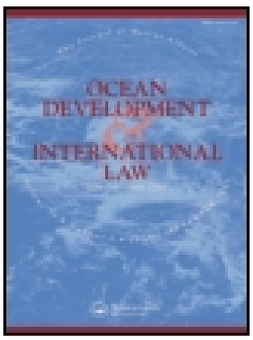

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# Considerations in Developing a Functional Approach to the Governance of Large Marine Ecosystems

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# Considerations in Developing a Functional Approach to the Governance of Large Marine Ecosystems

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*Interest in the management of the environment and its resources on an ecosystem basis has been increasing, in both terrestrial and marine contexts. In recent years, the concept of the large marine ecosystem has become a point of focus at the national and international levels as a possible unit for management of ocean and coastal areas. An ecosystem approach, however, challenges the manner in which marine resources and the environment that sustains them have been managed in the past.*

*Governance is a key element in ecosystem management and encompasses the formal and informal arrangements, institutions, and mores that determine how resources and the environment are utilized. This study explores some of the problems, concepts, and principles involved in efforts to provide needed governance arrangements if large marine ecosystem–based management is to be implemented and made effective.*

**Keywords** large marine ecosystems, ocean governance, marine ecosystem management

The focus of this study is the governance implications of attempts to manage fisheries utilizing large marine ecosystems (LMEs) as the unit of management. The concept of large marine ecosystems, as developed by Sherman and Alexander, refers to

> regions of ocean space encompassing coastal areas from river basins and estuaries on out to the seaward boundary of continental shelves and the seaward boundary of coastal current systems. They are relatively large regions on the order of 200,000 km$^2$ or larger, characterized by distinct bathymetry, hydrography, productivity, and trophically dependent populations.[1]

Consideration of LMEs as management units is a logical outgrowth from the extensive body of scientific work that examines the interaction of fish species with one another and with the physical environment that they inhabit, as well as how human activities[2] affect them, and occurs within a more general context of growing interest in environmental and resource management on an ecosystem basis.[3] Larkin suggests that the LME concept represents "a contemporary crystallization of broader perspectives in fisheries management."[4] Management practices that have centered on single species approaches, while neglecting species interplay, competing uses of habitat areas, and

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damage to or destruction of habitat, typically have been ineffective in allowing for sustained levels of catches of desired species. A more holistic perspective which considers fisheries in their wider ecological context has been adopted and promoted at a variety of national and international forums.[5]

The concept of LMEs, like that of the coastal zone, emerged from the growing base of knowledge regarding the significance of human activities on the natural environment and its resources. But coastal zone management efforts developed as an outgrowth of land use planning and, while obviously concerned with the land-sea interface, appear to emphasize shoreside and coastal concerns[6] while LME-based management, in its consideration of land-sea interplay, gives greater attention to the effects of human activities on the ocean environment and its resources.[7] Further, the LME concept has been "a science driven endeavor and not characterized by more issue-driven focus on governance processes and people management," as has been coastal management.[8] But continuing contemplation of ecosystem-based management gives new impetus to the need for a closer relationship between coastal and ocean management efforts and a need to move away from what Cicin-Sain and Knecht refer to as a "dual system" of management in which coastal and ocean management serve as separate points of focus.[9]

In nature, living resources do not exist in a vacuum but rather in an environment which supports them. Those who have formulated the concept of the LME are concerned with the living resources of the ocean; that concept, however, is concerned also with the natural conditions and requirements needed to sustain those living resources and the impacts of human activities on needed support systems. Recent amendments to the Magnuson Fishery Conservation and Management Act, for example, which provide for attention to habitat issues, underscore the growing effort to understand and to manage fisheries in the context of wider ecosystem considerations.[10]

In his consideration of LME sustainability, Sherman utilizes five linked modules to assess ecosystem sustainability: productivity of the ecosystem, fish and fisheries, pollution and ecosystem health, socioeconomic conditions, and governance.[11] The first three of these modules focus on natural systems, while the last two concentrate on human interactions with natural systems. To date, the first three have received the greatest attention. But as attempts are made to go from theorizing and conceptualization of system dynamics to operationalization and implementation of management strategies, greater consideration must be given to the human dimension of LMEs, represented by the latter two modules.

