation, scientific research, protection of national security interests, resource development and environmental protection, and interagency coordination. Recently, however, it has been argued that national Arctic research policy needs strengthening. Senate Bill 1562, "The Arctic Research and Policy Act of 1981," has been introduced to provide a comprehensive research policy dealing with national needs and objectives in the Arctic (see page 51). The Department of Defense has long been a major proponent of Arctic research and will continue to support efforts to enhance research with respect to national security interests.

The importance of shallow water in naval warfare was shown in World War II; a high proportion of merchant ship sinkings occurred in coastal waters. Besides ASW and the protection of shipping, other interests in shallow water include amphibious warfare, construction, and mapping and charting. Acoustic propagation in shallow water is of prime importance and is complicated by boundary interactions, reverberation, and oceanographic variability. Future research efforts will investigate these complications, along with improving hydrodynamic models and studying near-shore sediment dynamics and optical properties.

Assured access to shallow-water regions is obviously important to future research efforts. Primarily because of the provisions on deep-sea minerals, the U.S. recently voted against the current draft of the Law of the Sea Treaty. The Treaty contains articles that affect freedom of marine scientific research, potentially reducing our access to about a third of the world oceans. Several coastal nations



Merchant ships sunk by German U-boats off the Atlantic coast of North America from January to July, 1942. (Courtesy of Marvin Lasky — The Journal of the Acoustical Society of America.)

already have adopted consent requirements for research within 200 miles of their coastlines.

Navy ocean science works within the framework of national policy, reflecting international political constraints as well as opportunities. Impacts on research in shallow-water areas are ameliorated to some extent by the fact that the United States shares common security interests in these areas with a number of allies. Thus international cooperation will be an important element of studies in these regions (see page 13).

Sea straits are vital as choke points. For example, in wartime a large percentage of NATO's supplies from the United States would pass through the Florida Straits. Experiments in sea straits have been conducted sporadically, and only limited progress has been made in understanding the physical processes in these regions. New numerical hydrodynamic models, improved instrumentation, and remote sensing techniques will combine to permit significant advances in our understanding of sea straits during the next few years.

Because of their remoteness, the Indian Ocean and South Atlantic are generally undersampled, and thus not well understood, despite their importance as sea lanes. Multidisciplinary investigations in physical oceanography and marine geophysics are planned to improve our knowledge of these oceans.

The Future of Naval Oceanographic Research

The Navy's ocean science program is continuing to grow, and the 1980s should see important progress in many new directions, encompassing all the oceanographic disciplines. ASW and undersea warfare will continue as research focal points, particularly in the science of ocean acoustics.

While acoustic applications are central to the Navy's tasks, acoustics also provides a means for studying the ocean itself. Research in acoustics has led to new advances in marine biology, wave measurement, and the study of ocean dynamics on all scales. One noteworthy example of this is acoustic tomography (see *Oceanus,* Vol. 25, No. 2, p. 12).

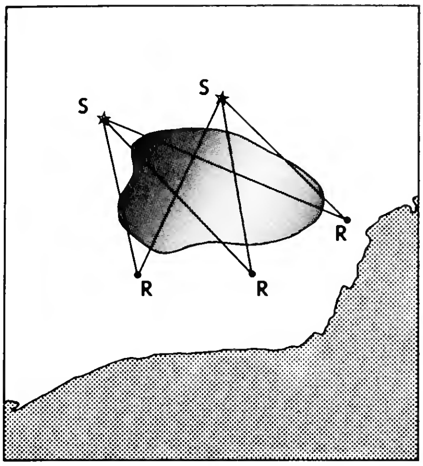
Acoustic tomography involves measuring variations in sound wave travel time between moored sources and receivers, and then using special mathematical methods to compute density and sound speed variations in the intervening ocean volume. The method is analogous to the medical CAT (computer-assisted tomography) scan procedure. Experimental results to date demonstrate the potential of tomography to monitor the ocean's mesoscale eddy field and to provide information on the dynamics of ocean fluctuations on a scale applicable to ASW.

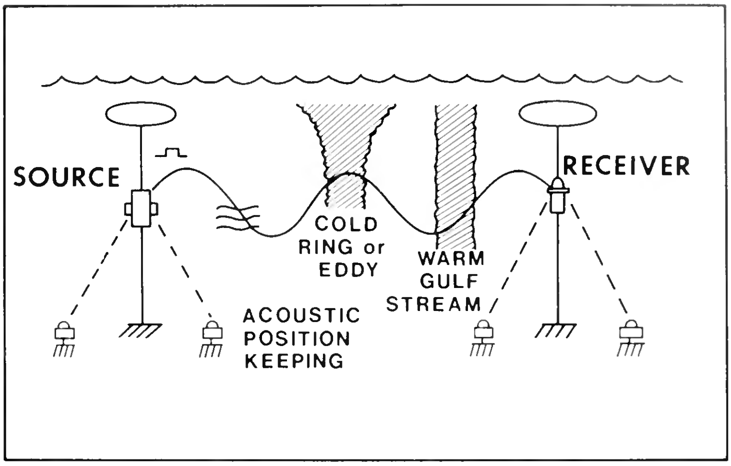
One of the Navy's goals in conducting research on the naval operating environment is to acquire improved predictive capabilities. Thus acoustic modeling is an important element of Navy ocean science. Although the basic physics of sound transmission in the ocean are understood, efforts are still required to improve the theoretical and empirical basis of acoustic models. To be realistic and reliable, models must be able to deal with complex, varying oceanographic conditions, and must be evaluated over a range of frequencies and situations.

Naval research programs in physical oceanography emphasize studies of the open ocean beyond the continental slope. Major research topics include general circulation, air-sea interaction, the deep-sea benthic boundary layer, numerical modeling, small-scale processes and upper ocean mixing, satellite applications, and mesoscale features. Programs will expand in the southern oceans and equatorial regions to test concepts developed in northern latitude research while investigating unique regional characteristics. Field observation will continue as the mainstay of physical oceanographic studies, supported by well-integrated theoretical, numerical, laboratory, and instrument-development efforts.

Physical oceanography in the 1980s will see a growth in interdisciplinary research. One noteworthy project is the study of air-sea interaction. The goal of this research is a better understanding of the transfer of kinetic energy, heat, momentum, and moisture across the air-sea interface, so as to construct more comprehensive and realistic models of the ocean.

The 1980s should also see major advances in numerical modeling. Large sets of oceanographic data obtained during the past decade are providing a





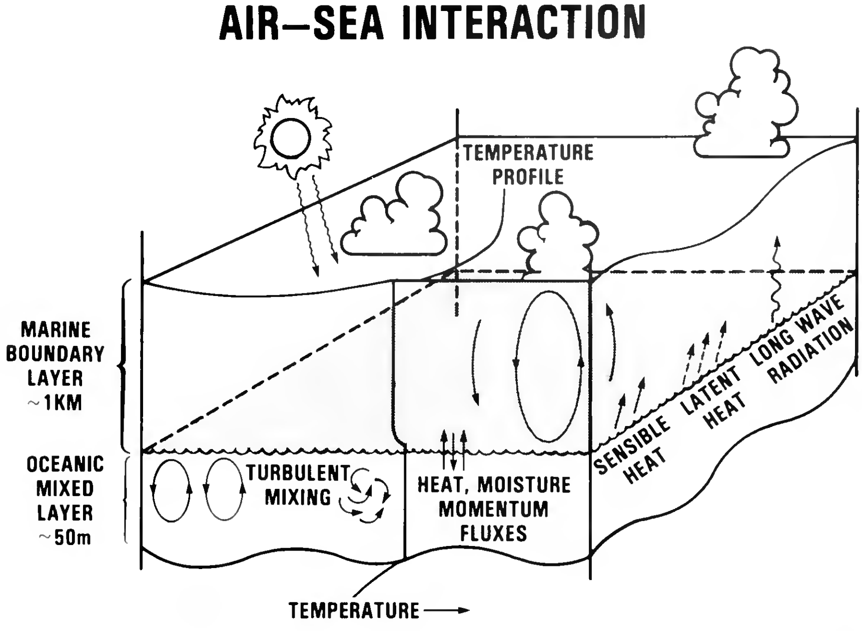
Acoustic tomography of the ocean became practicable with recent advances in computer, mooring, and acoustic technologies. These sketches depict a source-receiver field and the path between one of the source-receiver pairs. Transponders at the base of each mooring trace the movement of the suspended instrument.

basis for new progress. While advanced models are not yet practical on a global scale, work is under way on the development of regional, mesoscale, and upper-ocean mixed-layer models. In the future, large-scale numerical models should be able to assimilate satellite and ship data to analyze and predict ocean thermal structure in support of naval operations.

Another important research thrust will be directed toward gaining a better understanding of upper-ocean variability. The effects of weather on the ocean, properties of internal waves, spatial variability of temperature and salinity in frontal regions, and fine-structure variability are some of the subjects to be addressed.

Navy research in marine meteorology deals with the lower part of the troposphere over the oceans, known as the marine planetary boundary layer (MPBL). Scientists are interested in its interaction with the sea surface and associated weather phenomena. Mesoscale modeling, of high interest not just to the Navy but to the general scientific community, will be one of the primary thrusts of this research. Though superficially similar to synoptic modeling, mesoscale modeling represents a new order of technical difficulty, but the payoff will be the ability to accurately predict intense local weather events.

Oceanic biology covers many topics of interest to the Navy, including bioacoustics,



The active exchange of energy and moisture across the ocean surface makes for a complicated problem in numerical modeling.

biodeterioration, bioluminescence, zoogeography, physiology, behavior, and ecology. New acoustic and optical techniques for biological measurements will alleviate some of the inherent limitations of nets for sampling and the tedious work required to analyze the samples. Advanced measurement techniques, coupled with microprocessor technology, will make it possible to study many oceanic organisms in situ. Experiments will complement process-oriented physical oceanographic studies, thereby enabling a more comprehensive understanding of biological dynamics.

Advances in recombinant DNA technology, genetic engineering, and biochemical research promise new progress in the control of microorganisms that cause marine fouling. Efforts will be directed at understanding the genetic basis and biochemical pathways of "biofouling" and corrosion in the sea, and the possible use of biotechnology to control these costly problems.

Another new research effort involves studies of marine bioluminescence and the optical properties of the ocean. Using recently developed models of ecological succession, researchers will study the biological influences on light scattering, absorption, and luminescence.

In marine geology and geophysics, the development of plate tectonic theory during the 1960s and 70s and the data that has been accumulating during the last 30 years have established a basis for major new advances in the 1980s. Improved measurement technology will allow scientists to study features at both larger and smaller scales of resolution than in the past, and to put them into the context of global processes. Such studies are important for ASW, bottom engineering, navigation, and charting.

The *Argo/Jason* system, under development at the Woods Hole Oceanographic Institution, will provide a new capability for search and inspection in the mid-1980s, filling a range and resolution gap between current deep-ocean sonar and imaging systems (see *Oceanus*, Vol. 25, No. 1, p. 30). The installation of high-resolution multibeam echosounder systems, such as SEABEAM, in selected research vessels will provide high-quality bathymetric data for improving our understanding of the seafloor and for interfacing with *Argo/Jason*. The Deep Towed Array Geophysical System (DTAGS), under development at the Naval Ocean Research and Development Activity (NORDA) in Bay St. Louis, Mississippi, is a high-resolution geophysical system towed near the ocean bottom. It incorporates a high bandwidth, low-frequency sound source, a towed hydrophone array, and a high-data-rate communication system. DTAGS will help advance understanding of the geophysical and geoacoustic properties of the seafloor.

Multichannel reflection profiling, ocean-bottom hydrophones and seismographs, and ocean-bottom seismic sources will be applied to high-resolution, three-dimensional studies of the crust and upper mantle. New down-hole recording tools, such as the seismic data logger and borehole television, will aid in extending our knowledge to the deep crust.

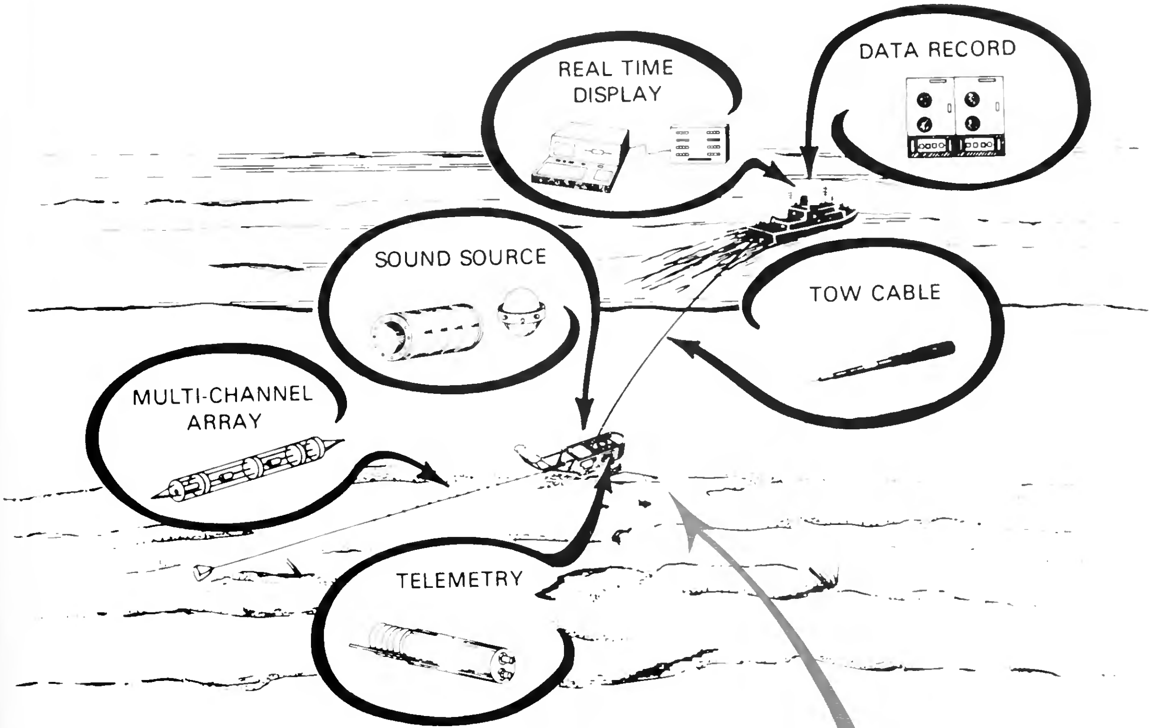
Satellite technology will benefit marine geology and geophysics in two ways. First, navigation with NAVSTAR will allow continuous fixes throughout the world and permit bottom sites to be relocated with confidence. Second, satellite observations of global gravity and geoid fields, combined with improved knowledge of crustal structure, will permit bathymetry to be inferred from satellite data.

