

A Changing Ocean Policy Horizon for Marine Science

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Abstract A requisite for rational Exclusive Economic Zone (EEZ) resource management is the continued integration of marine science and policy. Policymakers will increasingly need reliable scientific information as national borders expand seaward and as technology affords greater access to more marine resources. Developments in marine science should open new concepts of ocean and resource use, and these in turn will pose new sets of policy issues. Some of the science-policy possibilities include:

1. Expanding our knowledge of global ocean circulation, thus improving fish stock assessment, weather prediction, and innovative energy use;
2. continuing pollution research with a focus on the limits of acceptable degradation of an environment (including the problems of carbon dioxide in the atmosphere);

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3. integrating the discovery and eventual exploitation of marine minerals with the environmental, legal, and political constraints; and
4. ensuring access to all areas of the ocean for marine science research in light of the stringent conditions imposed by some nations on research in their territorial seas and exclusive economic zones.

Introduction

One requisite of rational Exclusive Economic Zone (EEZ) resource management is the continued integration of marine science and policy. As national borders expand seaward and as technology affords greater access to marine resources, the need of policymakers for reliable scientific information will become increasingly felt. This paper endeavors to describe likely future policy roles for marine scientific research, particularly as they relate to expanded development of EEZ resource potentials.

The past decades have seen major breakthroughs in our understanding of ocean phenomena. We have, among other things, developed workable hypotheses for the formation and evolution of the seafloor and have started to learn the implications of ocean-atmosphere interactions. The future for productive science is equally exciting. Among the primary objectives in coming years will be to increase our knowledge of the general circulation of the ocean, and through this, to appreciate better the apparently critical effect of the ocean upon climate. This increased understanding of ocean circulation will improve the opportunity for specific ocean uses such as fishing and waste disposal. The coming years may also pose further expansion of the plate tectonic theory with an objective of finding new polymetallic mineral deposits and understanding their origin. Technology, including satellites, sophisticated buoys with numerous accurate sensors, and powerful computers, will continue to provide a crucial component in new oceanographic research.

The linkage of science and policy has generally not been obvious to U.S. academic oceanographers. After the major growth of oceanography following World War II, marine scientists usually had to satisfy program managers only with the basic

scientific importance of their effort rather than with its relevance, its use, or its policy implications. If policy issues were a consideration, marine scientists would strive for those policies that made it easier for them to do science.

The alternative, to pursue certain types of marine science to fit or assist overall policy development, is a relatively new concept for practicing marine scientists in academic research, but not as much so for government laboratories or mandate agencies doing pollution research. As a rule, policy followed marine science rather than led it. That condition continues now, and probably will into the future.

The beginning of the link between marine science and marine policy (from the scientist's point of view) came in the mid-1970s with the abrupt awareness of U.S. energy vulnerability and the prospect that possible solutions could come from the marine environment, through increased offshore hydrocarbon development and innovations such as ocean thermal energy conversion (OTEC). Added to these factors were the looming difficulties of the Law of the Sea (LOS) Conference and funding restraints due to inflation and later to budget deficits.

The promise of ocean science and its potential influence on some parts of national policy may be considerable. National economic impacts could come from development of new resources like manganese nodules, or conceivably polymetallic sulfides, previously unobtainable resources such as hydrocarbons from the outer or deeper parts of the EEZ, or innovative resources such as OTEC. Other impacts may come from the security implications of global ocean knowledge, worldwide megaproblems such as the increase of CO₂ in the atmosphere or the probability of long-term climate prediction or climate control. In all of these, marine science will continue to open new concepts of ocean and resource use, and these in turn will pose policy issues. The following pages suggest some of the possibilities within these policy issues.

Ocean Circulation and Related Problems

A major obstruction to our clearer understanding of many critical marine processes has been our limited knowledge of ocean

circulation. Seawater moves, sometimes with considerable turbulence, sometimes at almost immeasurable speed, and overall with considerable temporal and spatial variation. Until the three-dimensional motion of seawater over various time scales is understood, our success will always be limited in solving climate, pollution, and related oceanographic problems.

The technological means may now exist for oceanographers to make considerable improvements in collecting the data necessary for circulation studies over most areas of the ocean. Measurements can be made via remote sensing from satellites, a worldwide pattern of floating instrumented buoys, chemical tracers, and acoustical techniques, as well as traditional oceanographic methods and procedures modeling. Satellites offer an excellent mechanism by which to obtain oceanographic data over the entire globe (including foreign EEZs), but surface-truth validation is often necessary for adequate interpretation of data. The continuing development of new and powerful computers allows the reduction of vast amounts of data and, thus, the modeling of complex systems such as the ocean.