Efforts to manage resources and the environment in the context of ecosystems are really about managing human behavior and encouraging and inducing behavioral patterns that take into account the operation of the natural world. People, of course, are part of that world and, given their increasing numbers and their use of resources and the environment, together with the implications of their employment of ever more sophisticated technologies, their activities have increasing or perhaps even dominant significance in the continued evolution of natural systems. Accordingly, careful attention must be given to human institutions, organization, activities, values, and their implications for the ecosystems and resources for which protection is sought.[12]

Taking as a given that fisheries management on an LME basis is desirable, what attributes must a governance system have to make such management effective? For the purposes of this study the term governance is defined as

> the formal and informal arrangements, institutions, and mores which determine how resources or an environment are utilized; how problems and

> opportunities are evaluated and analyzed; what behavior is deemed acceptable or forbidden; and what rules and sanctions are applied to affect the pattern of resource and environmental use.

As suggested by this definition, the concept of governance is not equivalent to government but rather incorporates other mechanisms and institutions that serve to alter and influence human behavior in particular directions.[13] The increasingly significant role of nongovernmental organizations in monitoring, evaluating, publicizing, and influencing coastal and ocean management efforts, both within countries and internationally, must be recognized.[14] Likewise, efforts to promote fisheries comanagement, in which the fishermen themselves have responsibility for resource management, must be acknowledged.[15]

In attempting to develop a model of governance that would have wide applicability, it is necessary to recognize that the 50 LMEs identified by Sherman[16] are located in widely disparate geographical locations, have distinct geographical and ecological features, and are bordered by a variety of states, which, while often sharing marine ecosystems, have differences in:

—governmental organization, processes, and priorities;
—levels of economic development;
—the degree of scientific capability and the ability to incorporate science into the policy process;
—patterns of social organization, culture, and values; and
—political relations with neighboring states.

These differences are significant in that, collectively, such factors affect the substance of what governance systems do and how they do it.

Moreover, LME literature indicates that various LMEs face different combinations of problems; in particular, attention is given to overfishing, pollution, and natural environmental variability.[17] Depending on the relative significance of each of these three factors in influencing stocks in a particular LME, policy and organizational prescriptions will be expected to vary.

Given the variance in the nature of the problems in different LMEs and in the governance structure of the states adjacent thereto, rather than attempting to devise a series of detailed policies and procedures which may or may not fit the particular LME problems or governance patterns in different parts of the world, the need is to develop a functional approach that seeks to comprehend the categories of generic activities that must be performed if LMEs are to be utilized effectively as management units. LME literature is replete with data on ecological interrelationships and the driving forces in the identified LMEs.[18] Such data may well be indicative of *what* needs to be done. But with a variety of ways to do things, to achieve results it is necessary to take into account local governance and cultural and socioeconomic conditions if needed change is to be achieved. *How* things are done and *who* does them is a matter to be decided regionally, nationally, or locally; what is important is that certain functions that need to be performed are performed effectively. In thinking about the governance of LMEs, it is necessary, then, to recognize the need for flexibility and to allow for adaptations in different settings.

Operationally, there is a need to develop

1. an understanding of what functions must be fulfilled to effectuate a working LME governance system and what basic principles may be used for guidance as those functions are carried out;

2. a current governance baseline or governance map that indicates who does what, who is responsible for what, how responsibilities are perceived, and what role is played by nongovernmental actors in the existing system;
3. an examination of how the existing system and pattern of governance may be reconciled with the needs that must be met for effective LME-based management. In particular, it will be necessary to identify inadequacies, voids, and gaps in essential elements of LME-based management systems. To this end, governance case studies that parallel the scientific studies of particular LMEs could prove to be very revealing, providing insights into significant problem areas; and
4. a series of recommendations based on such assessments indicating how identified problem areas could be addressed and how the gap between existing practices and those needed to bring about LME-based management could be closed.

