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THE EFFECTS OF THE LAW OF THE SEA ON FUTURE MARINE SCIENTIFIC RESEARCH AND OF MARINE SCIENTIFIC RESEARCH ON THE FUTURE LAW OF THE SEA

*John A. Knauss**

INTRODUCTION

In discussing how future developments in marine scientific research may affect future changes in the law of the sea, it is useful to consider the inverse question: how and why changes in the law of the sea have affected marine scientific research in the past and can be expected to affect it in the future. By examining these latter questions we can perhaps gain some insight into those developments in marine research that are most likely to influence the law of the sea in the future.

Field science was one of the last of the post-Renaissance flowerings. Laboratory sciences were well-established by the time of Newton, but the systematic study of plants and rocks did not attract serious attention for another century. From the time of Linnaeus to that of Darwin and Humboldt, naturalists were free to roam the lands making their observations and collecting their samples.[1] It was a rugged and often dangerous life, but the fulfillment of their goals was limited by sickness, poor food, and frustrating and often impossible logistical problems, rather than by national or international law that constrained travel, or limited observations or the gathering of samples.

Limited constraints were slowly applied in this century to scientists roaming the land, but those who explored the seas had essentially unlimited freedom until well after World War II. Prior to the 1958 Conventions on the Law of the Sea there was no accepted international law governing marine scientific research. Presumably the rights of coastal states within its territorial sea included the right to control marine scientific research, but from personal experience, and those of my colleagues, I know that many of us working at sea did not draw a fine distinction between work inside and outside the territorial sea and permission was seldom, if ever, requested. When it was, the request was

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1. See generally D. Boorstin, The Discoverers (1983).

often of an informal nature; for example, a letter from the director of a marine laboratory to a highly-placed person in a foreign government.[2]

The situation changed dramatically in the mid-sixties after the adoption of the four conventions of the 1958 Law of the Sea Conference. The limited rights of foreign vessels in the territorial sea did not include the right to conduct marine scientific research. More importantly, the right to conduct marine scientific research on the continental shelf was subject to the control of the coastal State. The year 1958 was also the start of the International Geophysical Year (IGY) which triggered a great increase in marine scientific research of all kinds in all oceans and an ever greater participation in scientific research which continues to this day and shows little sign of slackening. Coupled with this growth has come increasing legal constraint on how scientists can operate.

The Development of Legal Constraints on Marine Scientific Research

It is important to understand why these constraints were imposed on marine scientific research. As long as the primary economic value of the ocean was as a highway for international trade there were strong reasons to follow Hugo Grotius who in *Mare Liberum* in 1609 declared the ocean as *res communis*, a common possession of all and the private property of none.

It is the extraction of resources from the ocean that has led to extended national jurisdiction and with it constraints on the practice of scientists to move freely about the ocean. The primary reason for the 1958 Convention on the Continental Shelf was to provide the coastal State with sovereignty over the oil and gas resources off its coasts, just as the primary reason for the 200-nautical-mile exclusive economic zone (EEZ) in the 1982 Convention on the Law of the Sea is to give the coastal State control over its marine fisheries.[3] The most difficult negotiations of the 1982 Conference concerned the regime for the resources of the seabed beyond national jurisdiction. The failure at the Conference to reach a consensus on that issue may mean the remainder of the 1982 Convention will not be accepted as part of customary international law.[4]

Ironically it was the success of science and technology that has led to the constraints imposed upon them. It was marine geologists who led the oil developers offshore and it was the fisheries biologists and fisheries engineers who found new means of developing these resources that led to new ocean regimes and the erosion of the concept of the

2. Lecture by Paul M. Fye, Ocean Policy and Scientific Freedom, Columbus O'Donnell Iselim Memorial Lecture, Marine Technology Society Conference (Sept. 11, 1972).

3. A. Hollick, U.S. Foreign Policy and the Law of the Sea 62-102 (1981).

4. Burke, Cost and Benefits of Not Participating in the Treaty-Commentary, in The United States Without the Law of the Sea Treaty: Opportunities and Costs—Proceedings from the Seventh Annual Conference, Center for Ocean Management Studies, 1983, at 74 (L. Juda ed. 1983).

sea as *res communis*. The Truman Proclamation of 1945 in which he declared U.S. jurisdiction "'with respect to the natural resources of the subsoil and seabed of [its] continental shelf'" and implied other coastal States should do likewise was a direct response to the dilemma of an oil industry that wished to stake claims to mineral resources off the coast, but had no one with whom to file a claim for the seabed beyond the territorial sea.[5] The 1958 Convention on the Continental Shelf was largely the international codification of the 1945 Truman Proclamation.

Similarly the 200-mile exclusive economic zone can be seen as an attempt to regulate the exploitation of the world fisheries. Science and technology have made fisheries harvesting so efficient that distant water fishing fleets could effectively deplete a coastal nation's fishery.[6] The response was the granting to each coastal State a 200-mile exclusive economic zone in which it had exclusive jurisdiction over all resources including fisheries.[7]

With the granting of these new territorial regimes in the 1958 and 1982 Law of the Sea Conventions came constraints on marine scientific research. Article 5, paragraph 8 of the 1958 Convention on the Continental Shelf reads:

> The consent of the coastal State shall be obtained in respect of any research concerning the continental shelf and undertaken there. Nevertheless the coastal State shall not normally withhold its consent if the request is submitted by a qualified institution with a view to purely scientific research into the physical or biological characteristics of the continental shelf, subject to the provision that the coastal State has the right, if it so desires, to participate or be represented in the research, and that in any event the results shall be published.