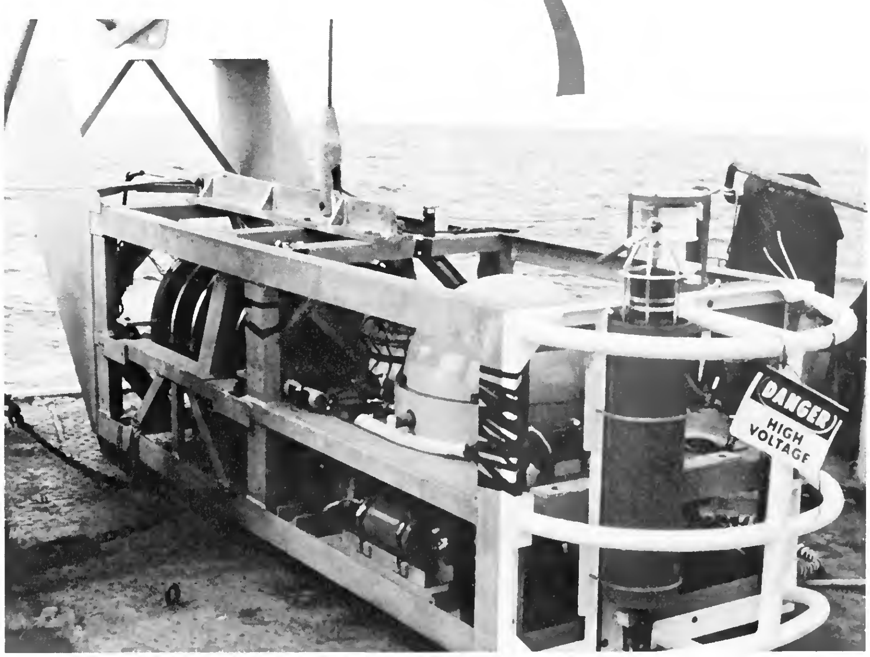
The technology of satellite remote sensing is likely to improve (see *Oceanus*, Vol. 24, No. 3). As in the past, it will be used to study ocean fronts, surface winds, internal waves, topographic and current variability, ice processes, and surface temperature distribution. Recently we have gained insights into the potential of synthetic aperture radar to observe surface waves, internal waves, current speed, and density structure. Other advances include the application of visible and infrared passive imaging to study oceanic processes and variability, and the use of microwave sensors to measure winds.

Microwave precision altimeters, in combination with satellite imagery and other data sources, will permit improved numerical models of the oceanic and marine boundary layers. Further development of such capabilities may lead to global, all-weather synoptic monitoring of oceanic processes. When combined with other techniques, such as acoustic tomography, the future for application of remote sensing is especially promising, both as a data source for supporting the fleet and as a research tool.

Robert D. Ballard, Associate Scientist at the Woods Hole Oceanographic Institution, with an early prototype of Jason, *a remote cable vehicle equipped with a television camera for an "eye." Deployed from* Argo, *a towed vehicle with an array of sonar and camera systems,* Jason *will one day eliminate the need for a human presence on the deep seafloor (see* Oceanus, *Vol. 25, No. 1, p. 30). (Photo by Ira Wyman)*

Deep-Towed Sub-Systems





With a hydrophone array up to 1,000 meters long and the capability to operate within 100 meters of the bottom at a depth of 6,000 meters, the Navy's Deep Towed Array Geophysical System (DTAGS) will provide detailed insights into the geoacoustic properties and sedimentary structure of the ocean floor. (Courtesy of NORDA)

Concerns for the Future

The Navy's ocean science program in the 1980s will continue to build on past progress while also growing in some new directions, reflecting new needs. Although there is cause for optimism, there are many challenges. To be healthy and robust, the program must have adequate funding and facilities, make efficient use of costly resources, and be responsive to mission requirements, all the while remaining flexible enough to respond to unexpected discoveries. Taken together, these requirements comprise a difficult order.

As naval systems become more complex, the incorporation of scientific advances into systems development and operation requires close interaction between naval oceanographers, systems developers, and fleet commanders. The fleet users must have the best possible characterization of the environment in their operations plans, while the designers must have a clear and early articulation of the oceanographic considerations to be factored into systems design and development. Promoting the necessary dialogue is one of the continuing challenges.

The high cost of maintaining an oceanographic research fleet is a major concern. The Navy requires research vessels capable of operating anywhere in the world, with a proper balance between large and small ships and between general purpose and specially configured vessels. The viability of this fleet is crucial, as an ocean science program cannot succeed without ships. Yet, during the last 10 years, the Navy had to reduce its research fleet by five ships. This reduction paralleled the general decline in the size of the national oceanographic fleet caused by increased costs, obsolescence, and constrained budgets. Pressures to economize and optimize ship use will continue during the 1980s, and fundamental changes in the composition of the national fleet are likely during the next few years. Navy assets are national assets, and the Navy, other federal agencies, and national organizations are jointly trying to address this concern.

Advances in data collection capability tend to be expensive and can create complex problems in data handling, storage, retrieval, and utilization. For example, the advent of satellite remote sensing, while promising to provide new opportunities to study the ocean, also presents the challenges of effectively handling the voluminous data flows and of correctly defining measurement requirements, to avoid unnecessary costs. In addition, major at-sea multiplatform experiments are costly. We may have reached the point where large-scale experiments like those done in the past are no longer affordable. Moreover, there is concern that in some instances we have not effectively utilized data that already exists. The increasingly high cost of obtaining new data demands good management of limited assets and existing data.

Central to all these issues is the basic problem of fiscal climate. Research budgets during the last 10 to 15 years have been severely constrained. Growth of a 600-ship Navy and development of new, costly systems, while generating increased needs for oceanographic research, is expensive and makes budgetary increases for research difficult.

These cautionary words notwithstanding, ocean science will continue to play an important part in this country's military use of the ocean. The Navy is committed to conducting a vigorous program to support its mission and to meet the scientific challenges of the 1980s, thereby contributing to an important national enterprise.

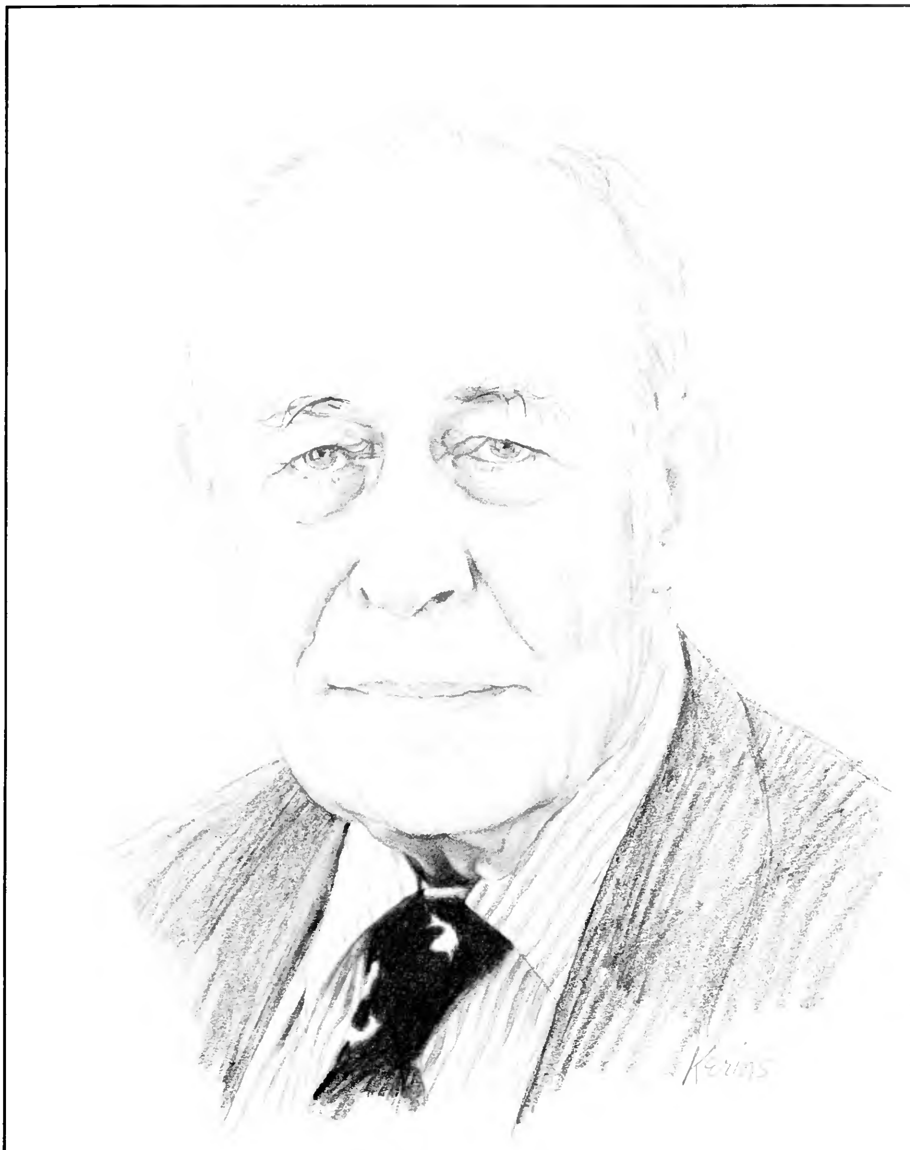
Robert S. Winokur is Assistant Technical Director for Ocean Science under the Chief of Naval Research in Washington, D.C. Commander Rene Gonzalez, USN, is Special Assistant for Ocean Science under the Chief of Naval Research.

Acknowledgment
The authors wish to acknowledge valuable contributions from their colleagues at the Office of Naval Research, the Naval Ocean Research and Development Activity, and the Naval Research Laboratory.

References

Kerr, R. A. 1982. Acoustic tomography of the ocean. *Science* 271: 38.
Kollmorgen, L. S. 1982. Research or relevant investigation — is there a difference? *Sea Technology*, January 1982: 21.
Lehman, John. 1982. Going for the high ground in the deep seas. *Marine Technology Society Journal* 16(2): 3.
MacLeish, W. H., ed. 1981. *Oceanus* 24(3).
Morse, R. W. 1977. Acoustics and submarine warfare. *Oceanus* 20(2): 67–75.
Ryan, P. R., ed. 1982. *Oceanus* 25(1).
Twitchell, P. F. 1982. Remote sensing research. *Naval Research Reviews* 34(1): 2–5.
Weinberger, C. W. 1982. *Secretary of Defense Annual Report to the Congress, Fiscal Year 1983.* Washington, D.C.: U.S. Government Printing Office.
White, A. E. ed. 1975. *The Ocean Science Program of the U.S. Navy.* Washington, D.C.: Department of the Navy.

profile **Roger Revelle**



Sketch by Charles Kerins

Senior Senator of Science

by William H. MacLeish

From any angle, Roger Revelle is an eminence. If you survey him, from his great shoes to his sharply stooped shoulders, you can see that once he was a very big man. And indeed he was. On occasion in his early days, he obligingly planted himself in the cold surf of California so his colleagues could use him as a two-meter wave staff. And if you review his career — no, his suite of careers — you can see that at 73 Revelle is now a senior senator of science, giving counsel and guiding projects in that ill-defined but increasingly important borderland between research and public policy.

Oceanographers tend to think of Revelle as the man who was Director of Scripps Institution of Oceanography during the 1950s and early 1960s, a time when marine science was experiencing one of its most impressive growth spurts. Some practitioners remember that when *Time* magazine decided to do a feature piece on oceanography in 1958, two men were selected as possibilities for the cover portrait. One was Revelle, the other Columbus Iselin, Director of the younger and smaller but independent Woods Hole Oceanographic Institution (Scripps is part of the University of California system). The choice could have gone either way. It went to Iselin, the remarkable sailor-scientist who died in 1971 at the age of 67.

But the sea is only part of this story. Revelle has helped to found a new university. He has advised developing nations, on problems ranging from agriculture to education to energy to population. He has helped establish the international machinery of oceanography. And he is an expert on one of the most powerful long-term effects of global industrialization — the rising levels of carbon dioxide in the atmosphere caused by the burning of fossil fuels.

Revelle was in Halifax, Nova Scotia, this past summer for the Joint Oceanographic Assembly when we caught up with each other. He was walled in by planning meetings and strategy sessions, but was free for a Sunday breakfast. We met in the coffee shop of one of the larger hotels in Halifax. Revelle ordered a large breakfast and sat down to regard me with eyes that, somehow, looked hooded and candid at the same time. He allowed as how he really isn't much in touch with the frontiers of oceanography these days.

"I went to a physical oceanography meeting in Tokyo and could only understand about 10 per cent of what was said. The young people have gotten so far ahead of my generation — in mathematics, in understanding hydrodynamics." The same, he said, was true of the group of modellers and mathematicians then gathered in Halifax to study oceanographic aspects of climatic change. I asked if he didn't happen to chair that group of geniuses. Yes, he said, for the past three years. "They need an old man like me to get 'em started."

Revelle himself got started in marine science by what he calls a series of lucky accidents. He was in Berkeley, a graduate student in geology, when the then director of Scripps dropped by shopping for someone to work on some deep-sea muds awaiting analysis back in La Jolla. "I applied for the job," said Revelle, "because I was about to get married to a girl who was born in La Jolla. I thought it would be nice to spend the first year of our married life in the place we'd gone to in the summers." Revelle did not mention that his bride's grandfather was James E. Scripps, founder of the newspaper dynasty.

"Like many big men he tended to be clumsy. You could tell pretty well where he was on the ship by the thumping noise on the overhead."

