The Oceans: Planetary Engineering and International Management

THIRD ANNUAL SEA GRANT LEC

THE OCEANS: PLANETARY ENGINEERING AND INTERNATIONAL MANAGEMENT

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3 October 1974

Report No. MITSG 75-3
Index No. 75-603-Wpe

ANNUAL MIT SEA GRANT LECTURE

The MIT Sea Grant Program plans the annual Sea Grant Lecture as a yearly milestone in the marine field, an opportunity for the Lecturer to review current problems and to present perspectives for the future. Reflecting the Institute's commitment to environmentally balanced ocean and coastal zone utilization, the Lecture provides a forum for discussion on the roles of engineering, science, and the social sciences in developing marine resources. We of the MIT Sea Grant Program dedicate this occasion to the identification and study of inventive approaches to major national and international opportunities in the oceans, and to all persons whose vocations or interests are served by the seas.

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Robert A. Frosch

The views I will express are not necessarily those of the United Nations Environment Programme (UNEP) or of the United Nations, but represent my own opinions, modulated by the eighteen months I have spent at UNEP. During the past year, I have been looking out over the Athi River plains from the twenty-first floor of the Kenyatta Conference Center in Nairobi. I shall be taking rather a long-term view of the subjects I am going to discuss.

First, I will set out for you a collection of facts, assertions, allegations, and theories put forward by various people (including myself). These should suggest a pattern of future environmental problems and possibilities. Second, I will describe some implications of this pattern for future technological and social problems and for our global behaviour. Third, I will enquire into and comment on the management problems arising from these implications. Fourth, I will examine international capabilities for dealing with such management problems. Fifth (and finally), I will discuss the possible role of the United States, of United States policy, and of the United States technological community in solving these management and technological problems.

Mankind is outgrowing its range. We are overcrowding our habitat. The number of people that the planet and our society must support is increasing rapidly, so rapidly that the long-term and perhaps the immediate possibility of feeding all of these people, even at the subsistence level, is doubtful. Those increased requirements in resources (food and other amenities) to provide affluent comforts to greater numbers of people complicate this problem. The high consumption of nonrenewable resources, including metals and fossil fuels, clearly gives reason for worry about the long run availability of these resources.

Over time, since the planet is finite, and since key resources are crustal, we may finally exploit them all. I know of no model that can avoid this eventual result, although new discoveries may defer the final reckoning. The optimists think in terms of 100 to 1000 years for petroleum, while the pessimists limit it to the order of 10 to 100 years. Fossil fuels are not recyclable.

Though metals are recyclable, since we do not lose them, but store them in refined and manufactured forms, and since they presumably are being deposited at crustal plate boundaries, our current rates of use far outrun any rate of deposition.

The growing population in many parts of the world is consuming renewable resources more quickly than they can be renewed. Forests are being cut down at a faster rate than regrowth, for construction wood or paper, for charcoal, or for additional arable land to support food crops. In other places grazing land is being burdened with ever greater num-

bers of animals and people, or is being turned to crops, resulting in increasing pressure on water resources. The history of land use conversion suggests great reasons for caution.

The destruction of forests has led frequently to severe land erosion, which prevents other use. When forests in the lower Himalayas were cut for wood but not regrown or replanted, the reduction of the land's water-holding power may have been responsible for an apparently greater flood frequency and severity in Bengal and Bangladesh. This effect certainly occurs elsewhere in the world, although not usually on so large a scale.

Attempts to convert tropical forests to crop or grazing land have been generally unsuccessful. The prevailing high temperature in tropical regions causes continuous microorganism activity which destroys organic matter very much more rapidly than happens in temperate zones. Thus there is no deep organic layer in tropical forest soil: most of the organic material is above-ground in the living forest, and the dead mulch is reused very quickly. When the forest is cut and removed, the resulting soil is generally poor; it rapidly becomes very hard and essentially untillable, as well as infertile.

Attempts at conversion of grazing land to crop production have led to spreading deserts in various parts of the world. Crops are usually introduced after several years of good rainfall, but in marginal semiarid areas there is insufficient rain in poor years for growing enough crop plants to hold the soil together. Both the United States and the Soviet Union have had relatively recent dust bowls, when grazing land converted to crop land blew away in years of poor rains. Plains grass survives better in drought than tender crop plants, and the accumulated sod roots hold the soil. Cultivation destroys this holding power.

Through the complex of our resource extractive and industrial operations, we have increased the liberation of particulate matter and gases, including carbon monoxide and carbon dioxide, into the atmosphere. We use large quantities of fertilizer and pesticide chemicals. These have increased agricultural production, but also have had numerous detrimental side effects. The excess chemicals wash off the land through and into various bodies of water; finally the unconverted residue reaches the sea. Increasing production of heavy metals and of new synthetic organic chemicals creates frequently toxic residues which have the same fate.

Greater needs for energy have increased the amount of waste heat being produced by the conversion of fossil solar energy and nuclear potential energy into usable form. Whether or not we find productive side uses for this waste heat, it eventually ends up in the atmosphere, the ocean, and the earth's crust.

These increasing demands on land and ocean resources, arising from population growth and from expanded expectations of more affluence than really necessary may have very large-scale and globally important effects.

For example, man-made inputs of particulates and carbon dioxide in the atmosphere seem now to be greater than natural inputs from volcanoes or forest fires. These already may have begun to affect the absorption of solar radiation and the effective albedo of the planet. Other chemical species liberated into the atmosphere may change the high altitude chemistry of the air, in particular that of ozone, which is the principal chemical species providing a shield against solar ultraviolet radiation. In the SST controversy, whether or not the conclusions about that particular source of input were correct, a number of unsettled questions were raised about possible high altitude chemical effects.[1]

In land use conversion, much the same situation holds. Major changes in the amount of forest cover, the amount of crop or grazing land, and the amount of desert will influence the planet's humidity balance and albedo. This is likely to affect climate. In the global climate equation, the term which accounts for humidity transpiration from forests is nonnegligible, but the effect on climate of reasonable variations in the term is not well understood. Neither the models nor the data are sufficiently detailed and precise as yet for such a sensitive examination. Indeed, what causes what in overall climatic variation is unclear. In some cases changes in land use may be forced by shifts or cycles in climate; in other cases a change in land character and use may produce an altered climatological effect. Certainly the heat islands of urban centres influence at least local, if not regional, weather.

Are the effects of increases in particulate pollutants and carbon dioxide, and of alterations in land use patterns, lost in climate's cyclic phenomena and weather's noisy character, or are these man-made events forcing changes in climate? It has been suggested that their combined effects in the atmosphere have caused changes in upper air movement which have shifted the southern monsoon belt further south, thus producing major droughts in previously monsoon watered areas, particularly the Sahel region.[2] Other meteorologists feel, from historical evidence, that the Sahel drought reflects the normal recent cyclic behavior of weather in this region.[3]

It has also been suggested that this extreme drought may be connected with range destruction through overgrazing made possible by the introduction of permanent watering points for cattle and resulting large sedentary rather than nomadic populations. Other observers implicate the conversion of grazing land to cropland.[3]

Recently, climatologists have been asking whether global climate is transitive or intransitive.[4] In engineering terms, is it stable, bistable, or multistable? Is there more than one reasonably steady state which could be a solution to nonlinear climatic equations and boundary conditions? Some climatological history suggests that the shifts between major climatic states, as between glacial and interglacial periods, occur in time periods that are short compared to the duration of the states.[5]

Shifts take place over 100 years, whereas steady states may last 10,000, indicating the bi- or multistability of the system. Changes in sea ice and continental glacier ice, by binding of heat and water and in their effect on regional albedo, may play an especially sensitive role in the triggering of this phenomenon.[6] The sill depth in the Arctic Ocean has been suggested as an important factor.[7]

So far I have said almost nothing about the oceans; but perhaps I have implied that if the results of some of our human interventions on land are a guide to the future, the oceans had better watch out, because here we come.

The oceans are clearly involved in global climate changes. They may control atmospheric carbon dioxide by dissolving it, after which it can be consumed in biological conversions, particularly photosynthesis, just as soil and soil organisms are said to deal with excess carbon monoxide. How much carbon dioxide could the oceans handle? With more carbon dioxide available in the atmosphere, will increasing amounts be dissolved until some chemical change (in pH for instance) results, which might produce later changes in the seas' biology? I believe that this question has been and is being examined.[8]

Unless absorbed in soils or chemically changed on the way, many of the chemicals discharged on land eventually reach the oceans. Are we poisoning the living oceans by gradual accumulation of man-made chemicals? With the major exception of DDT, to my knowledge relatively little evidence exists for large-scale spread of man-made chemicals in the oceans, although there is plenty of evidence for local and perhaps even regional effects. Global poisoning is merely a grim possibility for the future, but we should begin to worry about it, as well as about the impact of power generation's waste heat on local mixing phenomena and the direct effects of both heat and chemicals on marine life.