The implicit argument for that paragraph was the coupling of research with resources. If the coastal State controls the resources, the coastal State must be able to control research associated with the resource. Scientists have had little success in arguing that such a coupling ignores the complexity of the relationship.[8]

The marine science community was not formally represented on the U.S. delegation to the 1958 LOS Convention, nor apparently were marine scientists represented on any other delegation. Whether strong protestations could have eliminated, or at least modified Article 5, paragraph 8, is unknown. Spokesmen for the oil industry believed strongly at the

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5. See generally A. Hollick, supra note 3.

6. Nweihed, Assessment of the Extension of State Jurisdiction in Terms of the Living Resources of the Sea, in Law of the Sea: The Emerging Regime of the Ocean—Proceedings of the Law of the Sea Institute, 1973, at 393 (J. Gamble & G. Pontecorvo eds. 1974).

7. See generally A. Hollick, supra note 3.

8. Knauss, Development of the Freedom of Scientific Research Issue of the Third Law of the Sea Conference, 1 Ocean Dev. & Int'l L.J. 93 (1973).

time that such a paragraph was necessary.[9] Given their position it is unlikely that anything less than a well-organized campaign would have had any effect.

U.S. scientists were better prepared for the third U.N. Conference on the Law of the Sea; however, as King has pointed out, their education was slow and painful.[10] Gaining permission to do marine scientific research in waters claimed by coastal States was becoming an increasing problem. Although a small group of U.S. science activists was prepared to fight hard to minimize the constraints on marine scientific research in the forthcoming negotiations, they had little success in convincing their foreign colleagues to develop an international position.[11] Marine scientific research in connection with the Law of the Sea negotiations was widely discussed during the negotiations and attempts were made to alert the scientific community to the consequences of the emerging treaty.[12] In spite of these various activities, the consequences of that involvement were limited.[13] The 1982 Law of the Sea Convention gives the coastal State almost complete authority to control marine scientific research in its territorial sea, exclusive economic zone, and on its continental shelf—almost forty percent of the world's oceans.[14]

To the best of my knowledge no one has yet systematically traced the marine science issue in the Law of the Sea negotiations or analyzed in any depth the reasons for the results one sees in the 1982 Convention. As an active participant in these matters for more than a decade, I have drawn some conclusions which I believe are close to the truth. The case for maintaining freedom to do research in a coastal State's exclusive economic zone or continental shelf was weak because it was

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9. Recollections on this subject by one who was there indicate that it would not have been easy. Wilbert M. Chapman suggests it was the U.S. delegation that argued most strongly for the restrictions. See Proceedings of the Fourth Annual Conference of the Law of the Sea Institute, 1969 (L. Alexander ed. 1969). Milner B. Schafer describes early efforts to soften the effect of Article 5, paragraph 8. See Proceedings of the Second Annual Conference of the Law of the Sea Institute 113-17 (L. Alexander ed. 1967). The Department of Interior was against loosening constraints on marine scientific research on the Continental Shelf, and their position presumably reflected the position of the oil industry. Id.

10. King, Oceanography, Political Intelligence, and Freedom of Ocean Research, in Knowledge, Politics, and Public Policy—International Readings in American Politics 103 (P. Melanson ed. 1973).

11. See generally Knauss, supra note 8.

12. The Ocean Policy Committee of the Commission on International Relation of the National Academy of Science regularly reported on the state of the negotiations through newsletters, reports, and seminars. Additionally, the marine science issue was often an agenda item at various law of the sea discussions sponsored by such groups as the Law of the Sea Institute and the Marine Technology Society.

13. Miles, United States Distant-Water Oceanography in the New Ocean Regime, in Oceanography-The Present and the Future, 283 (P. Brewer ed. 1983).

14. Ross & Knauss, How the Law of the Sea Treaty Will Affect U.S. Marine Science, 217 Science 1003 (1982).

complicated. It was based on the concept that science is neutral, that the findings of science benefit all, that a big gap exists between science and resource development, and that as long as the coastal State controls the resources the findings of science can only be helpful and not harmful. This case was made in some detail by the author in 1973.[15]

The U.S. marine science community attempted to convince key members of the U.S. delegation of the validity of its case and to develop support within the international scientific community with the hope that their colleagues would generate similar pressure on their delegations. Although we succeeded in gaining some support within the U.S. delegation, we were singularly unsuccessful in generating significant support in foreign delegations. Only the Federal Republic of Germany and the Netherlands supported the U.S. position. At best there was passive support from the major maritime States. At worst there was strong opposition, as in the case of Canada. The reasons for lack of foreign science interest have been discussed.[16]

The U.S. scientific community probably made a mistake in not making a greater effort to broaden its constituency. For example, no serious attempt was made to join forces with the powerful environmental groups. We had slightly greater success in enlisting the support of the military, and we eventually succeeded in convincing the oil and deep sea mineral industry that our different goals were not mutually exclusive.