The Revelles settled in during the summer of 1931. Two weeks after he arrived, he got his first taste of life aboard a research vessel, a small converted purse seiner. They putted out to the San Diego Trough, where the larval oceanographer occupied his first station, catching water, sampling plankton, taking temperatures — and cooking.

"Scripps always feeds well," Revelle told me. "I cooked what I thought was a first-rate lunch of steak and boiled potatoes and sliced tomatoes. Everyone came down to the galley and wolfed the meal down in complete silence, as sailors do. Then they stood up, told me it was making them seasick down there. They went topside, saying I could wash the dishes." He did, and by the time the boat tied up that evening, back in San Diego, Revelle had decided something: "They were never going to get rid of me at the Scripps Institution; I had just had the best time of my life."

Revelle revelled. "I worked on the solubility of calcium carbonate in seawater, and the way carbon dioxide and boric acid buffer the seawater, maintaining the pH. I got involved in a little bit of physical oceanography and chemical oceanography. And I never really looked at those goddamn muds."

He did eventually. He wrote his dissertation on them and in 1936 got his Ph.D. "It wasn't a very good dissertation," he said. "But since I was determined not to leave, they decided they might as well put me on the faculty. I became an instructor instead of a research assistant. They raised my salary by 50 percent, from a hundred to a hundred and fifty dollars a month."

Revelle was spending perhaps a quarter of his time at sea. "Like many big men," a colleague recalls, "he tended to be clumsy. You could tell pretty well where he was on the ship by the thumping noise on the overhead." The old purse seiner had blown up, killing one crew member and maiming the other. The replacement, the *E. W. Scripps,* was a topmast schooner that had belonged to a movie actor. Refitted for oceanography, she plied the coastal waters from Baja California to southern Oregon. The Scripps Institution stayed within 200 miles of the North American coast until after World War II. Its first real venture into blue water came in 1950, when Revelle organized an expedition to the mid-Pacific. He became acting director of Scripps that year and the genuine article the next.

Administrative demands curbed Revelle's research a good deal. He worked with others on heat flow through the seafloor, on the interrelationships of sea level and the spin of the earth, and on carbon dioxide in the atmosphere. Drawing on his earlier work on the carbon mechanism, Revelle came to realize that "most of the CO_2 released by fossil fuels would stay in the air and not get into the water. Up until that time, everybody thought almost all of it would go into the ocean. We were able to show that only about half would go in, perhaps even less. That was quite an important paper."

"Roger is not always the most tactful man. When you have strong beliefs, you annoy more and more people over the years. They forget their agreements with you and remember the disagreements, and before long you've lost your brownie points."

According to some who have worked with him, Revelle the scientist has the habit, at once admirable and frustrating, of not letting go of a piece of work until he has squeezed it dry. "He's a perfectionist," says one. "But put in another sense, that also means he procrastinates. To do anything with him takes a helluva long time. I don't know if the result is any better in the end, because if you delay for too long a time you lose the thread of thought."

Walter Munk of Scripps, himself an oceanographic eminence, admits to "total prejudice" in his admiration for Revelle, whom he first met in 1939. Munk worked with Revelle on various aspects of nuclear bomb testing in the Pacific, on carbon dioxide problems, and on the sea level–spin rate problem. "He collects huge amounts of materials and reads them all, making long and complicated notes. He doesn't follow through, I think, by deductive logic. He's more like Conan Doyle. He assimilates a large body of evidence and then eliminates the unlikely."

Revelle's deliberativeness often seemed to affect the pace of his decision-making as director of Scripps, according to critics. But in another field, it brought him remarkable success. In the mid-1950s, when Clark Kerr, then president of the University of California, wanted to start a new campus near San Diego, he turned to Revelle for help. "I didn't exactly abandon Scripps," Revelle said, "but my principal activity was starting the new university."

Revelle went head-hunting. "The whole magic of his recruiting was very simple," says Munk. "He asked himself: what can we do to help this person perform better than he does in his present position? Roger listens well. He comes to know what people want to do, often better than they do themselves. That is how he was able to get some very remarkable individuals to pull up stakes and risk this educational adventure in a small California town."

One problem was the site of the adventure. Revelle wanted it right next to Scripps, "so as to start off with a bang and not like some struggling liberal arts college." The opposition was powerful. There was talk that Revelle's site was too close to San Diego flight paths and would require expensive soundproofing of buildings. But Revelle got ahold of a letter from a planning expert stating that a hospital scheduled to go up on a site even closer to the airport flight patterns should have no problem with noise. Two things happened. Revelle got his site for the University of California at San Diego. In so doing, he lost the job most thought he should get: the chancellorship of the new campus.

"Roger is not always the most tactful man," says Munk. "When you have strong beliefs, you annoy more and more people over the years. They forget their agreements with you and remember the disagreements, and before long you've lost your brownie points." The chancellorship went to Herbert York, now a colleague and close friend of Revelle. The Regents named the first college of the new university after Revelle.

To give York a free hand at La Jolla, and to give himself a change of pace, Revelle went to Washington, D.C., ostensibly as science advisor to John Kennedy's Secretary of the Interior, Stewart Udall. He ended up working more closely with Kennedy's own science advisor, Jerome Wiesner. Before he knew it, Revelle was working on problems of waterlogging and salinity in the Indus plain of West Pakistan. "I think the way it happened," he told me, "is that Jerry said 'Aha! We've got Roger. He's an oceanographer. He knows something about salt. Let's put him in charge of this.' "

Revelle and his multidisciplinary team soon discovered that the waterlogging problem could be addressed with modern agricultural techniques. The real problem was population growth pressing down on primitive technology. The interactions of food, education, and population trends fascinated Revelle. It led to his accepting, in 1964, the suggestion of several members of his Pakistan team that he come to Harvard to run a university-wide center for population studies. He stayed for 14 years.

"I never was a demographer or a family planning expert," he said. "I didn't think family planning was a university subject. What I was concerned about was resources, the kind of thing we'd done in Pakistan. We organized quite a group of people in a systematic approach to land, water, and energy. My idea was to concentrate on the population you're going to have rather than on methods of reducing population. When you provide education and give people mobility and hope, they'll have fewer children."

"I am thinking about the possibility of an ice-free Arctic Ocean and its effect on hydrology, on agriculture."

Our breakfast was finished. Revelle led the way to his hotel room, where resource maps lay like throw rugs on the floor. He exchanged his cigarettes for a pipe that wouldn't stay lit. He described his current work as professor of science and public policy at the University of California, San Diego — the place he founded. He teaches three courses there. He also works on energy and resources, particularly those in developing countries, and on the carbon dioxide problem. "I've stayed with oceanography mostly on a friendly or bureaucratic basis," he told me, and then outlined a series of huge oceanographic experiments planned for later in the decade. One will rely on remote sensing from satellites and acoustic measurement of seawater properties.

"I'm a member of the carbon dioxide assessment committee of the National Academy of Sciences," Revelle said, fiddling with his pipe. "My particular responsibility is all the odds and ends, especially concerning the polar ice caps. I am thinking about the possibility of an ice-free Arctic Ocean and its effects on hydrology, on agriculture. A report on that and related work is due in a year or so. Meantime, the theory that a doubling of carbon dioxide in the atmosphere would cause a two- or three-degree temperature rise globally is bearing up well under tough examination."

"It's going to happen if we keep on burning fossil fuel. It's a game in which some countries will win and others will lose. Probably the Soviet Union will be among the winners. They'll have a longer growing season, and a lot of their northern lands will be cultivatable. Canada also. The U.S. is liable to lose, because we're in latitudes where precipitation is likely to decrease — particularly in the corn belt. Sea-level rise is also a possibility with the warming. The question is how fast it will occur. If it happens over two hundred years, it would inundate a lot of places faster than people could easily adjust: practically all of the Netherlands, most of Bangladesh, most of Florida, a lot of big cities."

It was getting on to mid-morning. I stepped over the maps on my way to the door, and I couldn't hold back a remark about how much my host had done with his life. "Well," said Revelle, again with that gentle self-deprecation that can come with his kind of accomplishment, "I've lived a long time."

William H. MacLeish is a former Editor of Oceanus. *He is now writing a book about Georges Bank and serving the magazine as Consultant.*

Announcement:

Advertising/Information Section

With the next issue, we begin a full-scale adventure in paid advertising (actually, we accepted a few ads for this issue from advertisers who had specific deadlines to consider). We are accepting advertising for two basic reasons. First, the revenue will help us meet some of our rising costs. Second, we see advertising in *Oceanus* as an extension of our editorial matter in that the ads will give you additional information about the business side of Oceanography. If you are interested in books about the seas, or the marine programs of universities and institutions, or the latest instruments for laboratories or ocean research vessels, then you will find advertising messages about them to be a service. For these reasons, we welcome such advertising to our pages. We hope you will, too. Should you be interested in advertising, contact Lexes Coates, *Oceanus* magazine, WHOI, Woods Hole, MA 02543 or call (617) 548-1400, ext. 2393.

concerns

The Cessation of Commercial Whaling

Supporters of ban on commercial whaling celebrate outside Metropole Hotel in Brighton, England, after International Whaling Commission vote on July 23, 1982. (Photo by Pierre Gleizes — Greenpeace)

The problem of the over-exploitation of whales is one example of the complexities associated with the international nature of a marine resource. The problem combines a wide range of scientific, technological, political, economic, legal, diplomatic, and marine policy concerns that will fall under the new Law of the Sea Convention when and if it is ratified (see page 7). This article addresses the recent decision of the International Whaling Commission (IWC) for a cessation of commercial whaling, and, although not exhaustive, it attempts to give an idea of the difficulties in making a majority vote represent, in practice, an effective protection for one of the most remarkable groups of animals on earth.

A Little History

During the 1972 United Nations Conference on the Human Environment held in Stockholm, Sweden, 53 countries adopted a United States proposal calling for a 10-year moratorium on all commercial whaling. This expression of international concern over a dramatic decline in whale populations was described in the Japanese media as a U.S. maneuver to distract world attention from the problems of the Vietnam war. The next year, the United States formally proposed a moratorium on the International Whaling Commission agenda, and, in 1974, Australia called for an indefinite moratorium for all whale populations that had fallen below the level of maximum sustainable yield.

By 1975, the IWC established a New Management Procedure (NMP) which allowed catch quotas by species and stocks based on the best available scientific evidence. The NMP resulted in a rapid decline of quotas and the protection of highly depleted stocks. In fact, the whale catch in 1982 was about 14,000, compared to more than 45,000 whales in 1974.

In 1979, the IWC approved a ban on pelagic whaling by factory ships, except for minke whales. Also in 1979, a meeting of the Convention on the International Trade in Endangered Species (CITES), held in Costa Rica, adopted a proposal for the inclusion of the entire cetacean order in Appendix II (threatened species) of the Convention. By then, there was growing international awareness that whales were not the property of the nations that killed them, but that they represented, in the thinking of Arvid Pardo, the common heritage of mankind. In the meantime, the IWC membership grew, with the addition of such whaling nations as Spain, South Korea, Peru, and Chile, plus Switzerland (which supported the moratorium), and other non-whaling nations.

This international awareness developed parallel to the Law of the Sea negotiations in which all countries were giving serious consideration to their rights to marine resources. By July, 1982, more than two-thirds of the world's population was represented in the IWC; new members included China, India, Monaco, Egypt, St. Lucia, Kenya, the Philippines, Senegal, St. Vincent and the Grenadines, Costa Rica, West Germany, Uruguay, Dominica, Belize, and Antigua and Barbuda. This new membership shifted the traditional balance of power in the Commission.

The IWC's Scientific Committee makes recommendations, reflecting both whaling and non-whaling points of view, to the Technical Committee, where recommendations are adopted by a simple majority. These recommendations are put forward to a Plenary Session that requires a three-fourths majority for the adoption of a resolution. In 1980, there were 25 member countries. The nine remaining whaling nations — Brazil, Chile, South Korea, Iceland, Japan, Spain, Norway, Peru, and the Soviet Union — could block the conservation-minded nations because the majority rule required at least 27 votes to pass a ban on commercial whaling.

Japanese workers crating whale meat for sale in Japan. (Photo by Rebecca Clark, Greenpeace)

In February, 1981, an extremely important event took place. West Germany, in a meeting held in India, proposed the inclusion of the sperm, sei, and fin whales in Appendix I (endangered species) of the CITES Convention. All member nations supported the proposal with the exception of Japan. Listing in Appendix I prohibits all trade in an endangered species. The vote included Brazil, Peru, Chile, and other nations, which, in view of the highly depleted status of all sperm, sei, and fin-whale stocks, supported their inclusion in Appendix I.

At the July, 1981, meeting of the IWC, a proposal was put forth for a 0 quota for sperm whales, with a provisional 0 quota for the northwest Pacific stock (the Japanese fishing grounds), pending the result of a special meeting called by Japan for March, 1982, to examine the status of that stock. The 0 quota was approved by a vote of 25 to 1 (Brazil, Chile, South Korea, Peru, and Spain supporting it; Japan casting the only negative vote). During the meeting, another important proposal was adopted by consensus: a ban, beginning with the 1982/83 pelagic and the 1983 coastal whaling seasons, on the use of the nonexplosive (cold) grenade harpoon used to kill, with prolonged suffering, the relatively small minke whales.

The sperm whale and cold harpoon decisions were part of a negotiated compromise in which whaling nations agreed to support the proposals and not object later on the condition that they would be allowed a higher quota for the next year. In fact, an increase in the minke whales quota (1,030, Southern Hemisphere) was the price that conservationist countries had to pay for the passage of the sperm whale and cold harpoon bans. Subsequently, Japan, Norway, Brazil, and the Soviet Union (but not South Korea) filed objections to the cold harpoon ban despite the previous agreements.

At the special IWC meeting in March to review the scientific information on the northwest Pacific sperm whales, Japan presented a population estimate that would allow for the taking of 890 whales in the 1982/83 coastal season. The other members of the Scientific Committee presented a recommendation for a 0 quota. There was no agreement, and the matter was postponed until the July, 1982, annual meeting. At that time, the Technical Committee finally approved the recommendation for a 0 quota.