We must also be concerned about certain classes of accidents and their possible large-scale effects. For example, massive oil spills or leaking wells in the Arctic might have a local melting effect which could trigger a total melt of Arctic ice.[8] This would change the global climatic state and could cause major flooding, though some question exists as to the exact nature of the changed climatic state. There might also be large-scale effects from massive tanker spills; I refer here not to the effects of local accidents on local biological systems, but rather to the effect of major, critically located interference with atmospheric ocean interchange. The problem posed is whether, in other areas than the Arctic ice cap, interference with the ocean's surface could trigger changes in climate, if it is bi- or multistable.

Our problems with energy have led to a search for new sources. One proposal would use vertical temperature gradients in the ocean for the generation of electrical energy,[9] effectively a temperature mixing scheme which also extracts some of the heat from the water.

Some have suggested that artificial upwelling could provide fertile water for lagoon or open ocean mariculture. This could be combined with use of the cold water for the generation of energy, or for refrigeration, which, would allow extraction of fresh water from atmospheric humidity.[10] Deep-sea nodule mining might be an effective source of artificial upwelling.[11] This enforced vertical mixing of the local circulation might have broader effects than anticipated, depending on the real stability of the system involved. One might also question whether this use of deep fertility is in fact mining previously deposited fertility or whether it is just providing conditions for continuous production of a renewable resource. One presumes the latter case.

We might also investigate the effect of high plankton densities on sunlight penetration. By intercepting solar radiation, does a greater concentration of this living material at shallower depth than usual affect significantly the water's temperature profile, and thus possibly its circulation and the stability of the water column, or is this a negligible phenomenon? This question is also raised by proposals which would use urban sewage for mariculture by improving the fertility of the open ocean.[12]

We must also take note of proposals for major engineering works, such as the flooding of the Qattara depression in the Sahara by opening up a channel to the Mediterranean Sea. Intended to provide an artificial source of hydroelectric power while filling (1000 years #, ?), it would create a large new inland sea with unknown effects on weather, climate, and the fresh groundwater hydrology of the region.

The oceans must intercept about 70 percent of the solar energy reaching the earth. If someone succeeds in inventing a relatively cheap solid state device for conversion of solar to electrical energy, the ocean's surface could be covered with such a generating system, especially since, with increasing population, land will be more valuable for other uses. Such a system, covering significant amounts of ocean surface, would presumably change the effective albedo, at least locally, and thus affect local weather. Large-scale use would certainly change the net regional heat transfer to the oceans, and the moisture transfer to the atmosphere, with possible large-scale effects on weather and climate.

Many of the previous possibilities seem to be only of local interest. However, results of previous technological innovation show that if the techniques successfully generate significant additional quantities of food (particularly protein), and provide useful local side effects in energy and refrigeration, they would be considered important contributory techniques to productivity. Thus they would probably become very widespread, ultimately covering not only near-shore ocean but also probably increasing areas of deep ocean surface as well. The limitation in area would arise from competition with other uses of the sea and coast.

At this point I would like to admit that I have produced for your view a rather speculative chamber of environmental horrors. Many of these possibilities may vanish entirely at the touch of real science, technology, and economics, but some of them may turn out to be real events. Even small-scale changes could precipitate large-scale events, if adopted by many users. In North America, the conversion of forest and grazing land to farms changed the whole character of the land in something under 200 years (for much of the country under 100 years). No one made a specific continental policy decision, but individual and regional decisions accumulated.

The possibilities described would all be produced inadvertently, as side effects of changes being made for other purposes. But what we do inadvertently we can of course do advertently, by choosing what, where, and how much of the system to build. Then one could optimize the systems, not necessarily for their principal products but for their side effects, and these could themselves become technologies. For instance, we could not only use upwelling for energy or food, but, given the technology, we could choose to influence local weather or climate, if the upwelling has that consequence.

All of these possibilities might be regarded either as inadvertently damaging phenomena or as purposeful technologies. If the former, we must limit our behavior and use of certain technology if we are to avoid unpleasant global or regional consequences. If the latter, the conversion of side effects into technologies raises the possibility of "planetary engineering." I will give some examples.

If we understood the nature of climate change and the role of Arctic ice in this, and if a certain amount of melting did in fact cause a cascade effect, we could use the oil spill effect described previously to trigger a shift in global climate. This is only a modern version of the turn-of-the-century suggestion for spreading carbon black on the Arctic ice surface so that it would absorb more heat and melt. The consequences of purposeful or accidental manipulation would be, of course, the same.

We might purposely try to change the high altitude albedo and greenhouse effect by the injection of particulates or chemicals, either to force a shift in global climate or to compensate for global injections of waste heat from fossil or nuclear sources by albedo adjustment.

We might purposely use waste heat or wind and wave energy to cause upwelling, either for improving marine fertility or for changing ocean circulation, which would become equivalent to regional or global climate manipulation.

Another interesting case is posed by hurricane modification or manipulation. Project Stormfury[14] has already attempted to remove energy from hurricanes by seeding the storm clouds around the eye with condensation nuclei to stimulate precipitation. This would redistribute the storm's energy radially, lessening the maximum winds that are responsible for the greatest direct property damage and loss of life.

The energy for amplification of storms and perhaps for the creation of tropical weather disturbances into storms and hurricanes may be provided by heat transfer from the warm water and by moisture evaporation from the oceans in the subtropical belts.[14] If this heat and/or moisture transfer is key in amplification, then changes in the ocean's properties by the use of surface films or artificial upwelling might affect the birth and growth of such storms, or might be used for manipulating particular storms. Even though the storm has great energy, it is possible that the amplifier providing that energy could be controlled with very small manipulations, provided the right things were done in crucial triggering places. Much better understanding of the phenomena involved would be needed to devise such a system for manipulation.

Of course, any attempts to decrease storm damage by decreasing the fury of these storms, by preventing them entirely, or by steering their paths away from land, must be very carefully planned. Since these storms do transfer a great deal of water from ocean to land, they play a major role in the supply of water for agriculture in affected localities. Additional questions arise about liability for real or fancied damages caused by changing the characteristics or course of a storm.

The foregoing adds up to the real potential capability for manipulating some of the major environmental characteristics of our planet, atmospheric climate and circulation, ocean circulation and fertility, and, if certain instabilities exist, of planetary energy and moisture balance systems and hence the total global climate.

Putting the previous elements together, I assert that as our human pressure on our habitat rises, certainly the temptation will increase to effect many of these small possibilities, each of which individually may be of no particular difficulty, but the collectivity of which becomes a big change. We are going to be doing planetary engineering; the question is: shall we treat it as such and plan for it systematically? Through the course of human history, we have moved purposefully on land, but without very much general consideration of total end consequences, from small groups living in wilderness to the bulk of humanity living in some form of man-made or man-influenced ecosystem. In this country our change of heart now means that wilderness can be considered as something to be preserved rather than conquered. In much of the world, however, the balance of opinion between conquering and preserving wilderness is reversed.

There is nothing necessarily wrong with the construction of artificial ecosystems. As Dubos has pointed out, this is frequently successful, and may create precisely the kind of ecosystem in which man would like to live. We need wilderness as a reservoir of the origins of ecosystems, of their characteristics, and of genetics, and for aesthetic and social reasons as well, but a population of 10 billion people will be able to live only in some balance between wilderness and man-made ecosystems. To make our artificial ecosystems as livable, stable, and pleasant as

possible, we will need a discipline of ecological engineering built upon ecological systems science. For the oceans, the introduction of marine animal husbandry and mariculture, as in the creation of saltwater lagoons and of salt marshes breeding places, will all require such engineering and knowledge.

The ocean is essentially still a wilderness, though it is becoming a man-influenced ecosystem as a side effect of many human activities, including exploitation of marine resources. Shall we merely allow this to happen, or shall we carry out the changes purposefully? We have created enough examples of bad human ecosystems on land; it is clearly worthwhile to think about what we should do next both on land and in the ocean wilderness. We know how to make unproductive ecosystems from productive ones; perhaps we can learn the necessary engineering to reverse the process, even on a large enough scale to improve some major natural ecosystems for our own purposes. This does not deny our need for major preservation of natural systems.

This discussion leads to the question: can part of the ocean be managed as a wilderness, and part as a strongly man-influenced ecosystem? On land we do not really know the size of wilderness area that would be self-sustaining when isolated and surrounded by human ecosystems. How much more difficult it will be to understand and manage such situations in the fluid and moving ocean.