## Necessary Functions for LME Management

Several of the functions that appear to be universally essential if an LME management system is to be effective are discussed next.[19]

### *Determination of the Boundaries of the Relevant Ecosystem*

A study by the U.S. General Accounting Office (GAO) reviewing the efforts of governmental agencies to promote ecosystem-based management indicates that delineation of ecosystem boundaries and determination of the appropriate scale present many difficulties. Smaller ecosystems are nested in larger systems, ecosystems are interlinked and inseparable, and boundaries of such systems are dynamic in nature.[20] In this vein, Haeuber notes that

> [e]cosystems are dynamic, constantly changing, and vary continuously along gradients in space and time. They are open systems and their functioning includes inputs, outputs, cycling of materials and energy, and interactions among organisms, as well as between organisms and the physical environment. Ecological scientists operationalize ecosystem boundaries to monitor and understand ecological processes—depending on the process of interest, a dung pile is as much an ecosystem as a watershed. Thus, boundaries for the study or management of one phenomenon, process or issue may be inappropriate for the study of others.[21]

Assuming the scientific validity of the need to manage fisheries in the context of large marine ecosystems, the definition of the ecosystem is very significant from a governance perspective. The ecosystem boundary is important since it indicates whose actions and what human activities must be considered in providing for management of the LME and its resources. Clearly, the designated area has to be sufficiently inclusive so as to incorporate those factors and activities significant to the operation of the ecosystem; in ecosystem terms the geographic area needs to be at a scale that is compatible with natural processes.[22] In the case of fish, it is important that they be managed throughout their migratory range. If the extent of the LME is not properly understood, then activities that are considered to be outside of the LME may damage fisheries inside of it. Accordingly, the definition of a particular LME must have a strong basis in science,

taking into account relevant system interactions. Yet, one of the basic problems faced by those who favor ecosystem-based management approaches is the lack of congruence between what might be termed "politically defined space," that is, the geographic area encompassed by particular human governance systems, and "ecologically defined space," composed of the area over which natural ecosystems extend.

Among the ecosystem dimensions that must be considered are those which indicate how far seaward and how far laterally along the coast the system extends. Likewise, some determination is needed in regard to the inland reach of the ecosystem. What needs to be understood is the expanse and character of the area in which actions need to be monitored because of the potential for some degree of significant effect on the operation of the ecosystem of concern.

As noted in the definition of LMEs provided by Sherman and cited at the beginning of this article, LMEs incorporate both land and water, but the size and characteristics of the geographic area will vary in the case of each LME. Drafters of the Coastal Zone Management Act of 1972,[23] who were faced with an analogous problem of zonal definition, determined that the coastal zone should be understood as

> the coastal waters (including the lands therein and thereunder) and the adjacent shorelands (including the waters therein and thereunder), strongly influenced by each other and in proximity to the shorelines of the several coastal states and includes islands, transitional and intertidal areas, salt marshes, wetlands, and beaches.[24]

The inland boundary, accordingly, was to be defined by some consideration of system interplay. Under this act, coastal states were encouraged to develop a coastal zone management plan. Since it was understood that the geographical, ecological, and socioeconomic situation of each state was different, the legislation provided that, within broad guidelines, each state was left to determine the inland extent of its coastal zone system.

The Organisation for Economic Co-operation and Development (OECD) also has stressed the need for coastal zone management to reach inland as far as needed to achieve program objectives. An OECD study notes that in most cases an ecosystem approach is appropriate and that the coastal zone should be defined so as to "extend into the watersheds of rivers discharging into coastal waters."[25] Increasingly, coastal zone management experience has suggested a need to encompass watersheds and coastal drainage basins that feed into the sea and to recognize explicitly the links between coastal and ocean management efforts.[26] Experience with coastal zone management around the world should be considered as LME governance approaches are developed.