During 1981 and early 1982, three other isolated but important events took place: 1) the European Parliament banned, as of January 1, 1982, the import into the European Economic Community (EEC) of any whale products; 2) the Spanish Parliament approved a moratorium on whaling; and 3) the government of Chile indicated that it would impose sanctions on that country's only whaling company, and that no new permits for whaling would be approved, because of serious infractions made by the company. In essence, these events meant that the whaling block of nine countries might be reduced to seven, or even six. With only six votes, the whaling nations could be overcome by a majority of only 18 nations. In other words, for the first time in the history of whaling and the IWC, a moratorium was not only possible but probable.

International Pressures

The uncertainty surrounding the outcome of the July, 1982, meeting in Brighton, England, had interesting consequences. The most concerned country, of course, was Japan, the main buyer of whale products. Japan's Prime Minister at that time, Zenko Suzuki, had close political and personal ties with the whaling industry. On March 17, 1982, Suzuki addressed the Diet, attacking the anti-whaling movement and stating that "we are promoting various public relations activities through diplomatic channels in the non-whaling countries. The government is ready to further efforts for protecting and fostering the whaling industry."

Such a statement was a reminder of the extent of Japan's "public relations." In 1978, for example, Japan threatened to cancel a $9.7 million sugar deal with Panama unless that country dropped a proposal at the IWC for a whaling moratorium. Panama not only dropped the proposal, it withdrew from the IWC.

During 1981 and 1982, Japan's diplomatic missions pressured IWC members in a variety of ways. An example is Jamaica, which played a leading conservationist role at the 1981 meeting. Japan threatened to cancel the purchase of Jamaican coffee; the Jamaican government subsequently did not permit their commissioner to attend the special meeting on sperm whales in March of 1982. Coincidentally, he was invited to visit Japan on the same dates as the sperm whale meeting. The commissioner declined the invitation. Jamaica did not attend the 1982 regular annual meeting either. If the change in Jamaica's marine policy is due to external pressure, it sets an unfortunate precedent for the country that probably will become the headquarters for the Law of the Sea Treaty's International Seabed Authority.

Prior to the July, 1982, IWC meeting, Suzuki visited Brazil (which abstained on the moratorium vote in 1981) and Peru, signing several aid agreements and publicly requesting an "understanding" of Japan's whaling position. In Brazil, the Japanese tied a $400 million agricultural investment program to Brazil's vote at the IWC. In 1982, Brazil changed its 1981 abstention and voted against the cessation of whaling despite strong public support at home for an end to whaling. Other examples of Japanese political and economic pressure on the whaling issue can be found in public accounts of events in the Seychelles, the Philippines, Costa

Rica, Antigua and Barbuda, St. Lucia, and Switzerland. Suzuki's unexpected announcement, on October 12, 1982, that he would step down as prime minister may be partly related to his failure to counter, as promised, international opposition to Japan's whaling interests.

The Vote

All whale populations have been heavily exploited and almost all are seriously depleted. Scientific uncertainties, meanwhile, are very great. The assumptions made for estimating the population dynamics of whale stocks and their exploitation are highly questionable on both biological and statistical grounds. In addition, there are critical difficulties with models where data has been withheld or is inaccurate. However, the data on pregnancy rates, recruitment, differences in catches by sex, growth, stock definition and boundaries, migration, mortality, and behavior all suggest that commercial whaling should stop. Furthermore, commercial whaling is not the only factor operating against the survival of whales. Other threats are decreases in the availability of food due to fishing, pollution, increased shipping traffic, high noise levels in the sea, and pirate whaling.

At the 34th annual meeting of the IWC in July of 1982, the countries that had submitted proposals for a total ban on whaling withdrew them in favor of a proposal put forward by the delegation from the Seychelles:

> *Notwithstanding the other provisions of paragraph 10,* catch limits for the killing for commercial purposes of whales from all stocks for the 1986 coastal and the 1985/86 pelagic seasons and thereafter will be zero. This provision will be kept under review, based upon the best scientific advice, and, by 1990 at the latest, the Commission will undertake a comprehensive assessment of this decision on whale stocks and consider modifications of this provision and the establishment of other catch limits.*

The vote, on July 23, was: *In Favor,* Antigua and Barbuda, Argentina, Australia, Belize, Costa Rica, Denmark, Egypt, West Germany, France, Kenya, the Netherlands, India, Mexico, Monaco, New Zealand, Oman, Senegal, St. Lucia, St. Vincent and the Grenadines, Spain, the Seychelles, Sweden, the United States, Britain, and Uruguay. *Against:* Japan, Peru, Iceland, the Soviet Union, Norway, South Korea, and Brazil. *Abstaining:* China, Switzerland, Chile, South Africa, and the Philippines. *Absent:* Dominica and Jamaica.

The proposal, approved by a 25 to 7 vote, has four main advantages: 1) it is not an indefinite moratorium, 2) it allows the whaling industries a phase-out period, 3) it supports the work of the IWC and its Scientific Committee, and 4) it provides for a comprehensive review of the stocks by 1990.

Will World Opinion Prevail?

The initial 90-day objection period for the IWC expired on November 4, 1982. Four governments filed objections to the vote: Japan, as a controversial (in Japan) lame-duck action at the end of Suzuki's government; Norway, despite lawsuits against the government for acting contrary to the country's animal cruelty laws; Peru, where the only whaling company is a subsidiary of a Japanese fishing conglomerate; and the Soviet Union. The IWC decision will be binding if these countries withdraw their objections.

The only significant sanctions that can be imposed on countries defying the ban are based on U.S. legislation — the Pelly amendment to the Fisherman's Protection Act of 1971 and the Packwood-Magnuson amendment to the Fishery Conservation and Management Act of 1976. These amendments allow the United States to embargo fisheries imports from countries conducting fisheries operations that diminish the effectiveness of any international conservation program, and to cut by 50 percent or more a nation's fisheries allocations in the U.S. Fishery Conservation Zone if the country engages in trade that diminishes the effectiveness of the International Convention for the Regulation of Whaling. Japan imports the vast majority of whale meat caught by companies in other whaling nations. The U.S. Senate made it absolutely clear to whaling countries that it would use the Pelly and Packwood-Magnuson amendments to the fullest extent if there were objections to the IWC decision.

Since the 1972 Stockholm resolution calling for an end to commercial whaling, more than 300,000 whales have been killed. Until the IWC decision comes into effect, perhaps another 20,000 could be slaughtered. As Prince Philip, Duke of Edinburgh and President of the World Wildlife Fund, said, we have now achieved an important vote in the IWC, but what really matters is not the vote but the protection of the remaining whales.

The end of an anachronistic slaughter is in sight. What is needed most now is 1) U.S. determination to sanction countries that defy the IWC decision, 2) a growing number of nations in the IWC committed to protect whales, and 3) a commitment by all nations to preserve for future generations all endangered wildlife. Turtles, seals, manatees, orchids, elephants, caimans, parrots, and many other species and ecosystems are also threatened. Therein lies one of the most important biological challenges of our generation.

Francisco J. Palacio, Director, Tinker Center for Coastal Studies in Latin America, Rosenstiel School of Marine and Atmospheric Science, Univeristy of Miami, Florida.

The views presented in this article are the author's and do not necessarily reflect those of the institutions or other groups with which he is associated. Dr. Palacio represented the International Union for the Conservation of Nature (IUCN) at the 1982 annual meeting of the IWC.

*Paragraph 10 refers to the management procedures for the classification of stocks.

concerns

Women in Oceanography

"You know how perverse women are," one distinguished male oceanographer wrote to another in 1949. "If we made a policy prohibiting them from going out on the ships, we would find two or three in the chain locker every time we cleared the whistling buoy." Not wanting to appear closed-minded, this gentleman-scientist urged his colleague to "consider each situation on its merits," but followed with an entreaty to "think up reasons whenever possible to discourage women from participating in the work at sea," concluding: "An unwritten policy which does not prohibit but subtly discourages their presence will best achieve our rather dubious ends."

American society has changed since then. Although there are a few complaints from women in oceanography today, there is little bitterness. Women are not altogether new to the field. Many have made distinguished names for themselves — the list is long, and growing daily. Though this brief article cannot be a comprehensive history, it is worth noting that the early rosters of the first marine science laboratories in the United States show a healthy number of female biologists, and indeed the life sciences have always been more open to women than some other disciplines. It is the physical sciences — the "hard sciences," as men like to call them — that are just now getting their first women practitioners. In physical oceanography, marine geology and geophysics, and ocean engineering departments, for instance, it is still unusual to find a woman, whether it be the scientific staff of a research institution or the faculty of a university.*

*In the decade of the 1920s, women earned 4.8 percent of the doctoral degrees granted in the earth and environmental sciences, according to the National Research Council. This figure dropped slightly in the 1930s, rallied to 5.7 percent in the 1940s, slumped to lows of 1.9 percent in the 1950s and 2.0 percent in the 1960s, and has been rising since, to 10.2 percent in 1980. For all the physical sciences, women earned 12.2 percent of the doctorates granted in 1980. This compares with 25.2 percent of doctorates awarded in the life sciences, 34.6 percent in the social sciences, and 39.6 percent in the arts and humanities.

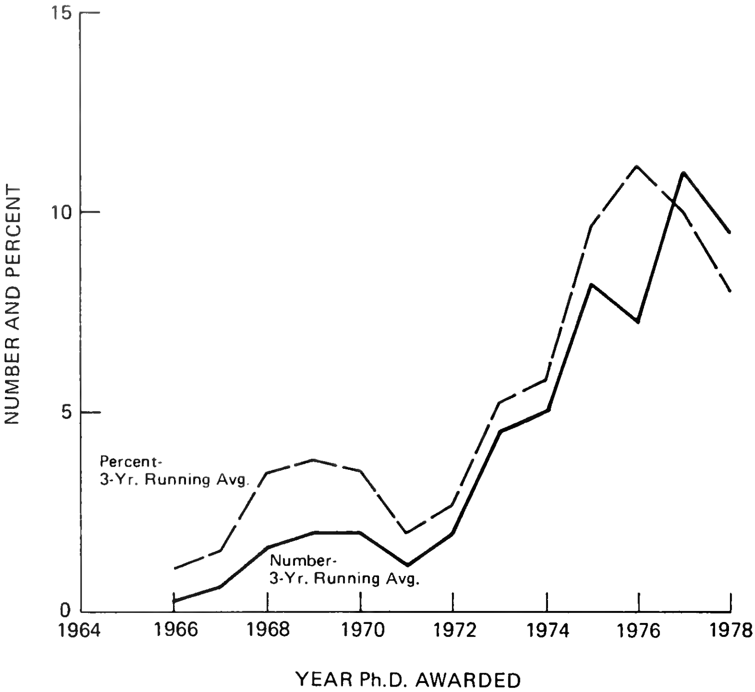
A summer class in "Invertebrates" at the Marine Biological Laboratory in Woods Hole, Massachusetts, in the 1890s. (Photo courtesy of MBL)

The number of oceanography doctoral degrees granted to women has gradually increased during the last 10 years. Figures for 1979 show that 9.4 percent of oceanographers were women, about halfway between the 5.7 and 15.1 percent totals for women scientists in the combined physical sciences and the combined life sciences, respectively. At the Woods Hole Oceanographic Institution (WHOI), there are presently six women (all in the chemistry and biology departments) on the 108-member resident scientific staff. Ten years ago (June 1, 1972) there were two women on a staff of 93.

Lawrence Peirson, registrar and assistant dean at WHOI, has been watching the trends. In the Institution's postdoctoral scholar program, there were only three women between 1961 (the first year of the program) and 1974, out of a total of 63. Since 1975, the program has averaged 23 percent women. Of the eight postdoctoral scholars now at WHOI, three are women. The Ph.D. candidates in the Institution's graduate program, a five-year course administered jointly with the Massachusetts Institute of Technology (MIT), are 33 percent women. And in the WHOI summer fellowship program for undergraduate students, the proportion of women applicants for the summer of 1982 reached a new high of 51 percent.

Then there are the salary figures. According to the U.S. Department of Labor, the earnings of women in 1981 in the life and physical sciences were 71 percent of the earnings of their male counterparts. The median weekly salary for men is substantially higher than for women, reflecting the fact that there are more men in senior positions. This comparison is for scientists only. Typical roles for women in science are still secretaries, technicians, and assistants.

Women interested in oceanography generally face three main obstacles. First, there is the problem of family obligations. Second, there is the longstanding tradition of male domination in the physical sciences. The scientists in most children's books are still men, and for decades schoolgirls were told they might as well not bother with higher mathematics. Finally, there is the whole mystique of men at sea, and that one dies hard.



The percentage of women receiving ocean science doctoral degrees in the United States has increased in the past decade. Because of the small number of individuals and a large year-to-year variability, three-year running averages are used to illustrate this trend. (From Doctoral Scientists in Oceanography, *National Academy Press, 1981)*

Judith Grassle, a biologist at the Marine Biological Laboratory in Woods Hole, Massachusetts, says there really isn't time to have both career and family, "but some women go ahead and do it anyway." Her choice to have just one child was a career-affected decision, she adds. "The problem I see is students who want to have a career and a family *and* they want to have a nice life as well. I think the nice life has to go by the boards."

One woman oceanographer remembers serving as the only female on a large committee to review applications for graduate school. One of the finalists, a man, had spent two years at home with his young children while his wife worked. In reviewing his file, the men on the committee saw those years as a detriment. The woman thinks this was a factor in the applicant's rejection, though only 20 percent of the finalists were accepted.

"No one would have cared if he had gone around the world hiking," says the woman, "but he decided, maybe for the only time in his life, to be there to watch his children grow up. One man said, 'That is what a woman does,' and that's when it really hit me that it's going to take a long time for this to become accepted; it's looked down upon by society. The family is still left up to the woman, so parental leave is an accepted thing only for a woman."

Some claim that many women have been turned down by graduate schools because of a longstanding male complaint that women graduate students are more likely to drop out before attaining their degree. Ironically, they sometimes drop out to become the wives of the scientists, professors, or admissions officers who voice such complaints. "It is tempting to go for that dream of settling down and starting a family," another woman told us, "as an escape from all the baloney you have to put up with to get through graduate school."