In 1983, a National Academy Workshop concluded that an oceanographic experiment on a global scale was now both feasible and desirable, and, as stated in the proceedings of the workshop, the major objective of the study ("World Ocean Circulation Experiment") would be to understand the general circulation of the global oceans well enough to predict ocean response and feedback to long-term changes in the atmosphere.¹ It was agreed that sufficient technologies do exist, but that a time period of about a decade may be necessary to achieve the goal realistically. Among the specific goals of this program are: to develop a basic description of the present physical state of the ocean, to determine the role of ocean heat transport and storage in the heat budget of the earth, to determine seasonal and inter-annual oceanic variability on a global scale, and to estimate its consequences.

Whether this program achieves these goals is, of course, hard to anticipate. Nevertheless, the depth and the scale of understanding are essential for a variety of ocean uses and can have spin-offs in seemingly unrelated areas. Knowledge of ocean

characteristics and circulation can be a very powerful tool. It would allow considerable improvement in fish stock assessment, weather prediction, and innovative energy use. The policy implications are likewise very broad and could lead to many new and constructive uses of the ocean. How to implement these uses, often before complete and adequate information exists, will be the major challenge. One example is pollution.

Pollution

Some pollutants, such as PCBs and radioactive material from nuclear explosions, are found in almost all parts of the ocean, often far removed from obvious sources. This observation is startling, considering the vast size of the ocean and the availability of some of these compounds for only 40 years or less. The ocean, nevertheless, appears to have a high assimilative capacity for many substances and can tolerate additional input. Marine disposal may be considerably less hazardous for some compounds than land disposal. In general, however, the long-term assimilative capacity of the ocean for a specific compound or set of compounds is unknown and eventual deleterious or irreversible effects cannot be predicted. At this time, outright prohibitions against ocean dumping are simply unreasonable and unnecessary, especially as pollution problems on land seem to be accelerating.

Present regulations often protect just one medium (air, water, or land) from waste disposal use, often with little regard for the impact of the regulation or whether it is focusing on the correct medium for disposal. For example, burning chlorinated organic chemical wastes at sea seems to be the best solution at present for disposal of these pollutants, in part because seawater with its high buffering capacity will neutralize hydrochloric acid—the main product of this technique. Perhaps other categories of chemicals could be included as technology improves.

Among the major problems for pollution research (and environmental research in general) is the ability to extrapolate from short-term, small area results to longer, more realistic, larger time and area scales. Policy questions focus on the limits of

acceptable degradation of an environment (it should be emphasized that what is scientifically acceptable may be quite different from what is economically or socially acceptable). Further, there must be a meaningful comparison between the various disposal media. The accepted policy should be flexible as new technology and more information become available. Likewise, once a decision is made, it should not mean an end to the research.

Disposal of radioactive material is a special case because of the long-lived nature (10,000 years or more) of some compounds involved. The choice of a permanent disposal site is a scientifically, politically, and socially difficult problem. Burial in the seafloor is an appealing option. Although questions remain, nothing to date has ruled out the deep-sea disposal option. The key scientific question is whether the sediments have a large enough absorption coefficient to prevent any escaping radionuclides from reaching the water column. Obviously a choice of the seabed for the disposal of high-level radioactive wastes would require a major analysis of legal, political, and international implications. This could be even more complex than the scientific and technical aspects.

CO₂ and the Greenhouse Problem

Over the last one hundred years there has been a measurable increase in atmospheric CO₂ levels due to industrial activities. While carbon dioxide in the atmosphere is essentially pervious to incoming energy from the sun, it traps a portion of the heat energy escaping from the earth. This is known as the "greenhouse effect" and, as the CO₂ increases, it is expected to result in higher global temperatures. Since it appears that the amount of atmospheric CO₂ may double in the next century, the questions then are, What will be the effect, can it be controlled, and what policy should governments follow?

The data on the rate of CO₂ increase vary, and potential large-scale interactions make modeling complex. Another still debatable point is how much of the CO₂ can be absorbed by the ocean without causing other problems. A 1983 National Research Council (NRC) report concluded that there probably will be a

worldwide increase in temperature and rise in sea level in future years.² If correct, this will have enormous impact on agriculture and coastal use for many countries. In spite of these serious possible effects, the main alternative, stopping the burning of fossil fuels, also has serious consequences. The NRC suggested, due to the uncertainty of both the scientific data and the economic and social variables, that no steps be taken at this time, other than the continued monitoring of CO₂ levels and climatic and environmental responses.