Shall we grasp the nettle, and at least begin to think seriously and collectively about the possibilities I have outlined and what they mean? Should we prepare ourselves to devise technology for managing the inadvertent effects of our otherwise constructive activities in the oceans? Shall we begin to consider how purposefully to manipulate regional and global characteristics of the ocean? Whether or not we ever decide to engage in such a dangerous form of management, I believe that we should study seriously the means for such management so that our choice between rejection and acceptance of possibilities can be based on knowledge. Without this knowledge, we could not understand how to stop inadvertent effects, nor could we even argue sensibly against their use as technology. Even now lack of knowledge about land systems prevents us from presenting convincing, heeded arguments against some manipulations of ecosystems. It is my personal view that we will find at some future time that we want or need to engage in some of these manipulations; we ought to begin to understand them now.

Some may suggest that I am merely rationalizing a desire to pursue technology, and that this is in itself dangerous. I can only say that as many cases of environmental damage seem to be produced by lack of knowledge and the technology to use it as are produced by incorrect use of technology. In both situations, the difficulty usually derives from lack of broad enough consideration of systems and system alternatives.

What tools will we need in order to be able to face these technological possibilities successfully; what will be the requirements for managing them and their results? First, we will need more data for better theoretical knowledge of the systems involved in order to understand the implications and consequences of the possibilities, whether purposeful or inadvertent.

UNEP is engaged in activities related to these problems. We are establishing a programme called Earthwatch, which contains, as a major element, the Global Environment Monitoring System (GEMS). GEMS will collect information on many of the global factors mentioned above, including key pollutants and chemicals that might affect human health or climate, and other environmental variables such as forest cover, or desert area, that could change the global environment. As another part of Earthwatch we are beginning an International Referral System for sources of environmental information and exchange of data, which will operate as a yellow pages or switchboard system to bring questioners and possible informants together. We also have a great interest in models of climate and other system properties which could lead us to a better understanding of the outer limits of inadvertent action. As I have already pointed out, this also will lead us to a certain understanding of what the effects of some purposeful manipulations might be.

Suitable technology is the second element that will be required for purposeful action. For example, we would need the capability to cause and manipulate large-scale upwelling, to use surface agents on the ocean, and to eject particulates and appropriate chemicals into the atmosphere. We would need the means to perform safe and reasonable experiments designed to explicate the inadvertent side effects, and then the means to carry these out on large enough scale to be manipulatory.

A third element would be the social technology to agree regionally or globally (according to the scale required for the problem) on the objectives or policies to be carried out using the data, the understanding, and the physical technology, While I believe that, with time, effort, and money, we have the capability to collect the required scientific data and to formulate the theoretical understanding and the necessary technology, I do not think that we even have a good technique for developing the background material required for sensible decisions. I am not referring to questions of politics and diplomacy in the strict sense, but am considering only the preparation of what are frequently known as policy papers: the input information for the legislator, the politician, and the diplomat (who though often called decision makers, are frequently indecision makers). The techniques called policy research, technological assessment, and systems analysis, as usually practiced, are not adequate to the job that is required.

All current means of doing such work seem to be predicated on analyzing alternatives in an adversary manner, with relatively little attention paid to the source of the alternatives. Procedures for generating alternative possibilities are inadequate; analysis of the alternatives is sel-

dom undertaken in the spirit of engineering design and of scientific theory and experiment. We need much more system synthesis than analysis, more careful and imaginative generation of possibilities, more laying out of alternatives and their consequences, with feedback from analysis to the construction of new alternatives. Current methods for preparing decisions lean too heavily on adversary processes; what we generally get is half-baked systems analysis of poor alternatives. In my view we need far more system synthesizers, idea generators, and designers than we need more systems analysts. As somewhat of an exaggeration, I would say that nearly anyone can be an analyst; the difficulty is finding the synthesists. Hundreds of physicists can solve stated physics problems, but very few can invent new ones or synthesize a worthwhile question. Thousands of engineers can analyze a stated system, but few can invent or design systems that are really worth analyzing.

If the situation with regard to the preparation of technical materials for policy decision is this poor, the situation with regard to the examination of social consequences seems to me to be even worse. The adversary nature of most policy decision processes obscures the fact that these are not zero sum games: the real goal is not deciding between the stated alternatives, but rather using the alternatives to construct a better design for what is to be done. This seldom happens in the policy formulation process as I have seen it operate. For example, the framework set up for the Environmental Protection Agency by the National Environmental Protection Act seems conducive not to the constructions of solutions, but only to interminable arguments intended to prove the rightness or wrongness of an original decision. This system affords little incentive for a design evolution philosophy. What we really need is a process which recognizes that policy formulation is not a zero sum game, but rather a search for ways to increase the sum available to all parties. There are trade-offs, but the items originally chosen are often not the correct alternatives for trade-off.

I believe that this situation has arisen because scientists and engineers have not been enough involved in defining the decision process. Too frequently, they have allowed the nature of their involvement to be defined by nontechnologically-trained people such as lawyers who have carried adversary decision making over into the area of technological evaluation and assessment without real consideration of its appropriateness for the job. In effect, the techniques of the scientist and engineer in decision making have been displaced by the techniques of the lawyer. I defend this strong assertion by noting that most discussions on public technological policy tend to be arguments of the "'tis, 't'ain't" variety. My experience in Washington and in the United States has not lessened my feeling that this is a fundamental problem with the techniques we are applying to social decisions.

I will give several examples. The policy and public level discussions on the safety of nuclear reactors have really hinged on the question: "Are they safe or are they not safe against certain classes of accidents?" Few have asked: "How could they be made safe with a certain probability, at a certain cost, in the face of a certain class of risk?" Some engineering analyses do discuss the problem in this way, but when these are converted to policy analyses they appear as advocacy documents for one side or the other, without laying a foundation for nonadversary discussions of engineering problems.

For instance, both public and private debate on the consequences and dangers of large tanker accidents have proceeded entirely on the basis of accident analyses that essentially assume the current nature of tankers, tanker systems, and tanker operations. In fact, the problem is entirely different. What are the possibilities for reducing tanker accident probability below a certain allowable amount, while simultaneously adjusting the probable circumstances of these small chances of accident in order to have minimum consequences? This is a system design problem: the engineering technology for analyzing such cases and for producing changes in the probability distributions exists.

The problem may not have a satisfactory solution: while the probabilities are small the risks may be too high. However, at the very least any tanker skipper could have definite guidance in these matters, or perhaps absolute control by a station with detailed information for the whole area of relevant ocean, in knowing precisely where he is, who is around him, or whether the weather and seas will be in the direction he wants to go. I am well aware of the numerous objections to these ideas, but suggest that re-examination of them in a problem-solving mode, rather than adversary discussions over poor alternatives, is what is really required for solving such problems. Only scientists and engineers are likely to force a change in procedure. It is a matter of social responsibility.

It appears to me that these difficulties are accentuated by a phenomenon I call policy displacement. It is assumed that a policy's effect will be that aimed at by the policy analyst or policy maker, not that chosen by the people to whom the policies are applied. However, the policy that one man can devise another can exploit, and he generally does. The writers of tax legislation seem perpetually astonished when the tax lawyers go home and say, "Now, how can I turn this new piece of legislation to my client's advantage?" This is the very nature of policy formulation and reactions to policies.

Public policies really are a system of incentives to guide people into sought-after behavior patterns. But one cannot expect people to operate mechanistically. Punitive policies that operate entirely by the construction of disadvantages generally lead to interminable wrangling, litigation, and evasion, rather than to cooperative attempts to solve the problems. Attempts to force pollution cleanup with disincentives are likely to fail because implicit or explicit policy definition of the system

concerned leaves the pollution problem out of the incentive system: although punitive action may be needed as a final weapon, making a clean situation advantageous is almost certain to succeed. We need more examination of ways in which pollutant side effects may be used to economic benefit, and considerably less discussion of punishment, disincentives, and difficult ways of avoiding pollutant outputs.

I am always disturbed when I hear discussions of local thermal pollution. (I have already mentioned the global waste heat problem.) While I recognize many engineering difficulties, it is news to me that a free supply of hot water is a disadvantage.

The desire for conversion of waste to advantage will become stronger. As resources become scarcer, the potential incentive to adopt the packing company motto, "We use everything from the pig but the squeal," will become greater and greater. The reasons for recycling and reuse of so-called waste are now not only matters of pollution control, but matters of economy in energy and materials. In an agricultural sense, we simply cannot afford any longer to discard the potential fertilizer in sewage and agricultural wastes of all kinds. This is not a case or organic versus chemical (as in the adversary relationship), but of the fundamental economics of resources: we need to use everything we have.

Adversary attempts to discuss these problems in zero sum game terms lead usually to a result in which the sum is decreased (short-term gains for one party or the other) rather than one in which it either stays the same or is increased.