Some of the younger women scientists we spoke with mentioned the problem of self-worth. Unless a woman has an inner wellspring of self-confidence, they say, she is headed for a downward spiral, personally and professionally. The federal Affirmative Action Program, while bringing more women into the work force, has given some men the impression that unqualified women have been hired just because of their sex. Remarks such as "You won't have any trouble — you're a woman," which one scientist was told when she applied for a job and again when she was up for a promotion, can be demoralizing.

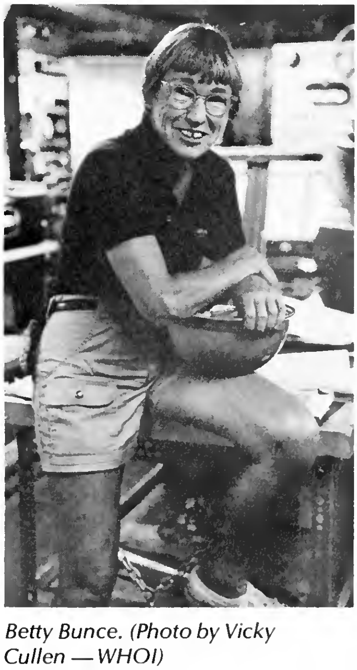
And there is the matter of looks. Woman scientists report that whether they are applying for graduate school, in line for a promotion, or presenting their life's work at a scientific meeting, men evaluate them for attractiveness as well as ability. One woman regularly sees letters of recommendation, from men on behalf of female applicants for graduate studies in oceanography, that mention the applicants' good looks. "They're really blatant," she says. "Some of them are so disgusting I just want to rip them up. They wouldn't think of saying that for a man."

It takes extra drive to overcome such obstacles. "Men, at this point in history, do not take women as seriously as they do another man," explains Ellen Druffel, a WHOI chemist. "You just have to compensate for it by being very competent. You can maintain their respect if you work at it — saying things twice and so on."

Thirty years ago, when a woman in oceanography was a real rarity, even more drive was required, according to Betty Bunce, one of two female scientists emeriti at WHOI. After running experiments on explosives for the Navy during World War II, Bunce went back to school for a master's degree in physics. Later, as a research associate back in Woods Hole, she passed a correspondence course in geophysical prospecting and taught herself seismic refraction. She recently came out of retirement to serve as Acting Chairman of the Geology and Geophysics Department on a part-time basis. Today's oceanography students have it easier, she says, pointing out the various fellowships and loan programs that did not exist when she was in school.

"My feeling is that if you put your mind to something, you can do it," says Bunce. "I never thought about my name being Betty instead of John — I did something because I wanted to do it. I'm not a women's libber." One of the first women to go out on a WHOI research vessel in the 1950s, Bunce was a minority of one on many cruises. "If you are going to sea with 50 men, you have to do something better than any one of them can do it," she advises.

Pat Biesiot, a WHOI–MIT graduate student, has noticed that a new female student gets more help. Because she is not expected to know already, all the men in the lab volunteer to teach her how to use the instruments. New male students, however, are on their



Betty Bunce. (Photo by Vicky Cullen — WHOI)

own. While this sort of polite condescension can be helpful at first, some women report that it works against them later in their careers. One scientist commented that women often lose credit for their own work. "When you team up collaboratively with a man, many assume that you are working for him instead of with him," she says. "And his reputation might swallow you."

Pioneers get lonely. The fewer women there are in a field, the less their needs and wishes are taken into account. But as women progress up through the ranks, it becomes easier to follow them. To have another woman nearby, especially one who has experienced the very frustrations you need to discuss, can be a confidence-builder. The most frequently cited problem for today's female oceanography students is the lack of role models.

Stephanie Pfirman is in her fourth year of the WHOI–MIT doctoral program. Specializing in marine sedimentology, she studies in the WHOI Geology and Geophysics Department, where nearly half the students are now women. Yet she never had a female professor in college, and she is usually the only woman on her scientific cruises. "Most men don't ever think about the role-model problem because there are so many other men around," she says.

Several of the women we talked to mentioned mothers or teachers who actively encouraged them to pursue a career in science. Indeed, the role-model issue touches on what could be the main reason there aren't more women in oceanography already — the lack of qualified female applicants.

Traditionally, our educational system, including family, counselors, teachers, and even textbook illustrators, has discouraged girls from succeeding at mathematics, the subject on which all the physical sciences hinge. The effect was to screen out future female scientists as early as junior high or even elementary school, simply because of the often subconscious though widespread perception that science was too hard for girls, and did not make for an appropriately feminine career goal anyway. Just suggesting this sort of thing to a child can have an impact, and of course most science and math teachers were men. Not until the 1960s was there a push for better science and math education that included girls as well as boys.

"I think the math block was real," says Bunce, recalling her college years. Women studying a science other than biology were frowned on, she adds. "They were not welcomed. They were discouraged. You just didn't compete with the men. Most gals didn't feature that they were going to have to earn a living; they were training to be wives and mothers."

What sets oceanography apart from other sciences is research at sea. It is here that women have made the most progress, but it has been a struggle. Up through the 1950s, research vessels were off limits to women, with a few exceptions. Gradually, more women scientists were allowed on cruises, but there are still restrictions at many universities and research institutions, and women crew members are extremely rare. Women were given all sorts of reasons for their exclusion. Probably the most commonly used were the lack of a special sleeping area or separate toilet facilities aboard ship. Lynda Murphy, a biologist with the Bigelow Laboratory for Ocean Sciences in West Boothbay Harbor, Maine, remembers being told as recently as 1966 that she could not go out on a National Oceanic and Atmospheric Administration ship because it was generally understood that the whole crew would walk off the job.

Naturally, those years had an effect on the careers of would-be women ocean-ographers. Those determined enough to stick with the field sometimes were diverted into clerical or editing jobs because they couldn't go to sea to make their own observations. A woman intent on doing research had to rely on men to take samples or readings according to her instructions. Bunce remembers how frustrating this could be. "They didn't take data the way I would have," she recalls. "There is only one way to take good data, and that's to go out and do it yourself."

Although accepted as the rules of the game by the few women oceanographers of the period, the exclusion from research vessels began to irritate some of the younger female students. One of these was a 23-year-old Radcliffe-Harvard graduate student who asked, in the summer of 1956, for permission to go out on a five-day WHOI cruise. The chief scientist for the cruise was her academic advisor at Harvard. When he turned her down, she appealed to the ship's captain and even to the director of the Institution, but the answer was "no" all around. Shortly before the vessel was scheduled to depart, she hid under its floorboards, just over the bilge, and stayed there 12 hours. Convinced she had waited until the ship was too far out to turn back, she came out of hiding, to the great surprise of the crew and scientific staff. The rumor, undenied by the chief scientist, is that she received a spanking from him.

Now a schoolteacher in Alaska, the stowaway regrets her action. She is convinced the angry backlash, in the form of a failing grade from a professor, cost her the master's degree she sought at Harvard. "It has made me very bitter after all these years," she told us. Enrolling in graduate school to study marine ecology, she did not learn of the unwritten men-only rule until she had paid her tuition and classes had begun. Her frustration led her to test and then to break the rule, as a protest. "I wanted to go because I was so interested in ocean-ography and I wanted to know more about it," she explains. "It wasn't just for fun; it was what I was interested in doing as a career." She finally attained the equivalent of a master's degree in 1981 at the University of Pennsylvania.

Richard Backus, a Senior Scientist at WHOI, has seen his colleagues gradually change their attitude since those days. "All the specific objections men had against women at sea were, one by one, proved to be superficial," he recalls. "For instance: they won't have separate toilet facilities. Well, you don't have separate toilet facilities for women at home either. The basic objection was that it was against tradition. Men defended the idea of the ship at sea as a male bastion. That's always been a reason for going to sea — to escape responsibilities — and those responsibilities involve women. Today women have made life at sea more like life ashore, with all the advantages and complications."

By 1964, the policy at some research institutions had loosened up enough for a student to be told by her supervisor that women were allowed on scientific cruises, but only if they were absolutely essential to the project.

"Nowadays if someone told that to a woman, they'd get punched in the nose," says Tanya Atwater, now a professor of geophysics at the University of California in Santa Barbara. "Men could go out for any reason at all, just to get the experience." A graduate of the Scripps Institution of Oceanography in La Jolla, Calif., Atwater eventually got her share of at-sea research, which she carries on today. She dove to the Galápagos hot vents in the WHOI submersible *Alvin*.

"Today there's a completely different feeling. The women feel like they have the right to be there [on a research vessel]." According to Atwater, the tables have turned: if a man denies a woman access to a research vessel, it is he who is challenged. "It used to be that the man was always right," she explains, "and the woman felt she might be a little crazy." She attributes the change directly to federal civil rights and equal employment opportunity legislation in the 1960s and early 1970s. "Some people say laws don't really make a difference, but I think they tend to set the spoken rhetoric in a society, and the rhetoric has a big influence on how a person feels about his or her acceptance in that society."

Though pleased with recent progress and optimistic about the future, Atwater is quick to point out that all is not yet rosy on today's oceanographic cruises. Because women are still a small minority in the field, there are bound to be problems, whether from short-sighted rules or insensitive men. Two rules that are still popular with administrators and ship captains often have the effect of keeping women off research vessels, sometimes "bumping" them from a cruise at the last minute: the requirement that there be an even number of women on board, so that each woman has a female roommate rather than rooming alone (called the "Noah's Ark theory" by its detractors), and its corollary, the taboo against a man and a woman sharing the same room unless they are married to each other.

Once a woman is granted accommodations aboard a research vessel these days, a remaining source of aggravation is the male mind. One woman, serving as chief scientist on a recent cruise, was busy organizing her project when the ship's captain brought her a pair of his ripped pants — he wanted them mended.

There is the pressure to prove you can work at sea, of course ("They're waiting for you to fall on your face," said one woman), and there is also the tightrope woman oceanographers walk between necessary assertiveness and what is seen by men as bitchiness. If a male scientist feels strongly enough to insist that certain work proceed in a particular way, an onlooker's response may be, "He really defends his project." The same insistence by a female scientist, however, can elicit a nasty remark such as, "That macho female."

The most common complaint we heard was that women at sea get too much attention. "You sort of feel like community property," says Maggie Goud, a WHOI–MIT doctoral student. "A lot of times you just get tired of always being in the spotlight; it starts to wear on your nerves. All your movements are watched so carefully. And if you ever get involved in a romance at sea, you must never display affection. There will be problems with gossip, jealousy, and morale, and it's always the woman's reputation that is at stake, along with her right to even be there."

The other side of the coin is that women now have the opportunity to "develop a kind of camaraderie at sea that is impossible in the day-to-day lab operation," as Goud put it. "It's sort of a club you're left out of if you don't go to sea."

Still another issue is the question of special treatment for women. On one cruise, four women oceanographers shared a cabin. One morning the ship's engineer knocked on the door and immediately walked in. He was there to fix the shower, but one woman, who was in her underwear, was so upset that she later wrote letters to higher-ups protesting the intrusion. "But that is exactly how the man would have entered men's quarters," one of the women points out. "The conflict is that a woman has to decide if she wants to be treated equally or specially. Here you are in a nontraditional field for women. You can't have it both ways. Every ship I've been on made an effort to give women the better accommodations. There is no reason for that. It is detrimental, in the long run, to the advancement of women."

The rewards and joys of scientific research — the unraveling of the mysteries of nature — are identical for men and women. And the call to "go down to the sea again" is just as strong for female oceanographers as it is for men. Some women we interviewed felt they had not been discriminated against in the least. One of these is Peggy Delaney, a fifth-year WHOI–MIT graduate student studying paleoceanography. "I think I've been lucky," she says. "I hesitate to say this, but I was talented; that made a lot of difference. We'll know we've really made it when women have the right to be mediocre at things."

In any case, the percentage of female students in oceanography continues to climb. As these students enter the job market in the next few years, they will test the commitment to fairness at research institutions, universities, government agencies, and corporations.

Marriages, too, will be tested, as more women search for ways to juggle an oceanographic career and a family. Joan Oltman-Shay, now in her fourth year of the doctoral program for applied ocean science at Scripps, sees herself as a fortunate beneficiary of the victories of the women's liberation movement. Yet she is likely to fight new battles of her own. Her husband, a geophysicist, is also an artist. It seems likely that he will someday quit his job to devote himself to his painting, and that would make her the breadwinner. "When I first accepted that, my stomach hurt for a few days," she says. Perhaps such marriages will bring about societal changes that will allow people still more freedom to choose their own roles, to live the lives they want to live.

— **Ben McKelway**

letters

To the Editor:

I would like to applaud John M. Teal's views, as expressed in your fall profile, regarding political involvement on the part of the scientific community. Having worked for Senator Lowell Weicker (R-Conn.) on the Clean Air Act during part of my year off from school, I was able to see firsthand the problems that arise when politicians make science policy decisions without an adequate background.

John Teal is right in saying that "you don't have much of an excuse for complaining about what is happening in society if you don't contribute." There is an urgent need for scientists to become involved and consequently take a much greater role in shaping the policies that shape our environment.

I sincerely hope that many other scientists will follow a path similar to that taken by John M. Teal and start to fill the void that is created by their absence.

Eric Jay Dolin,
Brown University,
Providence, Rhode Island

To the Editor:

The four pages of letters to the editor in your latest issue contained very little of value or interest. They might better have been devoted to a four-page article.

If you're going to continue to print letters to the editor, for Pete's sake, *be* an editor: cut them down to their essential content and eliminate those that just ramble on and say nothing.

One page of letters is enough, *not* four.

Carroll W. Dawson,
New York, New York

To the Editor:

I think that articles or, perhaps, entire issues of *Oceanus* on the following subjects would be of interest to your subscribers and other readers:

1) The international politics of the oceans, including territorial claims and jurisdictions, sharing (or not sharing) the oceans' resources, the provisions of any Law of the Sea agreements, and the Reagan Administration's refusal to support the current Law of the Sea agreement, the role of the UN (if any), implications for the United States' and other nations' naval strategies, and the means to enforce International Whaling Commission bans on whaling.

2) U.S. and Canadian university degree-granting programs in physical, biological, economic, and political oceanography, and information on any programs allowing for job experience as well as academic credits for entrance.

3) The sea-land interface and how it changes due to erosion and deposition, storms, rising sea levels (such as along the Delmarva Peninsula), and man's activities (dredging, filling, bulkheading).