Mineral Resources

Certainly one of the more exciting scientific events of the past two decades has been the discovery of vents emitting hot liquids and minerals along parts of the oceanic spreading centers. The vast amount of material discharged over time has changed many ideas about chemical processes in the ocean and the origin of seawater. Associated with these vents are unique forms of life whose sustenance comes from chemosynthesis rather than sunlight. Some have suggested that this environment is similar to that wherein life first originated. But the greatest interest has focused on the mineral deposits (generally called polymetallic sulfides) associated with the vents. These deposits contain intriguing amounts of zinc, copper, iron, with accessory amounts of silver, vanadium, gold, and platinum. Because of very limited data, an estimate of the value of these deposits is premature at this time, although several rather optimistic and exaggerated estimates have appeared in the press.

Some deposits have been found on the Juan de Fuca Ridge off Washington and Canada; another potential site closer to the United States is the Gorda Ridge. New exploration technologies and techniques such as SEABEAM (wide-angle multibeam echo sounding), side scan sonar, and bottom drilling capabilities, combined with the now testable plate tectonic hypotheses, should make further discoveries and resource evaluation easier in the coming years.

A more recent discovery has been the finding of thin (1-5 centimeters) cobalt-rich manganese crusts along the flanks of

several islands and seamounts in the central Pacific. Their shallow depth (1,000 to about 3,000 meters) and the fact that many occur within the U.S. EEZ have generated interest on the part of a number of government agencies. Another discovery has been the detection of hot springs on seamounts. One, about 500 kilometers off British Columbia and Washington, has sulfide deposits and some of the unique organisms found along the spreading centers. The shallowness of seamounts (about 1500 meters in this case) and the relatively modest relief of the region may make these deposits more technically accessible than those found on spreading centers.

Development of these potential resources will not be easy for various reasons, including the need to develop new technologies, the nature of international metal markets, the unknown extent and grade of deposits, and the rugged relief of the deposits. At present, the Minerals Management Service (MMS) of the Department of Interior, and the National Oceanic and Atmospheric Administration (NOAA) are examining methods that would provide access for commercial interests to these deposits. Many questions are yet to be answered: Are the deposits economic? Is enough information available for the government to proceed with a lease sale? How should the deposit be leased? The economic unknowns mentioned above will certainly add to exploitation costs.

One of the more critical issues for the mining of deep-sea marine minerals concerns the U.N. Convention on the Law of the Sea and the present U.S. position not to adhere to it. This treaty has specific rules for the mining of mineral resources beyond an EEZ. How the United States can (or even may) operate in this part of the ocean is at present unclear. However, most known polymetallic sulfide deposits and cobalt-rich manganese crusts occur within established EEZs. Other related questions include: Will marine mineral mining interfere with other traditional uses of coastal waters? What are the environmental impacts of mining? And what are the appropriate roles of the government, industry, and academe in exploring and eventually developing these deposits?

For the United States to claim and exploit some of the known

deposits off its coasts may require it to define its outer continental shelf—an area that can extend beyond its EEZ. Article 76 in the U.N. Convention offers various mechanisms for defining the outer continental shelf when it extends beyond 200 nautical miles (as it does for much of the United States). These definitions will be very hard to apply, sometimes impossible. Alternatives, including the so-called Hedberg Formula, could also be considered. The United States will ultimately have to make a choice on how to define its outer continental shelf boundary (using either Article 76 in the U.N. Convention or some other criteria), a choice that might set an example for other countries, and will clearly have implications for other ocean uses, including possible boundary conflicts with Canada and Mexico.

Fisheries

One category of marine use where policy has clearly outrun science is fisheries management. Although fishing is among the most important uses of the ocean, there is considerable controversy as to how to manage fisheries. Their distribution in the ocean and the critical oceanographic factors that influence this distribution are not well known. Indeed, it is not even clear if the continuation of conventional fisheries studies will give us further insight. The issue becomes even more confusing when the consequences of pollution (both catastrophic and chronic) are weighed with those of natural fluctuations and possible overfishing. Regardless of these uncertainties, fishery management plans have been developed and implemented in the United States. Specific and detailed scientific studies are needed to understand the interactions of fish with the environment as well as interactions between the various species of fish and other marine organisms. Among the critical questions are: What controls the number of individuals reaching a catchable size each year? And does fishing itself represent an important impact on commercial species? Given the large number of unknowns, the research protocol is far from clear.