The end result of the effort by U.S. scientists is a 1982 Convention that is perhaps marginally better than would have been the case if no effort had been made. Article 87 of the 1982 Convention lists freedom of research as an explicit freedom of the high seas; it was only implicit in the 1958 Convention. There are no constraints on scientific research in the Area which is defined as the seabed beyond national jurisdiction where the International Seabed Authority has jurisdiction over the resources. There was a period during the negotiations when it appeared that the Authority would have a stronger role in research in the Area, but this was one time when the military and the scientists were in agreement and prevailed.[17] The rights of a coastal State to control marine scientific research on the continental shelf beyond 200 nautical miles is much more limited than within 200 miles. This difference is clearly one that would not have been made if it had not been for the efforts of the U.S. delegation, particularly its head, Ambassador Elliot Richardson, who took a particular interest in the marine scientific research issue.[18]

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15. See generally Knauss, supra note 8.

16. See supra text accompanying notes 11-13.

17. Compare Article 143 of the Informal Composits Negotiating Text (ICNT) issue at the end of the Sixth Session in 1977 with the final form of Article 143 in the 1982 Convention.

18. The addition of paragraph 6 of Article 246 was not agreed to until 1979 during the Eighth Session of the Conference.

However, scientists lost the issue they believed most important and the one on which they had concentrated most of their energies. The coastal State exercises almost complete control over marine scientific research within the exclusive economic zone. Experts may argue the regime is marginally better than that in Article 8, paragraph 5 of the 1958 Continental Shelf Convention. It is considerably more complex. Perhaps there are some advantages in that the obligations of the researching states are better spelled out, but the bottom line is that there is a "consent regime" in the EEZ, despite the scientists' fight for a much less restraining regime. (Detailed analyses of the effect of the 1982 Convention on marine scientific research have been written).[19]

Some Effects of Legal Constraints on Ocean Science

One purpose in reviewing the history of the legal constraints that have been applied to ocean science by the 1958 and 1982 Law of the Sea Conventions is that many marine scientists believe that these constraints are shaping how one does science.[20] Additionally, there is a large amount of anecdotal material to suggest that the formal evidence from the State Department files does not tell the entire story. The following are examples illustrating this point.

Targets of Opportunity: During one summer in the mid-1960s the research vessel of the University of Rhode Island was working off the Icelandic "continental shelf" in an area it had received permission to operate; however, the weather was very bad that year with considerable fog and ice. The scientists were not able to complete the program as planned and the master of the vessel was concerned about the safety of the ship. The chief scientist decided an alternative target for their work could be off Canada and radioed me to see if I could secure permission. Permission was granted within forty-eight hours and we salvaged a successful program from what would have otherwise been several weeks of inefficient use of our research vessel.

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19. See generally Miles, supra note 13. See also Marine Scientific Research—Law of the Sea Constraints and Emerging State Practices, International Ocean Science Policy Group of the Board of Ocean Science Policy (Washington: National Academy Press) (forthcoming)).

20. In reviewing data available through the State Department, I said in a 1971 seminar sponsored by the Marine Technology Society, "Up until about 1966 I think at most four or five U.S. scientific research vessels were refused permission to work in areas other countries thought of as their waters or their continental shelves. In 1968 there were 12 such turndowns that one can note. In the first quarter of 1970 there were six. It is very difficult to find exact details because a lot of this negotiation is done privately . . . ." A later and more systematic study indicated that seven percent of the 441 requests were denied and "21 percent were subject to inordinate delays." Wooster, Research in Troubled Waters: U.S. Research Vessel Clearance Experience, 1972-1978, 9 Ocean Dev. & Int'l L.J. 219 (1981).

In contrast, I was in charge of a program of current measurements in the Equatorial Atlantic a few years later, and at the end of the program we were to make port in Recife, Brazil. During the course of the program we came across some anomalous water characteristics which we thought had their origin off the coast of Brazil. However, since our original program had not contemplated a series of observations in Brazilian waters, and since we had not filed a request to work in Brazil waters, I was reluctant to make these observations without permission as we steamed toward Brazil; and based on previous experience in trying to cut corners on their elaborate procedures for gaining permission, I knew it was not possible to get approval within a week as would have been required.

Areas not worked: Some States have developed reputations as being difficult to work with. Brazil has already been noted. India has a reputation for not allowing certain kinds of data to be published, as has Trinidad and Tobago.[21] As a result little research is done in these areas. It is too early to judge the effect of extended jurisdiction by all coastal States, but most observers believe marine scientists will find significant difficulties in working in at least some areas. The areas may change with time. For some years U.S. and western European scientists were denied the opportunity to study the fascinating coastal current off Somalia that changes direction with the changing monsoon. In 1977 the government expelled all Soviet Union military and civilian aides. Since then it has been considerably easier for U.S. oceanographic ships to work in this area. Similarly the warming of U.S.-China relations suggests it will be increasingly possible to work in areas off China.