4) Oceans as a recreation resource for sailing, surfing, swimming, fishing, and just enjoying the salt air and scenic beauty of coastal environments, including a capsule history of ocean resort communities.

5) Small oceanic islands: their unique features — physical, biological, and cultural.

John Sherman,
Dover, Delaware

To the Editor:

Having seen in practice (in the Fall, 1982 issue) some of the changes you suggested were in the wind, I offer some comment which I hope will be helpful.

I subscribed to *Oceanus* this year, as I subscribed to *Natural History* 14 years ago, because of sheer ignorance about oceanography. I read Susan Schlee's history when it first came out (history, I think, is the best way to approach any science), and I have followed the subject in popular articles and introductions to the subject written for laymen. The waters of oceanography do not, however, cover my feet. So subscribing to *Oceanus* was, for me, taking the plunge.

I can follow the articles in the first three issues I have received — somewhat uncertainly where the chemistry is involved — and would not want you to simplify. If I can understand, anyone can.

So far, I have been most fascinated with the nuts and bolts articles (such as submersibles in spring and Robert W. Knecht's discussion of methods of deep-sea mining in fall), but that may just be beginner's wide-eyed amazement, which may pass.

I am not so sure I need the "Concerns" section, though *Oceanus* might. Every publication needs a character it can get only through a few, anchored features. The book reviews, however, are a big plus from my standpoint; no one needs library help more than I do.

Contrary to the implication of my fellow Trentonian's letter in the Fall issue, I don't see how *Oceanus* can avoid articles on public policy, but its main thrust should be toward working science and research.

I know that it's the nature of sand to move, and, contrary to what F. W. Roebling III wrote about New Jersey's coastal management, the state is spending a lot of taxpayer dollars trying to prevent sand from moving. This may benefit someone — although King Canute didn't get far with a similar effort — but it isn't benefitting *this* taxpayer. If Senators Pell and Kennedy know anything about sand, this New Jerseyan would welcome their advice.

Tom Blackburn,
Trenton, New Jersey

To the Editor:

I am very interested in the ocean and sea. When I was 16, I had pimples. An old man gave me a small bottle of water. The bottle said "Black Sea" on it. He told me it was from the Black Sea. He told me to put the water on my face and my pimples would be gone. I thought to myself, "Sure, and I'm the Queen of England!" But I figured since I had tried everything else, I might as well try this. So I tried it and my pimples were gone in two days. I couldn't believe it! It was amazing. I'm 24 now, and to this day I can't find anything about this anywhere. I no longer have pimples, but I'd like to get my hands on some more of that stuff for my little sister.

Maryann Socha,
Sterling Heights, Michigan

To the Editor:

I became a subscriber to *Oceanus* for the first time this year. Please do not change a thing!

However, I see no harm in accepting advertisements if that will help pay the costs of printing. *Scientific American* is no less scientific for printing advertisements.

Geoffrey Wallis,
Master, M/V Nan Ta,
Singapore

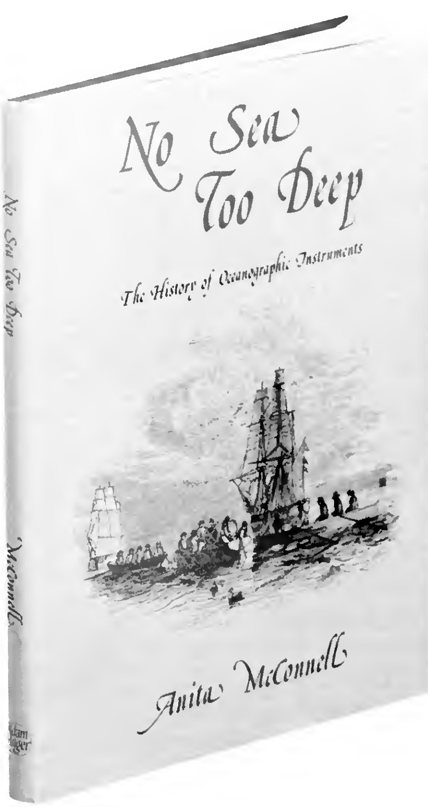
book reviews

No Sea Too Deep: The History of Oceanographic Instruments by Anita McConnell. 1982. **Adam Hilger Ltd., Bristol, England. 162 pp.**

Robert Boyle, Robert Hooke, David Brewster, Charles Cavendish, Humphrey Davy, William Thomson, Charles Wheatstone: these are only a few of the scientists who have taken an active role in the exploration of the oceans. Not all went to sea, but their ideas did, and through them the unknowns of the sea have gradually decreased. If I saw this list of names and was asked on what common problem these men worked, I don't believe I would have picked ocean instrumentation.

In this delightful book, Anita McConnell puts together the history of oceanographic instruments, for a period of approximately 300 years, from 1600 to around 1900. It was already known that the seas were not boundless in horizontal extent, but how deep they were and what currents and monsters lurked there, ready to make the way of an honest or dishonest seafarer difficult, were unknown. In *No Sea Too Deep* we see how these puzzles of nature were solved — slowly, by many people and many ideas.

Modern day (1980) oceanographers bemoan the fact that instruments can be lowered to all ocean depths only at certain maximum winch speeds; imagine what it was like when, for each ocean depth measurement, a crew of 20 hauled back the hemp in a many-hours-long process. But that is what they did, and that is how the ocean slowly became a better-known place.



Amply illustrated, with descriptions of how things worked, or were supposed to work, this book does oceanographers and those who are interested in how things happen a great service. For readers wishing to know more, the references at the end of each chapter will lead the way.

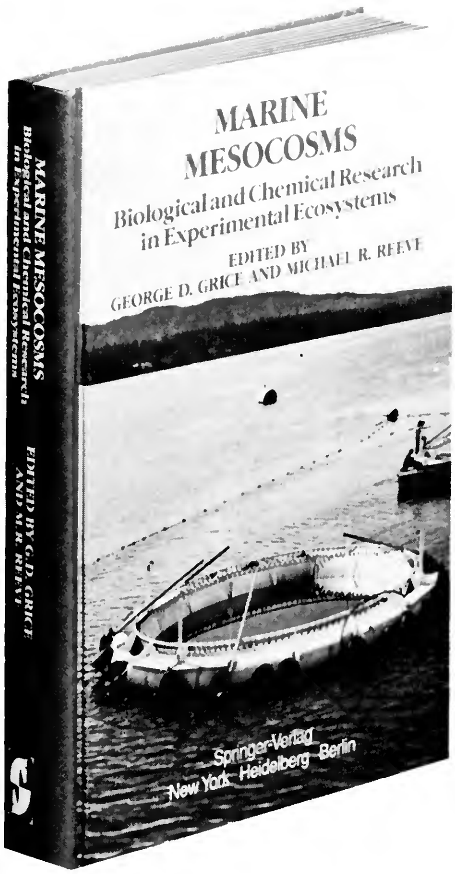
If you are an inventor at heart you will enjoy this book, because there are many examples of instruments used to measure current, temperature, and depth, with drawings and explanations. Or if you make measurements at sea, this book is worth reading. You will see how the chief engineer — or his equivalent — can come to the rescue; how an administrative decision can affect cruises because of resource allocation; how things are rediscovered, then forgotten. You will find that there are few "new" concepts, and that good measurements at sea are difficult. But that is how we learn about the ocean.

Earl E. Hays, Senior Scientist,
Ocean Engineering Department,
Woods Hole Oceanographic Institution

Marine Mesocosms: Biochemical and Chemical Research in Experimental Ecosystems, **George D. Grice and Michael R. Reeve, eds. 1982. Springer-Verlag, New York, N.Y. 430 pp. + xiii; $39.80.**

Mesocosms are experimental enclosures, larger than 10 cubic meters, designed to bridge the gap between experiments in laboratory flasks and observations in complex natural marine systems. The use of mesocosms as tools for interpreting relationships among marine plants and animals and their environments has mushroomed over the last two decades; the most famous enclosures were those constructed under the Controlled Ecosystem Population Experiment (CEPEX), with volumes of up to 1,300 cubic meters. This book, the proceedings of a conference held at the completion of CEPEX in 1980, reviews the contributions and limitations of enclosure research. Although the CEPEX data are the best represented, other data sets are discussed in detail, including those from Loch Ewe in Scotland, from the Marine Ecosystems Research Laboratory (MERL) on Narragansett Bay, and from the harbor of Den Helder, Holland.

Chapter topics include reviews of mesocosm-research applications in the study of plankton, larval fish biology, and chemistry; reports of chemical results from MERL (for example, radiotracers, natural radionuclides, and hydrocarbons); reviews of pollution-effect studies (oil, mercury, and trace metals); discussions of problems in enclosure research (sinking of plankton, experimental replication, effects of predators, and other manipulations and their effects); results of the final CEPEX experiment; and speculations on the value and future of experimental enclosure studies. The



book contains a wealth of information for plankton biologists and chemists interested in species responses to toxic substances and nutrients in the ocean. This data, plus that on biotic interactions and growth, plus the excellent reviews, make the book worth reading. Especially good are the reviews on the history of mesocosms by K. Banse, and on enclosures of pelagic systems by J. Gamble and J. Davies.

Enclosure research has moved beyond mere observational studies; C. O. Davis summarizes how dominance can be changed, from diatoms to microflagellates or dinoflagellates, by manipulating nutrients, mixing, and light. This is the first step, and a very important one, toward understanding populations, processes, and interactions of the ecosystem in a marine mesocosm. Certain parts of this special ecosystem are well understood (such as the predation rate of ctenophores on copepods), and *Marine Mesocosms* amply illustrates them. A strong case is made for mesocosm research; it must continue in parallel with other kinds of biological studies of the ocean. After all, how can we hope to understand the causes of changes in species and numbers of organisms in the real ocean when we cannot understand the causes of changes in ten cubic meters of water, under controlled conditions? Of course mesocosms are not reality, but research done in controlled environments may be the most effective way to improve our understanding of the ocean itself.

The editors and authors have produced a readable summary of the art of mesocosm research. They point out where we are today. One author, M. Mullin, even ventures to predict areas of research that could now be studied with mesocosms: turbulence and community structure; origins of control of community structure; population dynamics and the secondary production of zooplankton; coupling between pelagic and benthic communities; and zooplankton behavior. These are many of the important questions in modern plankton research, and the fact that they are considered here illustrates the power of the mesocosm in marine biological research. Just as important are the possibilities for studies of chemical and physical processes, and how they interact with the biota. The book does have some weak spots, but it provides a strong argument in favor of further mesocosm research.

John E. Hobbie,
Senior Scientist, Ecosystems Center,
Marine Biological Laboratory,
Woods Hole, Mass.

The Road to Jaramillo: Critical Years of the Revolution in Earth Science **by William Glen. 1982. Stanford University Press, Stanford, Calif. 459 pp. $37.50.**

For the uninitiated, the Jaramillo event was a reversal of the earth's magnetic field that occurred between 970,000 and 900,000 years ago. William Glen, a geologist turned science historian, focuses on the discovery of this event as one of the stepping stones on the road to the acceptance of sea-floor spreading and continental drift — the revolution in earth science.

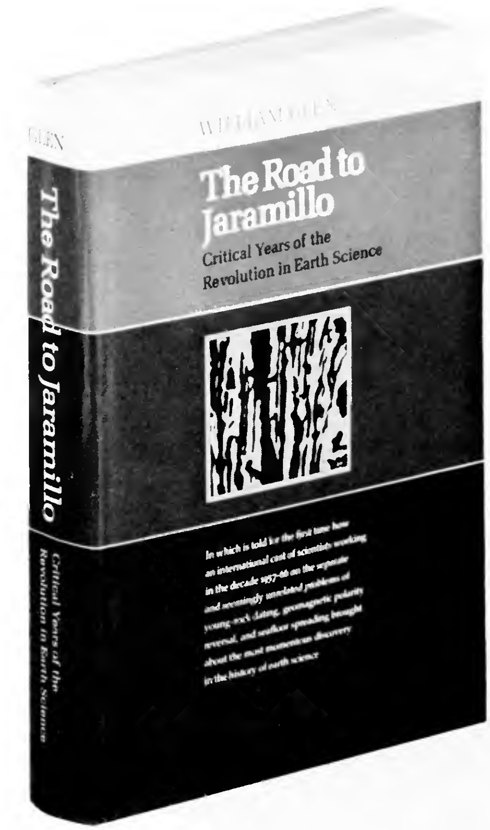
During the 1950s and 1960s, there was a rapid accumulation of geological and geophysical data, from all over the world, that allowed the identification of this sequence of reversals in the earth's magnetic field. The potassium-argon dating technique also was perfected, permitting the dating of magnetized rocks. Lastly, scientists found that these reversals could be seen in marine magnetic anomalies, and, as a result, they could date the seafloor and trace the path of drifting continents. Most of the people who worked on these problems are still with us today. Glen interviewed 89 of them and made tape recordings of most of their accounts.

First the author describes the early post-World War II mass spectrographs; these eventually were improved enough to be used to separate isotopes for radiometric dating. Glen then discusses the continuing problems of atmospheric argon contamination in the potassium-argon method. He describes the early identification of reversely-magnetized rocks, and the attempts that were made to explain them as being due to self-reversals. All of these things set the scene for the big push that Allan Cox, Richard Doell, and Brent Dalrymple made, when they documented and dated the earth's magnetic field reversals over the last few million years. Most of the book is devoted to the paleomagnetic and radiometric dating work that these three did at Berkeley, and later at the U.S. Geological Survey in Menlo Park, California, and how they interacted with the scientists in Europe, Iceland, Canada, Japan, Australia, and the United States, who were studying the same phenomena. The author tells of the scramble for credits (the sort of thing our science could do without) and the problems of getting funding; but mainly, Glen tells of the competence and dedication this group had, ultimately producing an accurate magnetic-reversal time scale. From 1959 to 1966, eleven different time scales for the last 3.5 million years were published, and each was an improvement over the one before. Most of them were published by the Menlo Park group.

By 1966, the Menlo Park scientists were struggling with the question of whether the measurements on normally magnetized rocks found at Jaramillo Creek, New Mexico, were to be believed. At the same time, marine magnetic anomaly studies were producing a continuous record of reversals, back 10 million years, clearly showing the Jaramillo event.