Social technologists need to find new methods for noncoercive cooperation and for better definition and achievement of social objectives. As an unashamed technologist, I believe that scientists and engineers will have a greater role in this process than heretofore. Many ideas formed in science and engineering over the past decades, including our ability to synthesize and analyze systems, our attitudes toward systems design, our increasing understanding of noise, signal and noise, and the whole set of statistical approaches to detection and control represent important new attitudes that should be brought explicitly into the construction of the policy formulation process.

Up to this point I have examined a set of assertions and suggested a resulting set of problems. I have commented on requirements for solution in terms of knowledge, technology, and policy formulation technique. Since these fundamental problems occur in a global context, it is reasonable to enquire what capabilities the international community has for dealing with them.

With regard to technological matters and policy, the United Nations family is a highly sectoralized collection of specialized agencies, each with its own constituency, legislature, programme, and budget structure. In large measure, these agencies compete for budgets and for an opportunity to follow out their own particular interests. There are structures which attempt to coordinate these organizations and to provide an integrated set of international ventures. However, in the U.N., as elsewhere, coordination seems principally to mean the prevention of duplication, rather than a wholehearted attempt to organize cooperative systems that cut across sectoral interests.

The difficulty arises partly from the structure of independent agencies, and partly from the usual competition among them, compounded by the policy behavior of governments. Since the various sectoral portions of the U.N. have, in effect, independent legislatures and budget processes, with only loose coordination through the Economic and Social Council and some coordinating committees, governments can treat each sector quite independently. Most governments characteristically send public health people to World Health Organization meetings, weather bureau people to the World Meteorological Organization, oceanographers to the Intergovernmental Oceanographic Commission, and agriculture people to the Food and Agriculture Organization. There may not necessarily be any policy consistency in the instructions given to each of these delegations. United States delegations are not immune to this.

As a result of these factors, policies of this collection of agencies have no built-in system consistency, even with regard to global problems. Attempts to provide coordination after the basic programmes and budgets have been formulated are obviously extremely difficult to carry out. There are many joint committees and joint programmes: for example, the International Global Ocean Station System of the World Meteorological Organization and the Intergovernmental Oceanographic Commission. There is joint work in agrometeorology between the World Meteorological Organization and the Food and Agriculture Organization.

However, most of the projects undertaken by these agencies remain sectoral with mild intersectoral coordination. Irrigation for agriculture and the public health aspects of water, for example, are handled in two separate independent agencies, each generally aimed at its own direct responsibilities. As a consequence, irrigation systems can become major spreaders of waterborne diseases, which then must be attacked after the fact. In essence, such problems are a major reason for the existence of UNEP, an institution which attempts to coordinate international activities for fostering a more system oriented and less sectoral view of environmental problems and the actions required to deal with them.

Our UNEP experiences in trying to foster such a generation of system attitudes across intersectoral boundaries have left me convinced that real difficulties must be overcome. These seem to arise not because the players are uncooperative, but because the system's structure and the implicit incentives do not push them to comprehend or implement cooperation on large-scale trans-sectoral problems.

I will now turn to the nations themselves and their behaviour. These days, nations talk a good deal about their interdependence; in fact, most are totally oriented to their own sovereignty, their own economics, and their own trade advantage. Interdependence, usually interpreted as economics of world trade, seems to be used principally as a lever for individual advantage even in that context. There appears to be little governmental concern with the interdependence arising from the global nature of some of our key environmental systems.

Though my current information on events in Caracas is quite incomplete, certainly the Law of the Sea Conference seems to have been almost exclusively concerned with carving up the territory, cutting the cake, and making sure that everyone has a reasonable chance to maximize his own advantage. This may be merely underbrush that has to be cleared before getting on to cooperation, but in my view it will not provide a terribly good foundation for cooperative examination of the ocean and the globe as systems. Many of the discussions on making policy for situations in which no one has either devised or analyzed the effects of real technical alternatives seem more likely to foment discord than to encourage cooperation.

However, some bright spots do exist. In an increasing number of cases, governments in a region combine their interest in the health of that region. There are several recent examples of this with regard to the oceans. We have seen agreement on the London Dumping Convention, on a regional agreement of the Baltic countries, and the agreement of countries in the Northeast Atlantic on the pollution problems of that ocean region. In UNEP we have high hopes for an agreement among Mediterranean littoral and maritime countries that will bring about the establishment of a real programme for improving that inland sea's environment.

International scientific circles show increasing interest in these global environmental problems. Programmes like the Global Atmospheric Research Programme, with its GARP Atlantic Tropical Experiment are real signs of cooperative attempts to obtain the necessary data. There are other examples as well.

Nevertheless, my examination of the international scene leaves me rather pessimistic; I feel we have neither the structure of international organization to force real cooperation on global system problems, nor the necessary interest on the part of enough nations in global environment problems. Most nations are still so entirely focussed on their own short-term economic advantage that it will be very difficult to get them to focus on global system problems. Tying together the United Nations organizations is UNEP's job. We think we have a fighting chance to improve the situation, but whether a major success will be possible remains to be seen.

This brings me to the question of the United States' potential role in this situation. The U.S. assets for playing a role are technology, understanding of technology, understanding of systems, the meaning of systems and how to deal with them, scientific expertise, and capacity for invention and innovation. The U.S. needs to bring these to bear on its capability for social experimentation in policy formulation in order to devise better techniques for bringing cooperation out of competition. The U.S. is rich, and thus can afford to be generous and take some chances with its generosity, without being foolish. It can afford to play a role of leadership in matters of food, climate, the oceans, and environment generally, without always hewing to a short-term view of its own advantages and disadvantages. It can afford to take a long view of the advantage to the United States in preserving or enhancing the habitat in which we all live, our planet. The biggest liability in the U.S.'s leadership role is that it is generally not trusted in large portions of the world, since its vested interests have led to past activities on behalf of its own advantage. The U.S.'s wealth and power make this a special liability, and the apparent ability of the U.S. to do and be everything everywhere compounds the problem.

I am reminded of a British wartime comment to the effect that the Yanks were "overpaid, oversexed, and over here."

I believe that the U.S. should try to establish more firmly a national attitude of informed concern for the global system. In spite of sectoral difficulties inside the government, the U.S. should make this a consistent policy in international forums, rather than a collection of bits and pieces of policy. Having been involved in trying to accomplish this sort of thing within the Federal government, I know that it is extremely difficult to do, but I believe that the U.S. has the technical and social capability to succeed.

The U.S. can afford to look at the long-term future in spite of its present problems, many of which may be solvable only in the context of a long-term planetary view anyway. While much of the world is bogged down in short-term problems of immediate survival, we could carry the load of helping others focus on key long-term global system problems. We must try to ensure that there will be a planet worth exploiting rather than a complete focus on immediate exploitative advantages.

The U.S. scientific and technological community should make itself more involved in designing the detailed mechanisms by which policy is set and most especially those by which potential policies are explored. Final policy determinations are frequently set legally and legislatively, but the mechanisms for bringing forward and exploring possibilities are open to simpler change, since they are mostly matters of administration.

As technologists we should be less ashamed of applying our specific knowledge to such problems, even when we are described as mechanists. Scientific knowledge and broad systems understanding are not irrelevant to these social matters. As it has in local commons, the tragedy of the commons, the global commons, will arise when all es-

tablish their rights, leaving no one to be worried about responsibility for the overall system. As usual in human affairs, the balance between rights, freedoms, and responsibilities becomes the key question. Perhaps we need a new discipline: a theory of morality as the statistical mechanics of acts, a better way of understanding why a collection of sensible and fair actions, of good acts, can produce evil results. A few children are adorable, but a billion can be a tragedy.

Having looked at a set of assertions and posed some problems that these imply, having questioned our grasp of the techniques necessary to manage the solutions to these problems, having examined our international status with regard to attacking these problems, and having commented on the place of the U.S. and the U.S. scientific community in all of this, I find in the end that I see much reason for pessimism and a few signs of hope. One of my reasons for hope is that the international community did find the will and the means to establish an environment programme chartered to look at many environmental problems in a global, international, and regional way, and to try to make those system connections across functional areas so essential in attacking these problems. Another reason for hope is my feeling that the United States and its technological community can play and will play a major role in supplying the ideas, the technology, and many new social means for solving these problems on the international scale. Perhaps U.S. attention to these problems, if they are real, and I believe they are, might help give the global system idea enough push to interest nations in really working together.

There is a recurrent theme in much historical writing and in much recent science fiction on the establishment of global unity in the face of a common external enemy. In the words of Pogo, "We have met the enemy and he is us." Perhaps we have reason to be frightened enough of our own capabilities, but also excited enough by what we can do with these capabilities, so that we can unite to attack these problems in the face of ourselves.