Sometimes the difficulties are temporal. A University of Rhode Island vessel had great difficulty in gaining permission to work on the continental shelf of a West African country where we had previously had no problem. We later found that our arrival coincided with an election and the party in power was concerned that the opposition party would somehow turn our visit to their advantage. Similarly, opportunities to study the Red Sea brines have varied over the years depending upon the political situation.

Cumulative effect: Progress in science is measured by what is accomplished. No one keeps score of lost opportunities. Furthermore, since significant progress in science is almost impossible to predict before the fact, there is no way to assess accurately the importance of lost opportunities. The costs have been real and the costs will be greater in the future as the area of the ocean under State jurisdiction increases. However, it must also be noted marine science moves on many fronts simultaneously. If one area or one set of problems is foreclosed, scientists shift to a new frontier. Only occasionally is a given area unique to a

21. See generally authorities cited supra notes 13 & 19.

problem of such general importance that there is a sense that marine science as a whole would be impeded if the Law of the Sea constraints were the primary reason the necessary measurements could not be made. A recent example is the desire to test theories about large scale ocean and atmospheric interactions, ideas which were triggered by the Peruvian El Nino event of 1980-1982. The program requires a complex observational network centered around the tropical Pacific. Without the cooperation of a number of coastal States such a program would not have been possible. Such cooperation has been achieved by mounting an elaborate international program.[22]

THE PROBABLE EFFECT OF THE 1982 LAW OF THE SEA CONVENTION ON MARINE SCIENCE

Based on recent trends it seems evident that the 1982 Law of the Sea Convention will strongly affect where marine scientific research is done and how it is done. It will even influence the techniques and instrumentation. The adjustments are already evident. It is assumed that whether or not the Convention is ever widely adopted, the EEZ provisions of the Convention, including the right of the coastal State to control marine scientific research within its EEZ, will become part of customary international law.

International Agreements: Increasingly, marine scientists from researching States such as the United States attempt to develop joint efforts with their colleagues from those States in whose waters they wish to work. One consequence is that such research programs are longer in the planning and are often more elaborate in their execution that was the case previously.[23] Joint plans often have at least a semi-official sponsorship from organizations within the two States.[24]

Some feel that we will soon see an increase in large, internationally sanctioned research programs by U.N. sponsored groups such as the Intergovernmental Oceanographic Commission (IOC), or the World

22. Webster, Studying El Nino on a Global Scale, 27 Oceanus 58 (Summer 1984). The study will be part of an international program Interannual Variability of the Tropical Ocean and the Global Atmosphere known as TOGA. It is sponsored by both nongovernmental organizations of the International Council of Scientific Unions and by two intergovernmental organizations, the World Meteorological Organization and the Intergovernmental Oceanographic Commission.

23. Ocean Research for Understanding Climatic Variations, Priorities and Goals for the 1980's: A report of the Ocean Science Board, National Research Council (Washington: National Academy Press 1983). Toward an International Geosphere-Biosphere Program, A Study of Global Change, A report of the Commission on Physical Science, Mathematics and Resources, National Research Council (Washington: National Academy Press 1983) F. Webster, An Ocean Climate Research Strategy (Washington: National Academy Press 1984); see also supra note 22.

24. As part of a joint effort to study the Brazil current, senior officials at the University of Sao Paulo and the University of Rhode Island signed a joint agreement.

Meteorological Organization (WMO), or by such nongovernmental international science organizations as the Special Committee on Oceanographic Research (SCOR) of the International Council of Scientific Unions. Two such programs for the future are the World Ocean Circulation Experiment (WOCE) and a major new program called Global Change which encompasses the land and the atmosphere as well as the oceans.[25]

Large programs of the scope of WOCE require several years of planning, but once States have agreed through the IOC or similar organizations to participate in WOCE, it becomes much easier for scientists from those States to develop joint programs. Perhaps as important, a program such as WOCE provides an umbrella under which a number of "spin-off" scientific programs can often find a home. Small additional programs often can be accommodated at the last minute as long as these last-minute programs are in the spirit of the original plan. When significant changes must be made (including major changes in ship schedules or ship programs) it may be possible to reach agreement within the international scientific steering committee without having to resubmit formal requests to the coastal State involved. In other words, large international science programs take time to establish, but once all participating States have agreed, the detailed planning and execution of the program can be facilitated. For these reasons, I believe we will see an increase in internationally sponsored marine scientific research.

Areas in which marine scientific research is undertaken: A dozen years ago, before there were significant constraints on scientific research in most parts of the world, an estimate was made of approximately how much time U.S. academic research vessels spent in waters which would come under coastal State jurisdiction. Both the Woods Hole Oceanographic Institution and the University of Rhode Island reviewed several years of their research ship programs and each came up with about the same answer. Some forty percent of the time was being spent in waters which would soon be some States' exclusive economic zone, and which henceforth would require permission if we were to work there. We are now in a transition stage between the old and the new, and it may be a bit early to make a careful survey of what effect the new 200-mile exclusive economic zones have had on where marine science is done. A quick survey of programs run from the University of Rhode Island's research vessel Endeavor during the four year period 1980-1984 shows that less than ten percent of the ship time was spent doing work in another State's EEZ. Part of that dramatic change could simply be a change in interests; for example, concentration on the Gulf Stream, deep ocean spreading centers, and equatorial currents—all of which can be studied without entering a foreign EEZ. However, as noted earlier, all things being equal scientists will concentrate their efforts on problems

25. See supra note 23.

that require minimum bureaucratic entanglements. The procedures which must be followed in many States to work in their EEZs add both problems and uncertainty of success to what is already a difficult work program. Thus, the trend we have observed in the work program of our own research vessel may not be an exception.