After 1966, marine magnetic anomalies and the magnetization of marine sediments became even more important. The magnetic anomalies permitted dating of the ocean crust, showing how the continents drifted and were reconstructed through sea-floor spreading. The roles of the marine scientists at Cambridge University and at Columbia University's Lamont-Doherty Geological Observatory, and their attitudes for and against sea-floor spreading, are detailed in *The Road to Jaramillo.*

The major contribution Glen makes is that he followed the scientists' thinking and actions on a personal level, beyond what they published, during these formative years of a major scientific discovery. As time lapses after any scientific study, many of these things are forgotten and a simplified picture, which may or may not be true, remains. Even the participants in the work reported here, which took place some 20 years ago, do not remember each event in the same way their colleagues do, nor as Glen reports them. But he certainly gives the flavor of the times, shows that



many scientists contributed to these discoveries, and has done an amazing job of putting the story together accurately. The tapes of his interviews, and other prime historical material, are on file at the Bancroft Library, University of California, Berkeley.

J. R. Heirtzler, Senior Scientist, Geology and Geophysics Department, Woods Hole Oceanographic Institution

Books Received

Aquaculture

Inputs as Related to Output in Milkfish Production **by K. C. Chong, Maura S. Lizarondo, Virginia F. Holaso, and Ian R. Smith. 1982. ICLARM Technical Reports 3, Makati, Metro Manila, Philippines. 82 pp. $4.00 surface; $10.00 airmail.**

The focus of this technical report is on the estimation of input-output relationships, or production functions, in the economics of the milkfish industry. The findings show that increasing certain inputs (such as stocking rates of fry and fingerlings, fertilizers, and farm size) can increase both production and profits. The authors recommend a more intensive technology be adopted by milkfish producers, and make a case for group farming.

Biology

Response of Marine Animals to Petroleum and Specific Petroleum Hydrocarbons **by Jerry M. Neff and Jack W. Anderson. 1981. Halsted Press Division, John Wiley and Sons, New York, N.Y. 177 pp. $34.95.**

The deleterious impacts of oil on the marine ecosystem may persist long after the visible oil pollution has been cleaned up or washed away. This book is the result of extensive research into the toxicity and sublethal biological effects of petroleum and specific petroleum hydrocarbons to marine organisms, summarizing the major results of this research.

The Estuarine Ecosystem **by Donald S. McLusky. 1981. Halsted Press, New York, N.Y. 150 pp. $29.95.**

The problems of estuarine pollution create interesting case studies of man's intervention in the normal working of an ecosystem. This book begins by describing the estuarine environment in a general way; examines trophic levels (primary producers, primary and secondary consumers); discusses the problems of life in estuaries; and examines human influences on estuarine ecosystems. Examples included are worldwide, showing the similarities and differences in estuaries with contrasting geographical conditions.

Early Life **by Lynn Margulis. 1982. Science Books International, Boston, Mass. 160 pp. $16.50 hardcover; $9.95 paperback.**

This book is an account of the evolution of early cells. These bacteria invented the chemical and biological strategies that make multicellular life possible, including moving, sensing, sex, and diverse energy-transforming and feeding strategies. Many questions are raised and discussed in a fashion that does not require one to have a specialized scientific background to understand.

Aquatic Entomology: The Fisherman's and Ecologist's Illustrated Guide to Insects and Their Relatives **by W. Patrick McCafferty, with illustrations by Arwin V. Provonsha. 1981. Science Books International, Boston, Mass. 448 pp. $50.00.**

As a book intended for a broad audience, this comprehensive volume incorporates biological and ecological information, much of which has been generated in the last 15 years, and provides a sound introduction to insects for the fly fisherman, with up-to-date association of scientific and fisherman's names for insects. Technical jargon is avoided. Binomial identification keys, aided by line drawings, classify the families of insects, and references are included for students interested in generic and species identification. There are more than 1,000 original illustrations, including 124 color paintings.

British and Other Marine and Estuarine Oligochaetes **by R. O. Brinkhurst. 1982. Cambridge University Press, Cambridge, England. 127 pp. $32.00.**

Knowledge of saltwater oligochaetes (worms) has greatly expanded in the last 10 years, and much taxonomic confusion has been straightened out. Brinkhurst, in his synopsis, employs an unusual style of keying that makes use of a series of decision levels based on a few readily visible characteristics. The purpose is to permit estuarine biologists to reduce the number of unidentified oligochaetes in their surveys.

Marine Ecology **by Jeffrey S. Levinton. 1982. Prentice-Hall, Inc. Englewood Cliffs, N.J. 526 pp. $35.95.**

Levinton aims this text at undergraduate/graduate courses in marine biology and biological oceanography. He starts with an introduction to the adaptations of marine organisms to their physical environment. Next, he outlines the structure and dynamics of marine communities, with emphasis on the distribution and abundance of species and the interaction of species within communities. The author then discusses the ecology of plankton and several benthic habitats, including the intertidal and subtidal benthos, estuaries, and coral reefs. Levinton emphasizes invertebrates in benthic communities.

The Biology of Seaweeds, **Christopher S. Lobban and Michael J. Winne, eds. 1982. The University of California Press, Berkeley, Calif. 786 pp. $85.00.**

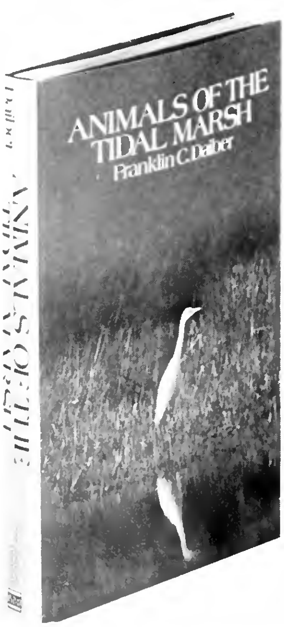
There are three major groups of seaweeds: the marine benthic red, brown, and green algae. This volume reviews their biology. Besides systematics and life histories, it covers ecology, physiology, biochemistry, and commercial utilization. The writers are teachers and research workers, all considered experts in the fields they discuss. The book is illustrated with photographs and line studies and has a long list of references following each chapter.

The Rainbowfishes of Australia and Papua New Guinea **by Gerald R. Allen and Norbert J. Cross. 1982. T. F. H. Publications, Inc. Neptune, N.J. 160 pp. $16.95.**

The rainbowfishes — Melanotaeniidae — are a small freshwater family of the Australia–New Guinea region. Their range, in which they are enormously abundant, includes lakes, ponds, streams, and swamps; some species live in brackish waters. The authors explain aquarium care for these animals, their classification, evolution, and zoogeography. There are keys to genera and species, a brief glossary, and many illustrations — from photos of specimens to maps of collecting areas.

Animals of the Tidal Marsh **by Franklin C. Daiber. 1982. Van Nostrand Reinhold, New York, N.Y. 422 pp. $19.95.**

Daiber's goal for this book was to bring together the literature pertaining to the biology and natural history of those animals characteristic of tidal marshes, from protozoa through the birds and mammals. In doing this, he specifically identifies the origins of the animals of the tidal marsh; examines plant-animal interactions, feeding, and trophic relationships; reviews community organization; and looks at the reproductive biology of marsh animals. Finally, the author briefly discusses those areas of tidal marsh ecology which are not well understood.



Educational Books

Islands of the Seals: The Pribilofs. **Alaska Geographic, Vol. 9, No. 3. 1982. Alaska Northwest Publishing Company, Anchorage, Alaska. 128 pp. $9.95, plus $1.00 for postage.**

The Pribilof Islands — St. Paul, St. George, and the much smaller Walrus and Otter islands — are due north of Unalaska in the Aleutians, 800 miles by air from Anchorage. This issue of *Alaska Geographic* explores the Pribilofs through their geography, natural history, and native people, the Aleuts. It explains the fur seal industry, which many people criticize but the Aleuts are dependent on. The issue is illustrated with many color photographs, making these faraway islands and their people much more real to those of us who will never have an opportunity to go there.

Essentials for the Scientific and Technical Writer, **Hardy Hoover, ed. 1982. Dover Publications, Inc. New York, N.Y. 216 pp. $4.00**

Practical help for the scientist, engineer, technician, or student who needs to improve his/her technical writing. Starting with organizing thoughts, or planning, the manual proceeds through sentences, paragraphs, and reports; also covered is "Writing to Spec." Each chapter has exercises and questions, and there are several checklists, designed to help writers improve communication quality and efficiency.

McGraw-Hill Encyclopedia of Science and Technology: **An international reference work in 15 volumes, including an index. Fifth edition. 1982. McGraw-Hill, Inc., New York, N.Y. $850.00.**

This updated edition of the encyclopedia has an astounding number of contributors, some 3,000. The editors' goal was to provide accuracy, clarity, comprehensiveness, and thorough research on each topic. There are 75 disciplines covered, from acoustics to vertebrate zoology, with completely new material on subjects such as genetic engineering and gluons. There are more than 15,000 illustrations; these volumes could be a good starting point for research outside one's own field.

The Discovery of the Sea **by J. H. Parry. 1982. University of California Press, Berkeley, Calif. 279 pp. $25.00 hardcover; $8.95 paperback.**

The purpose of this book is to narrate and explain the principal events of the late 15th and early 16th centuries, when Europeans gained access to great areas of the world previously unknown to them. It was then that the unity of the sea was discovered, along with southern and eastern Africa, southern and eastern Asia, and the Americas. The original edition of this book (1974, Dial Press) is heavily illustrated and correspondingly expensive. This is a more modest version visually; however, it has a revised text, incorporating results from recent research.

The Yankee Mariner and Sea Power: America's Challenge of Ocean Space, **Joyce J. Bartell, ed. 1982. University of California Press, Los Angeles, Calif. 299 pp. $20.00.**

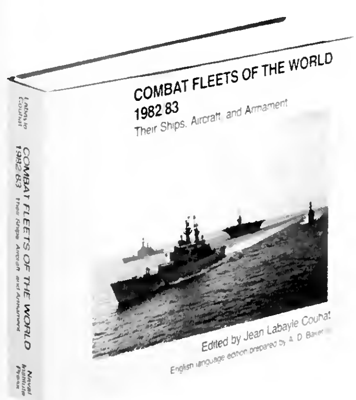
This is a maritime history, leading to discussion of contemporary uses of the sea. The book argues the importance of the oceans to the future of seagoing America. Its 15 authors investigate the commitment and scientific and technical support needed for the United States to "regain its momentum" in sea power.

The History of Modern Whaling **by J. N. Tonnessen and A. O. Johnson. 1982. University of California Press, Berkeley, Calif. 798 pp. $45.00.**

This history charts the progress of modern whaling. It began around 1864, off the coast of northern Norway, when steam-driven vessels carrying shell harpoons replaced open boats and hand-thrown spears. Soon ships, ever greater in size and power, hunted whales worldwide, backed by shrewd and powerful investors. This expansion led to "pelagic" whaling, using factory ships, and to the continuing battles over regulation and national quotas. The latter part of this history recounts the tale of national and private interests so intent on immediate gain or prestige that the warnings of scientists went unheeded.

Combat Fleets of the World 1982/83: Their Ships, Aircraft, and Armament, **Jean Labayle Couhat, ed.; English language edition prepared by A. D. Baker III. 1982. Naval Institute Press, Annapolis, Md. 873 pp., plus addenda. $78.95.**

This volume covers all the world's navies. The length of the edition (15 percent greater than the previous one) reflects the expansion of naval forces worldwide and the increased coverage of China's Navy. The guide has extensive information on the U.S. Navy, descriptions and photographs of the Soviet Navy's new ships, and an account of Britain's Royal Navy; much attention is paid to the world's smaller navies. Correspondents from around the globe did the research; the book contains comprehensive technical descriptions of naval ships, their personnel and paraphernalia, in a reference format.



Energy and Environment

The State of the Environment: 1982. **1982. A report from the Conservation Foundation, Washington, D.C. 2,139 pp. $15.00, plus $1.00 shipping and mailing.**

This report describes the resources and environmental problems of the United States, presents data to show whether the problems are getting better or worse, and discusses institutional changes and options that affect environmental and resource policy. The Foundation reports some progress in air pollution control and energy conservation. However, soil erosion is worse, and water quality control is not at hand. We have, the report states, improved awareness of such things as the consequences of toxic waste disposal, but scientific knowledge is limited in many areas.

The Dynamic Environment of the Ocean Floor, **Kent A. Fanning and Frank T. Manheim, eds. 1982. Lexington Books, Lexington, Mass. 502 pp. $39.95.**

Though many nonscientists may think it is an inert bowl, the seafloor is actually an active, important contributor to many marine processes. This book is designed for those who study benthic processes; it begins with a review of sampling methods, then has a section on the description and quantitative studies of the most important interactions between solid particles and water at the seafloor. Following that is a discussion of biological interactions, and then six chapters on interstitial trace metals. The book ends with two chapters on hydrothermal processes.

The Role of Solar Ultraviolet Radiation in Marine Ecosystems, **John Calkins, ed. 1982. Plenum Press, New York, N.Y. 724 pp. $79.95.**

In this volume, an international, multidisciplinary group of scientists outlines the methodology and the specific details needed to evaluate the role of ultraviolet radiation in marine ecosystems. Specialists in their fields discuss current concepts of the biological actions of this phenomenon, studies on the responses of plants and animals, ecological and evolutionary aspects of the ultraviolet components of sunlight, and the computation of the level of ultraviolet radiation reaching marine organisms.

Introduction to Tides: the Tides of the Waters of New England and New York **by Alfred C. Redfield. 1980. Marine Science International, Woods Hole, Mass. 108 pp. $12.95.**

Redfield hopes, in this book, to give those who work and play along the coast from Sandy Hook to the Bay of Fundy a better understanding of matters that influence the daily ordering of their lives. It is based for the most part on information given in the tide and current tables published by the U.S. Department of Commerce, and tries to explain why the tide locally is as it is, and why it varies from place to place.