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ALTERNATIVES FOR AN INTERNATIONAL SEA GRANT EFFORT

Dr. Judith T. Kildow

ALTERNATIVES FOR AN INTERNATIONAL SEA GRANT EFFORT

Judith Tegger Kildow

Introduction

This afternoon I'd like to talk about an important effort we've been conducting here at M.I.T. As most of you know, the National Sea Grant Program has focused primarily on domestic problems up to now. However, recent events have provoked thought of expanding this unique program to an international level. Before presenting some of the feasible alternatives for such an effort, I'd like to review the circumstances which prompted the consideration of an International Sea Grant Program.

Background

The passage of the Marine Resources and Engineering Development Act in 1966, as well as the National Sea Grant College and Program Act of the same year, marked a significant juncture in American politics—a recognition of the special importance and value of the oceans and the beginning of a renewed effort in the United States to focus on and coordinate policies to assure that the American people could reap the maximum benefits from the oceans.

Increased awareness of natural resource limitations, environmental pollution problems, and rapidly increasing demands on our coastal areas have brought augmented efforts in the forms of new programs and policies, resulting in accelerated innovations in marine technology, and major advances in marine scientific discovery.

Putting our expertise to work at home has been both admirable and necessary. Yet, many discoveries and innovations in marine technology necessitate intercountry cooperation to allow their real benefits to be derived. For example, while our engineers have been developing new and better processes to drill for offshore oil or to harvest manganese nodules on the ocean floor, we have discovered that many of the natural resources critical to maintaining the current standard of living and expected rates of growth may not be readily available to us. Political, economic, or physical reasons may stand in the way.

The accelerating world demand for natural resources and the accompanying increases in their value have added at least two new dimensions to the natural resource development process. First, those countries with the resources, but without the capability, are reluctant to allow others to control or even develop their resources as they may have done in the past. Since there is a common interest in optimizing the development, utilization, and management of the world's resources, it is in the interest of most nations to assure adequate capability for the development of needed resources. Thus, training and education of people from all nations should be available to assist them in the proper

development and utilization of their natural resources. Training should be provided for fundamental "blue and white collar" professions which would permit them to develop their resources, as well as training and education in utilizing and managing those resources. Such a program could help people understand the pros and cons to alternative uses for resources; the trade-offs between slow development and rapid development, between development and no development, or some other use of manpower and capital instead.

The United States and a few other industrialized countries are beginning to raise global consciousness about the need for carefully planned resource utilization and management. Some nations have understood these concepts for years, while others have no interests in these problems because of more immediate concerns. There appear to be too few coordinated efforts at approaching these problems on a global scale. A second new dimension to the natural resource development process is the gradual exhaustion of high quality, low cost resources on land and the consequent move to offshore developments. The rapid development of offshore technology in the past decade has enabled us to develop an almost virgin source of natural resources. At the same time that technology has progressed so quickly, international social change has occurred at an equal pace, producing new problems.

The skills and technology necessary for deriving benefits from the oceans are primarily the products of industrialized countries. Much of the ocean's wealth, however, is within the territorial jurisdiction of less industrialized nations or in international waters where the resources belong to "the heritage of mankind." How can equitable development, utilization, and management of the resources be realized if only a small portion of the world's nations possess the capabilities? Again, it is obvious that work needs to be done: scientists and technicians need to be trained, information must be made available to those who want and need it, and expertise should be supplied when requested. For nations to benefit from many of the world's resources, living and nonliving, nationalism must be put aside and cooperation substituted. That is not to say that nations should jeopardize their own interests, but rather, that they should look beyond those interests to identify cooperative arrangements with other nations from which they might mutually benefit.

Just as natural resources have a global character, so are transportation and navigation international in nature—they are the essence of international trade and commerce. The advent of new, improved ships requiring modern port facilities has created the need for new international maritime regulations. However, international cooperation is necessary to make these new regulations possible.

Exhaustion and mismanagement of fishery resources, the pollution dangers to near and offshore areas, and the already mentioned need for mineral resources are but a few of the many global problems which require scientists, engineers, and diplomats to cooperate with those of other nations for their effective resolution. Because marine science and engineering have heretofore been luxuries to many nations, there are not always trained people with whom scientists, engineers, and diplomats can work. Recognizing the potential value of the seas to their growth, many developing states particularly are anxious to have help in building the manpower and equipment to benefit from the oceans. The U.S. and a few other industrialized nations are in a unique international position today: not only do they have the technology, trained manpower, and capital to apply to ocean uses, but they can afford to consider long-range global problems as well as the more pressing short-term ones. These countries should use this opportunity to provide world leadership toward resolving some of the more critical problems mentioned above. How might they do this? What can they do?

Dr. Frosch has eloquently explained some of the pros and cons for using the UN system as a vehicle for international cooperation in these matters. However, the fractionated nature of the UN program as a whole —not to speak of the marine-related activities, and the highly politicized character of the body itself—make its current effectiveness questionable, in my opinion. Even if the Law of the Sea negotiations produce an "International Seabed Authority," its role has yet to be defined and its effectiveness will have to be proven. Yet the need is now and the demands are immediate. How can nations best respond to these needs?

Last year, the U.S. Congress amended the National Sea Grant College and Program Act to reflect its broadened perspectives of U.S. policies regarding the oceans and its concern for this problem. It legislated that a study be undertaken through the National Sea Grant College Program "of the means of sharing through cooperative programs with other nations the results of marine research useful in the exploration, development, conservation, and management of marine resources." (Section 205) The history of the legislation indicates the appropriateness for this study to focus on cooperative programs with developing countries or those countries with underdeveloped marine science capability. This study has been in progress since February 1974; the original time constraints for the study precluded a totally comprehensive look at the problem. It should be noted here that an important area was left out of this report but will be completed by December 31, 1974. The role of the private sector, particularly the multinational corporation, in the international marine field has been temporarily omitted, although it was felt to be a critical component to the study. The first phase results were sent to Congress just this week. A consortium of more than thirty experts representing academia, industry, and government throughout the country was brought together under our direction at M.I.T.; their professions included science, engineering, political science, economics, communications, and administration. Some of them authored papers, others reviewed papers, and still others acted in advisory capacities.

After establishing the need for expanded international marine-related programs, we measured and compared numerous possible alternatives with already existing efforts, and how they met the needs we identified. We struggled to clarify 1) the scope and objectives of such a program; 2) how it might be organized most effectively; 3) what its key functions should be; 4) how large it needed to be to fulfill the stated objectives; 5) who should be involved; and 6) where its most effective home might be.

Recognizing the imbalances in the international system in economic and political development and keeping our eyes open to the current issues confronting the system, we laid out a number of alternatives to consider. With regard to the scope and objectives of a new or expanded program, we considered several different alternatives. First, we asked whether we wanted this program to function as a "wet AID" effort or as a new concept in international cooperation and sharing. We concluded that generally, Agency for International Development (AID)'s performance left something to be desired in its approach character. We also decided that technical assistance as it had been practiced under the AID method was outmoded, and that a broader perspective and more balanced sharing concept could be more effective. After all, the United States does not have expertise in all fields, and can learn much from developing and other developed nations. We saw no reason why there should not be identifiable gains for the U.S., as well as for all other nations which might be a part of such a program.

Second, we questioned whether our objective should be to transfer hardware and money, or whether we should concentrate on the coordination of information and skill dissemination in the marine area, or whether the objectives should encompass both. We determined that the second alternative had been badly neglected and was a necessary base for any cooperative program. If programs are to function effectively, there must be people who can send and receive information and do something with it at each end of the communication link. In addition, private industry has handled the hardware end of the technology transfer process for a long time, through overseas marketing, and we felt that a reordering and better definition of the role of the private sector was necessary before government preempted that function. With a better understanding of the role of the multinational corporation in technology transfer, a government-sponsored program could complement the activities of the private sector, as well as encourage the private sector to coordinate its activities with government.

We also considered whether such a program ought to emphasize long- or short-term problems. While our political system puts constraints on long-term involvements, we felt that if there was a way for a new program to tackle some of the long-term global problems such as pollution and resource utilization and management, that would be one of the largest contributions we could make. We decided that a number of smaller, more immediate problems should also be included in the program, but within the context of broader long-term implications.

Next, we asked how comprehensive the program should be. Would a single-focused program (at least at the beginning) be effective (e.g. fisheries management, coastal zone management, or ship design, etc.)? Or, would a multifocused program involving a range of marine-related activities be more effective? Since a single-purpose program would limit the number of persons who might participate in both the U.S. as well as abroad, we concluded that whenever needs could be satisfied with available expertise, almost any marine-related area could be considered appropriate.