Research techniques: One of the important new tools of oceanography is the satellite.[26] Sensors aboard satellites allow us to measure the surface temperature of the ocean and to determine the "color" of the ocean and thus gain an indirect measure of its biological productivity. Satellite sensors can also determine the detailed shape of the ocean surface as well as the surface roughness, from which we can infer information about currents and waves. Most importantly, satellite sensors allow one to measure large areas of the ocean almost simultaneously. In a way never before possible, one can see the detailed structure of the entire length of the Gulf Stream at a single pass, or see the spatial patterns of biological productivity. Satellite information has one very important limitation. All the information comes from the surface skin of the ocean. Inferences can often be drawn about what is occurring beneath the surface, but the data are surface data. Considerable research is now underway to attempt to develop relationships between what can be seen on the surface with the often more important processes that occur beneath the surface. For example, scientists are now attempting to correlate the highly visible superficial scar that marks the edge of the Gulf Stream as seen by satellite with the "real" Gulf Stream that one observes from the more detailed measurements one can make from a ship.[27]

The 1982 Law of the Sea Convention is silent on marine scientific research from satellites. In fact, the subject was never formally raised during the negotiations. It is also noteworthy that nowhere in the Convention is marine scientific research defined. Research vessels wishing to do marine scientific research in a foreign EEZ must request permission, but satellites passing overhead do not need to request permission to collect information about the surface of the ocean.

The improvements in satellite technology in the past decade would have insured increasing interest of marine scientists in these kinds of data under any circumstances; the fact that these data are not subject to the constraints of the Law of the Sea Convention enhances the interest.

Marine scientists sometimes inadvertently gather information from a coastal State's EEZ without processing formal request forms. These are the data from drifting buoys, both surface buoys and subsurface

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26. Oceanography from Space—A Research Strategy for the Decade 1985-1995, Joint Oceanographic Institutions, Inc., 2100 Pennsylvania Ave. N.W., Washington, D.C. 20037, 1984.

27. Cornillon & Watts, Satellite Thermal Infra-Red Determination of the Gulf Stream North Wall, Journal of Atmospheric and Oceanic Technology (forthcoming).

buoys. A typical one might work as follows: a cylindrical tube, perhaps a few inches in diameter and several feet long, is designed to float with the currents at a depth of 1000 feet or so. It carries sensors to measure the temperature and salinity of the water, and perhaps such information as dissolved oxygen, or bioluminescence. By recording the time of arrival of sound pulses from a number of acoustic beacons scattered in the area, it is able to determine its position several times a day and this information is recorded on magnetic tape. After recording position information and data about the ocean for a period of several weeks a weight is dropped by a preprogrammed clock, and the buoy floats to the surface and radios the information it has stored to a communications satellite which in turn transmits the information to the scientist in the laboratory.

The use of these floating instrument packages is growing, both those that float on the surface and those that float at mid-depth. As far as the 1982 Law of the Sea Convention is concerned, the problem is that there is no way to guarantee which way they will float. There is little problem for buoys with a life span of a few weeks, but one set of buoys was tracked in the central North Atlantic for more than two years. Most stayed in the vicinity, but a few wandered off into the Caribbean. Although they were often out of range of the acoustic network, they occasionally sent back information about subsurface currents from one or another foreign EEZ.[28] If these systems grow in popularity in the future, it seems likely that some misunderstandings between researchers and coastal States will occur. What effect this will have on the continued use of the technique is uncertain.

THE EFFECT OF MARINE SCIENCE ON THE FUTURE LAW OF THE SEA

The most significant law of the sea trend since World War II is the seaward extension of national jurisdiction. The territorial sea has moved from three to twelve miles, and the edges of the high seas have been carved into the resource zones of the continental shelf and exclusive economic zone. To the extent that science has played a role in the development of fisheries and oil and gas resources, marine science has made a major contribution to this most significant change in the law of the sea. Will future discoveries of science have comparable effects?

Science can and will discover possible new ocean resources. However, the path from discovery to commercial exploitation is a long one and science usually plays only a marginal role in these latter developments.

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28. A float launched in the Western North Atlantic at a depth of 700 meters was tracked for 1170 days. It transmitted information on temperature and currents at that depth, although during the last two years the transmissions were irregular. The float moved with the currents at that depth and at one time, some four years after launch, was within 200 miles of the Dominican Republic.