Geology

Mineral Deposits and Evolution of the Biosphere, **H. D. Holland and M. Schidlowski, eds. 1982. Springer-Verlag, New York, N.Y. 333 pp. $19.00.**

Based on the Dahlem Workshop on Biospheric Evolution, this volume investigates the relationships between organic evolution and mineral deposits — the sedimentary ores. Sedimentary processes account for such things as aluminum, gold, gem minerals, and iron ores. Following the introduction, the book has background reports and group papers. The subject matter is divided into three areas: past and present microbial processes and ecosystems; morphological and chemical records of the Precambrian biosphere; and the relationships between the formation of mineral deposits and biological processes.

Geology of the Northwest African Continental Margin, **U. von Rad, K. Hinz, M. Sarnthein, and E. Seibold, eds. 1982. Springer-Verlag, New York, N.Y. 703 pp. $49.00.**

This volume concentrates on geophysical, paleontological, and geochemical studies, and on the structure and evolution of the onshore coastal basins and the offshore continental margin. It includes deep crustal geophysical surveys, studies of the Cape Verde and Canary Islands, paleoenvironmental research, and a comparison of the Northwest African continental margin with its counterpart off eastern North America.

Marine Policy

The Baltic Straits **by Gunnar Alexandersson. 1982. Martinus Nijhoff Publishers, Kluwer Boston, Inc. Boston, Mass. 132 pp. $32.50.**

This is part of a series from the Center for the Study of Marine Policy at the University of Delaware. Alexandersson describes the physical-hydrographic elements of the Baltic Sea and its approaches; he discusses the historical interests, both political and economic, of the littoral states, and the legal status and uses of the Baltic Straits over time. The Baltic region has an important role in the global struggle between the western alliance and the Soviet bloc, and this is highlighted in the author's examination of the various legal views of the straits, especially as they pertain to the emerging Law of the Sea Treaty.

***The Red Sea and the Gulf of Aden* by Ruth Lapidoth-Eschelbacher. 1982. Martinus Nijhoff Publishers, Kluwer Boston, Inc. Boston, Mass. 265 pp. $65.00.**

This study, also a part of the University of Delaware series, begins by describing the physical and historical features of the Red Sea and its surroundings. The author, who is a member of the Israeli delegation to the United Nations and legal advisor to the Ministry of Foreign Affairs, goes on to analyze the legal regime of the Red Sea and the Gulf. The Suez Canal is discussed, with special reference to the Canal's military and commercial importance.

Books Policy

Oceanus *welcomes books from publishers in the marine field. All those received will be listed and a few will be selected for review. Please address correspondence to Elizabeth Miller, editor of the book section.*

***Impact of Marine Pollution on Society*, Virginia Tippie and Dana Kester, eds. 1982. J. F. Bergin Publishers, Inc. South Hadley, Mass. 304 pp. $29.95.**

This is a compilation of papers and discussions from a conference of the same name, held at the University of Rhode Island's Center for Ocean Management Studies. There are five units, following the format of the conference program. They are: Status of Marine Pollution, outlining the political and social framework for controlling pollution, the development of our understanding of human impact on the marine environment, and international efforts to deal with marine pollution; three very different case studies; and Future Prospects and Strategies, in which the authors encourage linking public interest with scientific knowledge, to try to develop a working definition of pollution.

INDEX

Volume 25 (1982)

Number 1, Spring, Research Vessels: William H. MacLeish *Changing the Watch* — Derek W. Spencer *Ocean Science and Ships* (introduction) — Robertson Dinsmore *The University Fleet* — Allyn C. Vine *The Case for Semisubmerged Research Ships* — Eugene Allmendinger *Submersibles: Past, Present, and Future* — Robert Ballard *Argo and Jason* — C. Dana Densmore *Life in the A-Boat* — Ben McKelway *Hiller and the Knorr: A Marriage at Sea* — George B. Anderson and Raymond H. Richards *A Modern Research Sailing Ship: SRV Frontier Challenger* — John Van Leer *Sailing Catamaran Research Vessels for the 80s and 90s* — M. N. A. Peterson and F. C. MacTernan *A Ship for Scientific Drilling.*

Number 2, Summer, general issue: Thomas D. Galloway and Dennis Nixon *The Newest Federalism and Coastal Areas* — Robert C. Spindel *Ocean Acoustic Tomography: A New Measuring Tool* — John M. Edmond *Ocean Hot Springs: A Status Report* — a photo essay *Hot Vent Life Forms and Sea-floor Geology* — Leah J. Smith and Susan Peterson *Pitfalls in Third World Aquaculture Development* — a photo essay *Minute Marine Organisms Found in Tropical Oceans* — John E. Kelly and Cordelia E. Shea *The Subseabed Disposal Program for High-Level Radioactive Waste–Public Response* — Richard E. Moore, Philip Helfrich, and Gregory M. L. Patterson *'The Deadly Seaweed of Hana.'*

Number 3, Fall, Deep Ocean Mining: Paul R. Ryan *Comment* — Robert W. Knecht *Deep Ocean Mining* (introduction) — William P. Pendley *The Argument: The U.S. Will Need Seabed Minerals* — Joel P. Clark *The Rebuttal: The Nodules Are Not Essential* — J. K. Amsbaugh and Jan L. Van der Voort *The Ocean Mining Industry: A Benefit for Every Risk?* — Bernardo Zuleta *The Law of the Sea: Myths and Realities* — Clifton Curtis *The Environmental Aspects of Deep Ocean Mining* — G. Ross Heath *Manganese Nodules: Unanswered Questions* — Randolph A. Koski, William R. Normark, Janet L. Morton, and John R. Delaney *Metal Sulfide Deposits on the Juan de Fuca Ridge* — William H. MacLeish, Profile: *John Moline Teal–Marsh Man* — Paul R. Ryan, Concerns: *Navy Studying the Disposal of Old Nuclear Submarines* — M. Grant Gross, Concerns: *Big Ocean Science in the 1980s* — Letters — Book Reviews.

Number 4, Winter, Marine Policy for the 1980s and Beyond: Paul R. Ryan *Comment* — John A. Knauss *Marine Policy for the 1980s and Beyond* (introduction) — Paul M. Fye *The Law of the Sea* — David A. Ross and Michael C. Healey *International Marine Science: An Opportunity for the Future* — James P. Walsh *The Coastal Zone Management Program: Will Revenue-Sharing Save It?* — Spencer Apollonio *Fisheries Management* — John W. Farrington, Judith M. Capuzzo, Thomas M. Leschine, and Michael A. Champ *Ocean Dumping* — Melvin A. Conant *The Call of the Arctic* — Robert S. Winokur and Rene E. Gonzalez, Jr. *Ocean Science and Military Use of the Ocean* — William H. MacLeish, Profile: *Roger Revelle–Senior Senator of Science* — Francisco J. Palacio, Concerns: *The Cessation of Commercial Whaling* — Ben McKelway, Concerns: *Women in Oceanography* — Letters — Book Reviews — Index.

Oceanus

The International Magazine of Marine Science and Policy

Published by Woods Hole Oceanographic Institution

SUBSCRIPTION ORDER FORM

Please make checks payable to Woods Hole Oceanographic Institution.
Checks accompanying foreign orders must be payable in U.S. currency and drawn on a U.S. bank.
(Outside U.S. add $3 per year to domestic rates.)

Please enter my subscription to OCEANUS for

☐ one year at $20.00
☐ two years at $35.00
☐ three years at $50.00

☐ payment enclosed. (we request prepayment)
☐ bill me

Please send MY Subscription to:

Name (please print)

Street address

City State Zip

Please send a GIFT Subscription to:

Name (please print)

Street address

City State Zip

Donor's Name

Address

9/82

The Coast, Vol. 23:4, Winter 1980/81 — The science and politics of America's 80,000-mile shoreline.

Senses of the Sea, Vol. 23:3, Fall 1980 — A look at the complex sensory systems of marine animals.

discovery of animal colonies at hot springs on the ocean floor.

Sound in the Sea, Vol. 20:2, Spring 1977 — The use of acoustics in navigation and oceanography.

Issues not listed here, including those published prior to Spring 1977, are out of print. They are available on microfilm through University Microfilm International; 300 North Zeeb Road; Ann Arbor, MI 48106.

A Valuable Addition to Any Marine Science Library

PLACE
STAMP
HERE

Oceanus

Woods Hole Oceanographic Institution
Woods Hole, Mass. 02543

PLACE
STAMP
HERE

Oceanus

Woods Hole Oceanographic Institution
Woods Hole, Mass. 02543

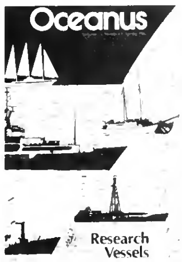
Unanswered Questions — Randolph A. Koski, William R. Normark, Janet L. Morton, and John R. Delaney *Metal Sulfide Deposits on the Juan de Fuca Ridge* — William H. MacLeish, Profile: *John Moline Teal–Marsh Man* — Paul R. Ryan, Concerns: *Navy Studying the Disposal of Old Nuclear Submarines* — M. Grant Gross, Concerns: *Big Ocean Science in the 1980s* — Letters — Book Reviews.

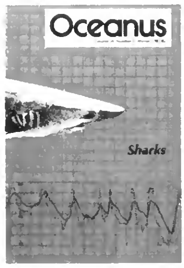
Number 4, Winter, Marine Policy for the 1980s and Beyond: Paul R. Ryan *Comment* — John A. Knauss *Marine Policy for the 1980s and Beyond* (introduction) — Paul M. Fye *The Law of the Sea* — David A. Ross and Michael C. Healey *International Marine Science: An Opportunity for the Future* — James P. Walsh *The Coastal Zone Management Program: Will Revenue-Sharing Save It?* — Spencer Apollonio *Fisheries Management* — John W. Farrington, Judith M. Capuzzo, Thomas M. Leschine, and Michael A. Champ *Ocean Dumping* — Melvin A. Conant *The Call of the Arctic* — Robert S. Winokur and Rene E. Gonzalez, Jr. *Ocean Science and Military Use of the Ocean* — William H. MacLeish, Profile: *Roger Revelle–Senior Senator of Science* — Francisco J. Palacio, Concerns: *The Cessation of Commercial Whaling* — Ben McKelway, Concerns: *Women in Oceanography* — Letters — Book Reviews — Index.

Oceanus back issues

WOODS HOLE OCEANOGRAPHIC INSTITUTION 1930

Limited quantities of back issues are available at $4.00 each; a 25-percent discount is offered on orders of five or more. We accept only prepaid orders. Checks should be made payable to Woods Hole Oceanographic Institution; checks accompanying foreign orders must be payable in U.S. currency and drawn on a U.S. bank. Address orders to: Oceanus Back Issues; 1440 Main Street, Waltham, MA 02254.





Deep Ocean Mining, Vol. 25:3, Fall 1982 — Eight articles discuss the science and politics involved in plans to mine the deep ocean floor. Also included are a profile of a marine scientist (John Teal), book reviews, letters to the editor, and a concerns section (an article on the U.S. Navy's plans to dispose of old nuclear submarines and a piece on the future of big ocean science in the 1980s).

General Issue, Vol. 25:2, Summer 1982 — Contains articles on how Reagan Administration policies will affect coastal resource management, a promising new acoustic technique for measuring ocean processes, ocean hot springs research, planning aquaculture projects in the Third World, public response to a plan to bury high-level radioactive waste in the seabed, and a toxic marine organism that could prove useful in medical research.

Research Vessels, Vol. 25:1, Spring 1982 — Despite rising costs, ships continue to play a key role in marine science.

Sharks, Vol. 24:4, Winter 1981/82 — Shark species are more diverse and less aggressive than the "Jaws" image leads us to believe.

Oceanography from Space, Vol. 24:3, Fall 1981 — Satellites can make important contributions toward our understanding of the sea.

General Issue, Vol. 24:2, Summer 1981 — A wide variety of subjects is presented here, including the U.S. oceanographic experience in China, ventilation of aquatic plants, seabirds at sea, the origin of petroleum, the Panamanian sea-level canal, oil and gas exploration in the Gulf of Mexico, and the links between oceanography and prehistoric archaeology.

The Coast, Vol. 23:4, Winter 1980/81 — The science and politics of America's 80,000-mile shoreline.

Senses of the Sea, Vol. 23:3, Fall 1980 — A look at the complex sensory systems of marine animals.

A Decade of Big Ocean Science, Vol. 23:1, Spring 1980 — As it has in other major branches of research, the team approach has become a powerful force in oceanography.

Ocean Energy, Vol. 22:4, Winter 1979/80 — How much new energy can the oceans supply as conventional resources diminish?

Ocean/Continent Boundaries, Vol. 22:3, Fall 1979 — Continental margins are being studied for oil and gas prospects as well as for plate tectonics data.

Oceans and Climate, Vol. 21:4, Fall 1978 — *Limited Supply only.*

General Issue, Vol. 21:3, Summer 1978 — The lead article here looks at the future of deep-ocean drilling. Another piece, heavily illustrated with sharply focused micrographs, describes the role of the scanning electron microscope in marine science. Rounding out the issue are articles on helium isotopes, seagrasses, paralytic shellfish poisoning, and the green sea turtle of the Cayman Islands.

Marine Mammals, Vol. 21:2, Spring 1978 — Attitudes toward marine mammals are changing worldwide.

The Deep Sea, Vol. 21:1, Winter 1978 — Over the last decade, scientists have become increasingly interested in the deep waters and sediments of the abyss.

General Issue, Vol. 20:3, Summer 1977 — The controversial 200-mile limit constitutes a mini-theme in this issue, including its effect on U.S. fisheries, management plans within regional councils, and the complex boundary disputes between the U.S. and Canada. Other articles deal with the electromagnetic sense of sharks, the effects of tritium on ocean dynamics, nitrogen fixation in salt marshes, and the discovery of animal colonies at hot springs on the ocean floor.

Sound in the Sea, Vol. 20:2, Spring 1977 — The use of acoustics in navigation and oceanography.

Issues not listed here, including those published prior to Spring 1977, are out of print. They are available on microfilm through University Microfilm International; 300 North Zeeb Road; Ann Arbor, MI 48106.

A Valuable Addition to Any Marine Science Library

(ISSN 0029-8182)
WOODS HOLE
OCEANOGRAPHIC
INSTITUTION
Woods Hole, MA 02543
Postmaster: Please Send
Form 3579 to Above Address

SECOND-CLASS
POSTAGE PAID
AT FALMOUTH, MASS.,
AND ADDITIONAL
MAILING POINTS