Other important knowledge gaps include the relative abundance and trends of specific fisheries; this information is needed

so that reasonable predictions can be made and used in management schemes. Any scientifically realistic management scheme should focus on a multi-species approach within a given region. At the present time our data and models are neither realistic nor complete, and, as previously stated, it is often not possible to separate natural impacts on a system from human impacts, such as that of fishing pressure. Even if all these scientific questions were answered (or answerable), there are still critically important economic, political, and social questions that must be considered in any effective management plan.

Fisheries management illustrates an area for which policy is made and will continue to be made in the absence of, or with a lack of, scientific knowledge. Aquaculture also provides an opportunity on which to capitalize since many of the attendant biological problems have been moderated and markets already exist for the products. The outstanding problems are legal and social ones, such as legally setting aside (reserving) specific areas to be used for the culture of shellfish or the growth of salmon. For the fishery managers of the United States these are hard questions. They have to consider where management is applicable, what its objectives should be, and exactly what should be managed—fish or fishermen. Until an adequate understanding of the processes controlling fish, especially within the total ecosystem, is achieved, fishery management may continue to be less than successful.

Ocean Access and the EEZ

An important requirement for achieving the above and other scientific objectives is access to all areas of the ocean. The free and essentially complete ocean access for marine science that existed in the past has clearly been lost due to changing coastal state attitudes as reflected in the U.N. Convention. Scientific research in the world's 200-nautical-mile EEZs will involve new costs and commitments, additional time for developing research programs, and possibly delays in implementation for U.S. scientists. Nevertheless, an active research program in these waters (which currently supply about 90 percent of the world's present ocean fish catch and all of the offshore oil and gas) is necessary

for our scientific growth. New policies and approaches will be needed to ensure U.S. marine scientists continued access to foreign waters and to prevent further research restrictions in all parts of the ocean. A national policy that maximizes access and other benefits for U.S. scientists seems appealing. However, there are risks in implementing scientific efforts that are developed without adequate discussion and consensus within the scientific community.

The United States is deliberating its continued participation in international scientific forums such as the Intergovernmental Oceanographic Commission and regional organizations such as IOCARIBE. Further, the federal government could, as appropriate in its various interactions and negotiations with other governments, specifically try to develop favorable arrangements, treaties, etc., for marine scientific activities. In regard to specific countries such as Mexico and Canada in whose waters much U.S. research occurs, bilateral marine scientific arrangements have been considered with the cautionary note that bilaterals may have hidden costs that need special evaluation.

In general, the marine scientific community has often been effective in defining and implementing long-term programs. Yet, there is limited experience as well as enthusiasm within this community in dealing with issues pertaining to the U.N. Convention on the Law of the Sea. One concern is that scientists will avoid controversial geographical areas and Convention issues and will focus their research in more accessible regions. If so, this will ensure that the marine science conditions in the treaty essentially become restraints, discouraging important research in foreign EEZs. It should be stressed that EEZs encompass that part of the ocean which often has the most variability, receives most of the land erosion and waste products, and is also the most used and abused part of the ocean. To exclude this region from active research would narrow our effectiveness in ocean science studies.

Fortunately, however, an excellent opportunity exists for encouraging EEZ research—the declaration by the United States of its own EEZ. The President, in proclaiming such a zone, has claimed mineral resources (most fisheries were already claimed within a 200-mile zone by the United States in 1976) out to 200

nautical miles. A further extension is possible. The size of the U.S. EEZ, including that of the Commonwealth of Puerto Rico, the Commonwealth of the Northern Mariana Islands, and the U.S. overseas territories and possessions, is about 3.7 billion acres—compared to 2.3 billion acres of onshore land. The size of this territorial acquisition is unmatched in U.S. history and offers exciting opportunities for scientific and technological research. A well-planned, national EEZ program could yield important benefits to the United States economy and could serve as a model for foreign countries in developing their EEZs. For the United States much is already known about the types of its potential ocean resources, although little is known about their abundance, their impact on the environment, or the technology necessary for their exploitation. Thus, we are presented with a unique opportunity to develop a broad scientific and environmental program for the U.S. EEZ, an opportunity that could lead to adequate management and conservation schemes being in place when exploitation is appropriate.

Conclusion

The above examples show some future marine science objectives and how they relate to policy. It is anticipated that marine science in the future will proceed independently or ahead of policy issues. However, the implication of developments such as the U.N. Convention on the Law of the Sea and possible governance schemes for the U.S. EEZ suggests that marine science in the future will be working under more rigorous constraints than in the past.

Notes

1. National Research Council, *Global Observations and Understanding of the General Circulation of the Ocean, Workshop Proceedings*, August 1983 (Washington, D.C.: National Academy Press, 1984).
2. National Research Council, *Changing Climate* (Washington, D.C.: National Academy Press, 1983).