Successful exploitation depends upon engineering technology, and most important of all, the development of commercial markets in competition with other sources of the same or similar resource. The slowing of interest in the mining of manganese nodules of the deep seabed these past five years has not been because of any missing science, or even any lack of engineering technology. The primary reason has been the worldwide decline in mineral markets and mineral prices. Until those markets recover, there will be no significant effort in mining the nodules of the sea floor.[29]

The remainder of this paper examines some of the trends in ocean use in which science will play a role. The last three examples might be thought of as countervailing forces: ocean use which will reduce, or at least slow down, the seaward creep of national jurisdiction resulting from increased exploitation of the ocean's natural resources.

Seabed Resource Development: Recognizing that science is but one component in the economic development of ocean resources, one can still speculate on what the development of new resources will have on the law of the sea. The most obvious conclusion is that new, commercially exploitable resources found within the EEZ or the juridical continental shelf will have no effect on the law of the sea since the coastal State controls those resources.

The exploitation of oil and gas started at the shoreline and proceeded seaward. National jurisdiction has been extended seaward to allow the coastal State to control those resources. The edge of the continental shelf in the 1958 Convention was simply defined as where the water depth exceeded 200 meters or where the oil was exploitable, whichever was deeper. As oil exploitation reached ever greater depth, so did the juridical continental shelf. Whatever lack of precision there is in the 1958 definition, it at least resolved the issue of who had jurisdiction. The continental shelf in the 1982 Convention is defined in ten paragraphs of Article 76. Its twin goals are to find a precise geological/geographical definition and, at the same time, insure the coastal State jurisdiction over all oil and gas off its shores. It is too soon to judge whether it has been successful.

Given past practices, I expect that national jurisdiction will continue to grow seaward if mineral resources are found that are first exploited within the EEZ or continental shelf and can then be tracked seaward. Most ocean mining experts believe it will be a long time before the polymetallic sulphides of the deep seabed are commercially exploited.[30] If and when they are exploited, one can begin the practice within the jurisdiction of one or another EEZ, since these ridge cracks run for great lengths across ocean basins. Having developed the necessary tech-

29. Telephone interview with Marne Dubbs, formerly in charge of the deep seabed mining program of Kennecott Copper (Sept. 8, 1984).

30. Id.

nology within coastal State jurisdiction it seems likely that the coastal State would continue to claim jurisdiction as the crack proceeds seaward beyond its EEZ or continental shelf. In the absence of a strong countervailing force such as a viable International Seabed Authority I believe national jurisdiction will creep seaward.

Not all mineral resources can be tracked seaward from the EEZ. The primary reason for the long debate about a proper regime for the mining of manganese nodules was that this resource was found on the seabed far from shore, and it seemed self-evident, at least in 1970, that this resource was well beyond the jurisdiction of any coastal State. The formal reasons given by the United States for withdrawal from the Convention were technical issues concerning the details of the International Seabed Authority and the regime of the deep seabed beyond national jurisdiction.[31] Additionally there was widespread discussion concerning the precedent setting implications of the deep seabed regime to the New International Economic Order. It has been suggested that these philosophical concerns played a more important role in the U.S. decision than the technical reasons given.[32]

However, in addition to the aforementioned political reasons, some concern was also expressed that the LOS regime for the deep seabed was expressly designed for the mining of manganese nodules and might not be well-suited for other resources of the deep seabed. During the twelve-year period of the negotiations other possible resources of the deep seabed have been found. These include the polymetallic sulphides found along spreading centers that separate the larger tectonic plates, and the so-called cobalt crusts found on the tops of some underwater seamounts.[33]

If, as seems likely, other deep seabed resources are found to be economically viable, then it would appear that some modification of the deep seabed regime of the 1982 Convention will be in order. Although many of the articles are generally applicable, it is equally clear that those who negotiated the details of Articles 151 and 161, for example, did so under the implicit assumption that the primary resource of the area was manganese nodules. Annex III of the Convention is even more obviously tilted toward that resource. Thus, a complex regime that is at best marginally capable of encouraging economic development of the manganese nodule resource of the deep sea may prove completely incapable

31. Statement of Ambassador James L. Malone, Special Representative of the President for the Law of the Sea to the Plenary meeting of the Conference (Apr. 30, 1982) (explaining why the United States would vote against the Convention).

32. Ratiner, The Law of the Sea: A Crossroads for American Foreign Policy, 60 Foreign Affairs 1006 (1982).

33. Holser, United States Government Initiative in the Assessment and Development of the Mineral Resources of the Exclusive Economic Zone of the United States, Open file report 84-110, Dep't of Interior, U.S. Geological Survey (Washington, 1984).

of encouraging the development of other resources of the deep seabed that science and technology may uncover.

Development of Living Resources: Unlike mineral resources, most living resources of the ocean are mobile. However, with the exception of whales and tuna, nearly all of the economically important living resources of the ocean are presently caught within 200 miles of the coast. They exit in the EEZ of one nation or another, and are thus subject to conservation and exploitation schemes developed by the coastal State. To the extent these State management plans are complicated by stocks that migrate along the coast and move from one State jurisdiction to another, bilateral or multilateral arrangements may be required.