We felt that the new program should reach the maximum audience possible, both in this country and in others, and should not restrict its scope arbitrarily; that scientists, engineers, social scientists, and administrators should be included, and that people from government, industry, and academia should qualify. We also asked if we should focus on cooperation with particular nations. Should this program encourage those countries whose interests most intersect with those of the U.S., or isn't that relevant? Should this program seek nations with no marine capabilities, those with moderate or advanced capability, or should there just be a random collection of participants? Finally, should this effort be primarily for industrialized nations, lesser-developed nations, or all classes of nations? While there are no clear-cut answers for these questions, practical financial constraints dictate some limitations, although we feel flexibility in judgment should always be maintained. All other things being equal, we concluded that preferences should be given those nations whose interests most intersect those of the U.S., that is—those nations whose marine activities often come in contact with those of the United States; nations which had shown at least some interest and commitment to developing a marine capability before; and finally, that the U.S. should strive to bring developed, as well as developing nations together in cooperative programs to provide the broadest possible range of expertise for problem areas.

After delving into these questions, we concluded that the key functions of this new international marine program should be those of a broker and memory bank, matching needs with expertise and information; that it be able to identify expertise in all phases of our society and abroad. We concluded that ships and ship time might fall within this definition to a limited extent, but that the program could contribute most by helping to locate ships for those who need them. Rather than advocating a massive financial outlay we agreed that a small seeding program would be appropriate for projects and their results.

Recognizing its limitations, we proceeded to analyze how the program might be best organized. For instance, should it be a unilateral effort only carried out by the U.S. for other nations with a one way transfer of information and skills, or should it be bilateral involving more bal-

anced sharing? Or third, should it be a multilateral type program involving any numbers of countries in a particular project? We had mixed feelings about this problem. Recognizing imbalances in the international system, particularly between advanced and lesser developed nations, we assumed that all benefits could not be uniform, but felt that the program should strive to make them as equitable as possible, and avoid being an aid program.

Moreover, we realized that small programs involving as few bureaucracies as possible and emphasizing personal contact, have probably been the most effective. At the same time, we wanted to assure that all nations who desired, could both get and give; thus developed nations could benefit along with lesser developed nations. It was concluded that the projects should be kept small and easy to handle, but could involve persons from any number of countries as long as their role was appropriate and justifiable.

Finally, we asked whether this program should be administered through already existing international programs such as the UN, whether it should be run quite apart from other international efforts, or whether it should function as a separate unit, but have strong liaisons with other national and international marine programs. We decided that the new international marine program should function as a separate unit with strong liaisons. As I stated before, the UN programs currently have too many problems, and only time will tell us whether there will be a new International Seabed Authority and how effective it will be. We suggest that any new U.S. international marine program keep an eye on UN events to make sure that cooperation takes place when possible, and that future coordination with UN or similar efforts be kept flexible.

Lastly, we decided that the National Sea Grant Program had several very strong qualities to contribute to an international effort. It has a large reservoir of skilled people from whom it can draw information and expertise. There would be no need to set up a program similar to the AID 211D program of university bloc grants to develop centers of expertise in certain fields. In addition, Sea Grant is university-based and can use already established mechanisms to call up university efforts. Finally, Sea Grant, like Land Grant, has incorporated the extension agent concept, which seemed basic to any international program. We thus concluded that this new international marine effort should incorporate this extension concept as fully as possible, while at the same time being careful not to impose a system useful to us on others who may not find it appropriate.

In summary, after analyzing the many possible alternatives for an international Sea Grant effort, we concluded that it should start out small (about 5-7 million dollars); that it be multifocused over a range of marine activities, and that it reach as broad an audience as possible, but reserve certain guidelines for its project selection. Perhaps the most important work of this new agency would be to make sure that people everywhere become fully aware of the implications of long-term global problems such as marine pollution and the proper utilization and management of our resources. If such a program fulfills these qualifications, the U.S. and other governments would be making a good investment for the future.

THE LAW OF THE SEA CONFERENCE: WHERE WE STAND NOW

Mr. Richard R. Baxter

THE LAW OF THE SEA CONFERENCE: WHERE WE STAND NOW

Richard R. Baxter

The Second Session of the Third Conference on the Law of the Sea was held in Caracas this past summer. The Third Session will be held in Geneva next spring, and the Fourth Session, it is hoped, will be a signing session in Caracas. But if, as appears possible, a further working session is called for, the long-awaited new conventions will be signed at the Fifth Session of the Third Conference.

The task is a stupendous one—the drafting of a constitution for a majority of the earth's surface. One is struck by the enormous complexity of the process. On the Conference agenda, the number of separate items which have been allocated amongst the Plenary and the three Committees of the whole is 92.[1] Nearly 150 states, in addition to a substantial number of international and nongovernmental organizations, sent delegations to Caracas. One hundred-nineteen names are listed for the United States in the delegation list.[2] The range of governmental representation and of interest groups, such as various types of fisheries, environmental organizations, scientific bodies, the oil industry, meant that the United States Delegatioin was in itself a mini-conference. National and international forces converged on the leader of the delegation, Ambassador Stevenson, and his principal deputies and assistants. These individuals found themselves, as it were, poised between two conferences.

The lack of concrete results, in the form of agreed articles, has been widely reported, and has been the subject of comments which have run the gamut between the wroth and wry. As the speeches droned on, a restive delegate might remark to an equally restive friend in the back of the room: "We heard this two or three years ago in the Seabeds Committee." The Conference was still engaged in the long, slow process of receiving proposals, sorting them out, and trying to reduce them to a few alternatives. This was nothing more than a continuation of the work of the Seabeds Committee. Actually, the Committee and the Conference are a continuum, the transition from one to the other being marked by the addition of nearly 60 states that had not been members of the Seabeds Committee of the General Assembly.

So many were the levels on which the Caracas Conference operated that observers and even delegates themselves could not be fully aware of what was happening throughout the Conference. These levels were something like this:

—The Plenary and the three Committees of the whole conducting their deliberations on the record.

—The Committees meeting in informal working sessions, without any summary records being kept.

—The "Group of 77," consisting of more than 100 developing coun-

tries, which sat as a conference within a conference.

—Various regional and functional groupings, such as the Asian countries, or the group of landlocked and "geographically disadvantaged" states, or the "Group of Five," in which the United States participated.

—Various negotiating, working, and drafting groups and the "Juridical Experts" (in the private language of the Conference, the cover name for the "Evensen Group"—a group of experts who had rallied round to seek accommodation when the work of the Seabeds Committee had gone slowly).

—Bilateral negotiations about particular issues and particular geographic areas.

Only the first two of these levels are documented in any way, and the second only in the form of "Conference Room Papers," "Chairman's Working Papers," and the like. The historian will be hard put to reconstruct what was happening from the written record.

The number of participants and issues, and the importance of what is at stake, rather than deliberate stalling, explain why so little progress was made. Delegations of one or two men could simply not keep up with all of the meetings and with all of the issues. A legal adviser of a medium power, a sophisticated and able lawyer, remarked that he simply could not follow all of the complexities—legal, technical, economic, scientific and political—of the law of the sea, when he had to deal with the whole range of legal questions involving his country, and thus could spend only a few weeks of the year on the law of the sea. Faced with the prospect of having to take positions on matters which it did not fully understand and of making decisions the consequences of which could not be foreseen, a delegation would often respond by postponing decisions, by adopting the position which would seem to provide the most to its country, and by banding together with other states to secure the largest possible slice of the pie. The gains which were sought were immediate economic ones and increased power, authority, and jurisdiction in the oceans. This power over the oceans could then be employed as bargaining counters which might thereafter be traded for economic or political advantage. If, for example, a coastal state can control scientific research in a 200-mile coastal zone, then permission to conduct research can be traded for the transfer of technology from the researcher to the coastal state.

The impression that a spectator might have of the Conference is that it resembled a computer into which too much data had been fed and which had been called upon to perform calculations beyond its capacity. The Conference forces us to consider whether the machinery of the state and conference system is capable of solving important problems facing the world—but that is another question, on which I shall not dwell here.

Some simplification of the issues was seen in possible agreement on what was referred to as "The Package"[3]—that is to say, the general outline of a bargain that might be struck by the various groups on the major issues facing the Conference. Such a structure of agreement might make the issues manageable, but even if such a bargain were struck, there would still be the long, tedious process of fleshing out the agreement in terms of treaty articles. Any obstructionist knows that a battle may be fought twice—first on the question of principle, and then on the implementation of the principle.

At the moment, as the quest for agreement goes on, the lines seem for many purposes to be drawn between the developing countries, organized as the Group of 77, and the developed countries, amongst which the United States is the most prominent. This is not to say that there is monolithic solidarity in either group. The Group of 77 has its own regional subgroups and the national interests of developing countries are by no means uniform. The appearance of divergence may also be somewhat misleading. The spectator can hear only the statements on the record, or those made in an informal session of a committee of the whole. He is not privy to all that goes on below the surface. But the outward appearances are of a developing country-developed country split. This divergence may be observed in varying degrees in a number of areas.