There is little question that there are more living resources in the ocean than are being exploited and it is likely that marine science will turn up even more in the next twenty-five years. As with ocean minerals, the question is not so much the presence of resources, but is there a market. One resource that has received considerable publicity is the large krill fishery of Antarctica. The Soviet Union, Japan and Chile have conducted exploratory fishing in the area.[34] The Antarctic Treaty includes all States that have laid claim to portions of the Antarctic Continent, as well as those that have conducted extensive research programs in the area, but explicitly does not address the issue of territorial claims. A recent addition to the Antarctic Treaty addresses the issue of living resources in the Antartic Ocean outside the 1982 Law of the Sea Convention. It should be noted, however, that the status of the Antarctic Treaty itself has been questioned within the United Nations General Assembly.[35]

I am not aware of any coastal stocks being fished seaward of the 200-mile EEZ. If a combination of science, technology, and markets result in an economic coastal fishery beyond 200 miles, I would expect we will see an extension of State jurisdiction over those fish whether or not there is a formal extension of the 200 mile EEZ. Article 63 would appear to give the coastal State some special standing.

I am less sanguine about the role of the Law of the Sea if science, technology, and markets combine to develop fisheries which are currently truly high seas fisheries. The inability of the International Whaling Commission to manage whales and the failure of States to agree on a rational management scheme for tuna, which are found in the high seas as well as within the EEZ, does not instill confidence that international

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34. Kaczynski, Economic Aspects of Antarctic Fisheries, in Antarctic Politics and Marine Resources: Critical Choices for 1980's, Proceedings of the Eighth Annual Conference of Center for Ocean Management Studies (University of Rhode Island) (forthcoming).

35. In 1983 Malaysia called for the Secretary General to submit a report on the question of Antarctica. The report has been completed and Antarctica is expected to be an agenda item for the 1985 General Assembly.

agreements will be any more successful in managing new high seas fisheries whatever they may be.

The role of science in the development of any of the aforementioned resources is probably minimal. Development will depend mostly on technology and economics. Salmon ranching, however, is another story. Experiments are now underway on the west coast of the United States to spawn salmon in privately controlled streams. The young salmon swim out to sea, grow large and return to spawn in the same stream. Experiments conducted at the University of Washington over a number of years have shown that such techniques can be used to breed salmon with certain characteristics. If salmon ranching, as this form of aquaculture is sometimes called, becomes a significant business it may raise a number of legal issues. What rights, if any, does the salmon rancher have to protect his salmon from other fishermen when the salmon are on the high seas or the EEZ? Can one mark salmon, as one brands range cattle? Even if this were possible, can agreement be reached about private property rights to such salmon?

Military developments: One of the most important military issues of the Law of the Sea hinges on what science has been unable to do. The oceans remain relatively opaque. Radars and satellites can track airplanes and missiles over hundreds and sometimes thousands of miles in real time and with pinpoint accuracy. If one can credit newspaper stories, Russian submarines can slip in and out of Swedish fjords with comparative ease. Although all military powers are close-mouthed about their ability to track each others' submarines, it is no secret that even the most elaborate and sophisticated techniques achieve limited success. Electromagnetic radiation, including visible light, radar and radio waves, penetrate the ocean poorly. On the other hand, sound waves are transmitted much more effectively in the ocean than in the atmosphere; however communication and detection systems in the ocean based on sound are vastly inferior to analogous systems in the atmosphere based on electromagnetic radiation. Although improvements can be expected, it seems unlikely that underwater detection systems will ever make the ocean as transparent as the atmosphere.

The continuing opacity of the ocean was an important element in the negotiations leading to the 1982 Law of the Sea Convention. If submarines are to remain undetected they must remain under water. The 1958 territorial sea convention requires submarines to remain on the surface while in another nation's territorial sea; that requirement is continued in the 1982 Convention. An important treaty goal for every military power with nuclear submarines was to insure that submarines could remain beneath the surface while transiting narrow international straits such as Gibraltar and remain beneath the surface while passing through the seaways established by archipelagic States. Both goals were achieved in the 1982 Convention.

If science should find a truly effective way of tracking submerged submarines, the advantage of continual submergence will be less important

in any future reopening of the 1982 Convention. Both the United States and the Soviet Union invest heavily in research and development in this area and one cannot rule out some important new breakthrough. However, the laws of physics would appear to be on the side of the submarine. For every advance in detection technology, there appears to be the opportunity for a comparable advance in avoidance technology.

Long-range weather forecasting: The need for a global network of meteorological observations to record and predict weather is sufficiently self-evident that States continue to transmit regularly their observations under all but the most difficult political situations. Being able to predict changes in weather patterns is of sufficient common good that each State is prepared to make its contribution to the global network to insure that the global data its forecasters have is of the highest quality. Forecasting changes in seasonal trends and weather patterns more than a few days in advance is still almost as much art as science, but improvements are being made. It is recognized that the oceans are a key to accurately predicting changes in seasonal weather patterns. Small changes in ocean circulation patterns are later reflected in changing weather patterns. A major goal of the present TOGA program and the World Ocean Circulation Experiment planned for the nineties is to better understand the complex interaction of ocean and atmosphere.[36] Scientists hope that their understanding of this complex system will soon be adequate to justify the establishment of a global ocean observation system analogous to what is now in place for the atmosphere. Satellites will be useful in gathering some of this information, but it will also require instrumented buoys and similar techniques. The establishment of a worldwide ocean observational network may contribute to further international cooperation in other marine science programs and a relaxation of present constraints on marine scientific research allowed under the 1982 Law of the Sea Convention.