The United States has publicly declared its support of the concept of the 200-mile economic zone,[4] but there are economic zones and there are economic zones. At the one extreme, one can envisage coastal state rights that are indistinguishable from the form of sovereignty that a state exercises in its territorial sea. At the opposite extreme, the coastal state would enjoy only limited rights of jurisdiction for special purposes in that portion of the 200-mile economic zone extending beyond the 12-mile territorial sea, upon which there seems to be general agreement. Many of the developing coastal states incline in the first direction, while the United States supports only limited coastal state rights over resources within the coastal zone.

Whatever may be the outcome of the Geneva Session of the Law of the Sea Conference, the United States is fast approaching unilateral establishment of an economic zone of 200 miles off its own coasts. We already claim a continental shelf in the legal sense which is of indeterminate width, and if the Magnuson Bill for a 200-mile fisheries zone[5] is enacted shortly—as is predicted—the United States will be in the position of claiming both the natural resources of the seabed and subsoil and the living resources of the water column in a zone off its coasts. States which have gone to 200 miles already or which advocate a 200-mile economic zone may justifiably say to us, "Well, we see you've joined the club." In this respect, we are very quickly approaching the position taken by the developing countries, although, of course, much remains to be decided on precisely what sort of rights the coastal state may exercise in that 200-mile zone.

Some countries, such as Australia and Argentina, which have very broad geographic shelves, already lay claim to more than 200 miles of the continental shelf and resist the notion that coastal state rights in the shelf could be confined to 200 miles. To withdraw to that line would, they say, amount to giving up territory which is already theirs under the exploitability test of the Geneva Continental Shelf Convention of 1958.[6]

The landlocked states, which have their own particular perspective on the coastal zone, have been joined by other countries which consider themselves to be "geographically disadvantaged states," notably by reason of having very small slices of the continental shelf or of a 200-mile economic zone. We have learned to speak not only of "landlocked" countries but of "shelflocked" and "zonelocked" countries as well. Coastal developing states have tended to reply solicitously to these concerns by promising that regional arrangements will permit landlocked and geographically disadvantaged states to share in the exploitation of the coastal zone.[7] But whether agreement can be achieved and, if so, in what form remains to be seen.

So far as fisheries are concerned, the United States has followed a line which is consistent with its acceptance of the concept of a 200-mile economic zone: anadromous fish could be caught only within the zone. The catching of highly migratory species, such as tuna, within the zone will be regulated by international arrangements applicable to these fisheries as a whole. Two issues on which the United States and developing countries had substantially different positions are thus nearer to resolution. Still in dispute are the rights of the coastal state and of other countries to that portion of a coastal species which is not harvested by the coastal state. States with extensive distant water fisheries, such as the Soviet Union, certain East European states, and Japan, remain dissatisfied by the course of events.

If the gap between the United States and developing countries has narrowed in the case of the coastal zone, it has not, so far as can be observed, with respect to straits. Straits states ask why it is that Soviet and American submarines should be allowed to pass submerged through straits. These submarines may be on a mission hostile to one of the coastal states, such as preparing to launch missiles or to land troops. The argument that the security of the sea-based deterrent is the best guarantee that nuclear weapons will not be employed by the "superpowers"[8] does not carry much weight with a developing country. Those states which border upon gulfs or enclosed seas maintain that there is no reason to allow free transit by submarines, other warships, or military aircraft through such straits as the Bab el Mandeb, Hormuz, and Tiran. While developing countries generally may not have strong views on the subject, they cannot be roused to much enthusiasm for a straits regime which is seen as favoring the interests of the strong naval powers. I have dwelt at some length on the position of developing countries only so that you may understand the strong opposition that still exists to the firm position of the United States, the Soviet Union, and the United Kingdom that there should be free transit on, under, and over straits used for international navigation.

The way in which the seabed and subsoil are to be exploited is also a major source of controversy between the United States and developing states. The Group of 77 proposed that the Authority itself be vested with the sole power to explore or exploit the resources of the area.[9] There would be no licensing of states or companies to exploit the hard minerals (manganese nodules) or oil deposits to the deep seabed and subsoil. The very term "licensing" is anathema. The most that companies could expect is that they might participate through joint ventures or service contracts concluded with the Authority. In plain words, there would be an essentially socialist regime for the ocean depths. The United States with some support from Japan and Western European states continues to take a strong position in favor of licensing of companies.

The fundamental ideological difference between developed free enterprise states and developing countries on this score is also reflected in attitudes toward related matters. One of the high points of the Conference was a three-hour speech by Mr. Ratiner of the United States Delegation spelling out exactly what detailed provisions would have to be incorporated in the rules and regulations of the treaty itself in order to encourage companies to make the huge investments which would be needed. The Group of 77 resisted the incorporation of precise and detailed provisions in the treaty and preferred to give much greater latitude to the Assembly to decide the terms on which exploitation might be conducted. The United States's view is still that the center of power should be the Council, in which those states having a greater interest in the deep seabed and subsoil would have a louder voice. The Group of 77 also favors production controls in order to hold up prices, while major industrial powers importing large quantities of minerals resist a controlled economy in the oceans.

The divergence of positions between the United States and the developing countries is very great. Much is thought to be at stake. There seems to be no appreciable drawing together on these questions.

In this confrontation, the Group of 77 has the votes and the United States and a few other highly industrialized states have the technology. Enough votes are there to adopt the concept of direct exploitation and its corollaries, but the votes are of no use if the Authority lacks the technology and the capital to get on with the job. If a compromise is achieved, it will be the result of an awareness that a middle way must be sought between technology without power and power without technology.

Environmentalists can see little cause for satisfaction in the work of the Caracas Session of the Law of the Sea Conference. The environment is a motherhood issue. What is actually to be done to protect the marine

environment, and how use and preservation of the oceans are to be balanced, do not lend themselves to any such simplistic solution. A number of countries, by no means exclusively developing ones, may see concerns about the environment as a means of securing wider control over the oceans. A coastal state desiring a wide measure of control, even sovereignty, over a 200-mile economic zone will assert that it must have a plenitude of powers over the ocean in order to protect the waters from pollution. So also, it may be argued that the international seabed resource authority should have broad powers to protect the marine environment. Each competence which is vested in the international authority makes it that much stronger and that much more capable of exacting a high price from those who wish to exploit the natural resources of the seabed and subsoil or to import such minerals for their industries. A country's expression of concern about maintenance of the quality of the marine environment off its coasts may arise out of a genuine concern for that environment, out of nationalism, out of a desire for power and wealth, or a combination of these motives.

Developing countries tend to favor a double standard, which would apply environmental standards in all their stringency to the developed industrial states but would allow exceptions in favor of developing nations in order to assist them in catching up. The great industrial states have had their freedom to industrialize and pollute. Developing countries, so the argument goes, should be allowed a period of comparable freedom in order to catch up.

States line up in a similar way on scientific research. Developing countries complain that they cannot distinguish pure research from exploration for resources or research directed to military ends. They, therefore, seek the power to control scientific research in the 200-mile zone and would like to see the international authority for the deep oceans vested with full powers to control scientific research there. Those countries, such as the United States and the Soviet Union, which conduct extensive oceanographic research wish their freedom to be maintained through provisions which would allow access to the 200-mile zone upon compliance with certain conditions, such as allowing observers from the coastal state aboard the research vessel, sharing of data, and the like. The question of scientific research has also stimulated demands from developing countries for wider sharing of technology.[10] It may well be that access will have to be purchased with information. Very little was accomplished in either sphere at Caracas, and some gained the impression that Committee III, in which these matters were taken up, was simply waiting for the outcome of the debates on the economic zone and on the deep seabed.

Archipelagic states tend to fall in the developing category and to secure a certain measure of support from other developing states. It remains to be decided whether archipelagos will be confined to high-seas archipelagos or will also include coastal ones. And the definition of an archipelago and the determination of its boundaries remains unresolved.

Islands, in general, are troublesome. They may have their own territorial seas, but should they also have their own 200-mile economic zones and continental shelves? If a state has been able to establish an undisputed claim to a rock which is at all times above water, should that claim have as one of its consequences that the state should acquire rights over large areas of the adjacent oceans and seabed? And, consistently with a theme heard in other quarters as well, some developing countries are heard to say that those islands which are under foreign and colonial domination should be given special treatment.[11]

Some progress was made at the Conference on the important issue of dispute-settlement,[12] which was handled on a technical basis and thus remains relatively free of the political considerations that dominated discussion of other questions.