Global pollution: "Spaceship earth" ceases to be a cliche when pollution becomes a transboundary problem. To date, the responses to such problems have been relatively simple, for example, the establishment of a Canadian-United States Great Lakes Commission to consider pollution problems in the Great Lakes and agreement on Mediterranean protocol under United Nations Environment Program sponsorship dealing with common pollution problems in the Mediterranean. It is yet to be shown that States have the capacity to respond effectively to such problems other than to agree to a joint study. It seems likely that global or transboundary pollution problems will increase in the future, for example, industrial pollution in the United States which affects Canadian streams and forests, industrial pollution in the Soviet Union which may effect the heat balance in the Arctic Ocean, and significant changes in

36. See supra note 22.

the carbon dioxide content of the atmosphere which in turn results in a warming of our climate.[37] The list is certain to grow during the next 25 years because (a) advances in our knowledge of the oceans and atmosphere guide us in what to look for; (b) improvements in analytical chemical techniques make detection easier; and most importantly of all, (c) an increasing population coupled with an increasingly industrial society results in more opportunities to generate global pollution problems.

If the past is a guide to the future, we can safely assume that the first response to any claim of significant pollution problem will be similar to the UNEP Mediterranean response or the U.S.-Canadian Great Lakes response—an agreement to conduct further studies. Perhaps global pollution problems will be a mechanism to increase cooperation between states to study oceanic and atmospheric processes.

Waste Disposal in the Ocean: The deliberate disposal of waste material in the ocean is regulated by the Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Matters, commonly known as the London Dumping Convention. Some fifty-eight States have ratified the Convention including the United States, the Soviet Union, Japan and most European countries. In addition to requiring each state to keep a record of what it deposits in the ocean, a series of annexes spell out the kinds of material that cannot be dumped (Category I) and the material that can be dumped under agreed upon controls (Category II). To date, parties to the Convention have been able to reach agreement on the annexes with comparatively little difficulty. An issue, however, which is presently causing some controversy and promising to cause more in the future, is the use of the ocean for the disposal of radioactive waste.[38] The disposal of low-level waste is permitted under the Convention under controlled circumstances, but the disposal of high-level waste is forbidden. No one is currently considering using the ocean as a disposal site for high-level waste, but an international research effort is presently considering the safety and feasibility of depositing such material deep in the sediment of central ocean basins.

Finding a suitable disposal site for the spent fuel rods of nuclear power plants is not easy since they require isolation for at least ten thousand years. It is too early to judge whether the proposed plan will pass all of the safety and technical hurdles before it. Research studies to date are promising. The first option of the United States is to bury the material deep beneath the surface in a geologically stable site. The United States probably has a number of suitable geological options. Smaller nations such as the Netherlands, Japan, and the United Kingdom

37. Global Tropospheric Chemistry, Report of the National Research Council (Washington: National Academy Press 1984).

38. Nuclear Waste Management and the Use of the Sea, A Special Report to the President and Congress, National Advisory Committee on Oceans and Atmosphere (Washington: U.S. Gov't Printing Office 1984).

may not be as well-endowed geologically. The subseabed option may be particularly attractive to them if further research demonstrates its safety.[39]

The disposal of both low- and high-level radioactive waste is an emotionally charged issue. Passing technical muster does not automatically assure agreement by the signatories to the London Dumping Convention. The alternative to agreement could mean some States withdrawing from the London Dumping Convention and making their own arrangements for subseabed disposal.

Whichever scenario occurs, it seems likely that concern about waste disposal in the ocean, particularly the disposal of radioactive waste material, is going to generate increased attention and interest. Careful and controlled use of the ocean commons for waste disposal may be a strong force for international agreement on ocean use.

CONCLUSIONS

If this paper has a theme, it is that the discoveries of marine science have led to the development of the ocean and its resources and the consequent flow of private property rights in the ocean as well as the seaward extension of national jurisdiction. To the extent that the goal of marine scientists was to keep the oceans "free" for scientific study, they have been the victims of their own success as national jurisdiction over marine scientific research now extends to perhaps forty percent of the ocean. Science will contribute to future resource development which in turn will probably extend national jurisdiction even further seaward.

On the other hand, science will contribute to ocean use programs which will require significant international cooperation. The use of a global ocean observational network to improve significantly long-range weather forecasting, including forecasting seasonal trends in weather, will require international cooperation. That and concern about global pollution and the use of the ocean and the seabed beneath the ocean for the disposal of waste material, including high-level radioactive waste, may contribute to development of programs that will place some limits on the seaward creep of national jurisdiction.

The response of marine scientists to the increasing constraints on marine scientific research appears to include the following: (1) development of science programs that minimize the requirement to seek permission to work in foreign EEZs; (2) development of large internationally sponsored programs which, once in place, facilitate negotiating the bureaucratic maze of requirements for permission to work in foreign

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39. Id.

EEZs; and (3) increased interest in techniques such as satellite observations which are outside the law of the sea.