Despite the professional optimism of the diplomats, and the congratulations of chairmen upon the formulation of alternative texts and the clarification of views, the Caracas session was far from being a success. The United States and other countries must now be prepared to contemplate the possibility that there will be no convention of a comprehensive character or that, thanks to the voting power of developing countries, there may be unsatisfactory treaties to which it would be unwise to become a party. Eventually, certainty and order, which are values in themselves, must be weighed in the balance with the terms of treaties which are less than satisfactory from the perspective of this and other developed countries.

Faced with the prospect of an unsatisfactory treaty or none at all, a state might be justified in contemplating the possibility of going it alone. Such a course of action, which can only be sketched in barest outline here, might involve the following courses of action and consequences:

- —The unilateral establishment of a 200-mile economic zone exclusively for the purpose of exploiting natural resources. The state establishing such a zone would accord freedom of navigation and research within it and would claim corresponding rights in the economic zones of other states. It would be for an objecting state to fire the first shot, as it were.
- —The continued exercise of a right of free transit through, over, and under international straits as in the past—justified on the basis of historic or customary rights. Protests from the straits states would be rejected, and any employment of force by the straits states would be regarded as a violation of Article 2, paragraph 4, of the United Nations Charter, giving rise to the right of self-defense and reference of the matter to the Security Council.
- —Immediate steps to begin the mining of manganese nodules from the seabed.[13] If there were then an attempt to put such natural re-

sources under international administration, the state already conducting the mining would be in a far stronger position to bargain with those states that have only the power flowing from the one-state one-vote formula of international conferences and the General Assembly.

It is not enough that a treaty is drawn up at Geneva, or Vienna, or Caracas, or wherever the Third Conference on the Law of the Sea completes its labors. It must be a treaty that is generally—perhaps universally—acceptable, for a few renegades not bound by the treaty are in a position to wreck the most carefully conceived and executed schemes. Other countries must be made aware that any treaties will have to be subjected to the scrutiny of our Senate and that it lies within the power of that body to keep the United States out of the new treaties. The fact that the treaty might not be generally acceptable to members of the international community could only strengthen the case for unilateralism.

The consequence of a failure to agree or of a treaty not widely accepted would be decades of conflict. Customary international law might be formed through the interaction of states, but at the expense of possible resorts to violence, any one of which, in our tinderbox of a world, could lead to a major conflagration. But perhaps as states groped their way through the problems, solving them one by one in a pragmatic manner, new customary rules might develop, which could then be codified in treaties.

I do not necessarily advocate this course of action, but I believe that the balance of power within the Conference and the poverty of its work-product should force us to consider the alternatives. At its worst the Conference might turn into something resembling the mythological Leviathan,

> "a seven-headed monster, a slippery, twisting creature, dangerous to rouse and futile to seek to tame."

At its best it could offer a hope of a peaceful and just ordering of the oceans for generations to come.

FOOTNOTES

1 Third Conference on the Law of the Sea, UN Doc. A/CONF.62/28 (1974).

2 UN Doc. A/CONF.62/INF.3/Rev.1 and Corrs. 1 and 2 (1974).

3 See, e.g., the Statement by Mr. Jens Evensen, Minister of Commerce and Shipping of Norway, in the General Debate on 2 July 1974.

4 Address by Ambassador John R. Stevenson, Special Representative of the President and U.S. Representative to the Law of the Sea Conference, before the Plenary Session at Caracas, Venezuela, 11 July 1974, Department of State News Release, 11 July 1974.

5 S. 1988, 93d Cong., 2d Sess. (1974).

6 Convention on the Continental Shelf, done at Geneva, 29 April 1958, art. 1, 15 UST 471, TIAS 5578.

7 See Second Committee, Informal Working Paper No. 4, 9 August 1974, Provision X.

8 See Tsipis, Cahn, and Feld, The Future of the Sea-Based Deterrent. Cambridge: MIT Press (1973).

9 Art. 9, UN Doc. A/CONF.62/C.1/L.3, p. 6 (1974).

10 e.g., Nigeria; Draft Articles on the Development and Transfer of Technology, UN Doc. A/CONF.62/C.3/L.8 (1974).

11 Second Committee, Informal Working Paper No. 13, 20 August 1974, Provision II.

12 Australia, Belgium, Bolivia, Colombia, El Salvador, Luxembourg, Netherlands, Singapore, and United States of America: Working Paper on the settlement of law of the sea disputes, UN Doc. A/CONF.62/L.7 (1974).

13 Not necessarily on the precise terms specified in the "Metcalf Bill," S. 1134, 93d Cong., 2d Sess. (1974); see S. Rep. No. 93-1116 (1974).

BIOGRAPHIES OF SPEAKERS

ROBERT A. FROSCH

Dr. Frosch, Assistant Executive Director of the United Nations Environment Programme, headquartered in Nairobi, Kenya, has brought to the UN expertise in theoretical physics, ocean and systems engineering, and research and development management.

He came to his present post in 1973, after ten years of service in the US government, first as Director of Nuclear Test Detection in the Advanced Research Projects Agency, Office of the Secretary of Defense (1963-1965), then as Deputy Director of the Advanced Research Projects Agency (1965-1966). In 1966, Dr. Frosch was appointed Assistant Secretary of the Navy for Research and Development, a position he held until joining the UN in 1973.

A native of New York City, Dr. Frosch was educated at Columbia University, where he received the AB degree in 1947, an AM in 1949, and, in 1952, a doctorate in physics. He was with the Hudson Laboratories of Columbia University from 1951 to 1963, and directed the laboratories from 1956 to 1963.

Dr. Frosch is a member of the American Physical Society, the Seismological Society of America, the Society of Exploration Geophysicists, and the American Academy of Engineers. Honors include fellowships in the American Geophysical Union, the American Association for the Advancement of Science, the Acoustical Society of America, and the Institute of Electrical and Electronics Engineers. Other professional specialties are underwater acoustics and oceanography.

The MIT Sea Grant Program welcomes Dr. Frosch as its third Sea Grant Lecturer.

JUDITH T. KILDOW

Dr. Kildow, Assistant Professor of Ocean Policy in MIT's Department of Ocean Engineering, has just completed a major study for the National Sea Grant Program on the international potential of the program's unique approach to ocean problems. Drawing on experience and education which have focused on marine affairs, international relations, and policies for scientific research on the seas, Dr. Kildow has also participated, with Mr. Baxter and others, in the development of a joint subject in law and ocean engineering, an educational project sponsored by the MIT Sea Grant Program.

Graduated from Grinnell College in 1964 with a major in political science, Dr. Kildow then attended the Fletcher School of Law and Diplomacy at Tufts University. Awarded a grant from the Fletcher School, and the Celia M. Howard Fellowship of the Illinois Federation of Business and Professional Women's Clubs, she received the MA degree in 1965, an MA in Law and Diplomacy in 1966, and the PhD degree in 1972.

Her professional experience has included assisting in the foundation of the Center for Marine Affairs at the Scripps Institute of Oceanography of the University of California at San Diego, accomplished during 1971 and 1972. Dr. Kildow has also held research appointments at MIT, jointly with the Department of Ocean Engineering and the Center for Policy Alternatives in 1972-1973, and with Dr. Eugene B. Skolnikoff in the Political Science Department and the Center for International Studies (1967-1969).

Dr. Kildow currently holds a Lilly Foundation Teaching Fellowship in the Department of Ocean Engineering at MIT, and is a member of the Massachusetts Governor's Task Force on Coastal Resources.

RICHARD R. BAXTER

Mr. Baxter has been a professor at Harvard University Law School since 1959, where he specializes in international law and organizations, law of the sea, and military law. He has written several books on the law of international waterways, including the St. Lawrence Seaway and the Panama Canal.

Following his graduation from Brown University in 1942, he received his law degree degree from Harvard University in 1948, a diploma in international law from Cambridge University in 1951, and an LLM degree in 1952 from Georgetown University. From 1954 to 1959 he was successively research associate, lecturer, and assistant professor at Harvard Law School. He was a member of the Law Faculty at Cambridge University and a Guggenheim Fellow in 1966-1967.

Mr. Baxter has served the U.S. government in several capacities. In 1954 he was attorney in the Office of General Counsel for the Secretary of Defense, and was a Counselor on International Law for the Department of State in 1971-1972. He has also been a consultant to the Department of Defense (1955-1960), to the Department of State (1964-1965, 1970), to the Naval War College (1955-1965, 1967-1971), and to the UN's Human Rights Division (1969).

Mr. Baxter is a member of the American Law Institute and President of the American Society of International Law. He is Editor-in-Chief of the American Journal of International Law, and member of the American Branch of the International Law Association.

He has returned to Cambridge only recently after spending the summer in Caracas, Venezuela, with the UN's Law of the Sea Conference.