On the ocean side, the extent of LMEs also provides jurisdictional difficulties. While encompassing some inland areas and internal waters such as bays, estuaries, and marshes —areas in which the coastal country has sovereignty—LMEs then stray into what, jurisdictionally, is the territorial sea, an area in which the coastal country has sovereignty, but sovereignty limited by the international servitude of innocent passage.[27] Beyond the territorial sea to 200 miles from the baselines used to measure the territorial sea, coastal state sovereignty disappears, to be replaced by the regime of the exclusive economic zone in which the coastal state has sovereign rights, a more limited type of control than that associated with sovereignty.[28] And though the 200-mile limit may be of great significance to diplomats and lawyers, it does not correspond to the physical limits of the LME. Should the LME extend beyond the 200-mile limit, as well it could, since, in a

number of locations, continental shelves extend beyond 200 miles, attention must be paid to the jurisdictional zone of the high seas. In this area the coastal state has neither sovereignty nor sovereign rights and, under traditional international law, has been viewed as an area that may be used by all with few limitations.[29]

The recent dispute between Canada and Spain over fisheries found just beyond the Canadian 200-mile limit in the northwest Atlantic illustrates some of the constraints of coastal state authority to managing fisheries unilaterally and effectively.[30] Further, aside from the problems associated with straddling stocks and the seaward reach of the LME, the lateral extent of the LME may be such that several adjacent states may share the LME, with the effect that the actions taken in each state could impact the LME and its transboundary resources as well.[31] LME use management in such situations, of necessity, would have to provide for international coordination and cooperation.

It is apparent, then, that the range and the dimensions of an LME have substantial significance for governance opportunities and problems. Examination of the 50 identified LMEs indicates that at the international level there is a lack of congruence between the areas within national zones of jurisdiction, in which the coastal state exercises either sovereignty or sovereign rights, and the areas encompassing those LMEs.[32] In fact, a clear mismatch between natural and political or legal systems at both the international and national levels adds a significant dimension of difficulty to achieving a goal of ecosystem-based management.[33] Addressing the consequences of this divergence will require substantially increased transaction costs as well as a willingness of states to surrender sovereign prerogatives. And even in situations in which some states are willing to cooperate, their efforts may be undermined by a "free rider," that is, a state that derives benefits from the collective action of others without making any contribution of its own.

In addition to a spatial anomaly, in a number of countries jurisdictional divisions and problems are found between national and subnational governments. In the United States, for example, the division of responsibilities between the federal government and subnational governmental authorities is such that the latter may play significant roles in coastal and even ocean management,[34] thus necessitating efforts at intranational coordination. Moreover, governments, national or subnational, are rife with a multiplicity of departments and agencies with varied sectoral responsibilities for some aspects of coastal and ocean policy. Such factors are very important and can serve to thwart needed holistic approaches to ecosystem use management.

### *Assessment of Resources in the Ecosystem and the Development of an Understanding of the Ecological Balances Encompassed Therein*

Efforts at rational and effective management of the uses of ecosystems will be information intensive.[35] The collection and analysis of relevant data will be a key part of an ongoing process of management of the uses of large marine ecosystems. Decisions will have to be made as to what data are relevant, how they should be collected and standardized, and how they will be used in analysis of the complex interrelationships of the ecosystem. The development of ecosystem baselines will be required so as to provide sign posts for changes and trends in the resources and their sustaining natural environment. In a number of locations, data covering a relatively substantial time span is available and attempts at ecosystem modeling have been made; in other areas such efforts have been more limited.[36]

Computers, satellites, automatic data collection devices, and geographic information systems (GISs) have already made and could make ever more significant contributions to efforts at resource and environmental quality assessment. In regard to coastal management, it has been noted that more data than ever before is being collected, more sophisticated models for data analysis are being developed, and the technology and capability to manage data and incorporate them into these models are being enhanced.[37] But in many parts of the world, the use of such capabilities may be constrained by financial limits and the lack of individuals trained to collect and interpret data. It is not surprising to find, therefore, that considerable emphasis has been placed on the subject of "capacity building," which refers to both the availability of needed resources and the skills needed to use them effectively, as coastal and ocean management efforts in developing countries are considered.[38]

### *Appraisal of the Varying Human Uses of the Area of the LME and Their Relevant Interplay with One Another and with the Environment*

The areas encompassed by LMEs are typically marked by multiple human uses; moreover, they are the parts of the world's oceans most heavily utilized by humans. Activities there range from navigation and waste disposal to fishing and oil and mineral exploitation. Each of the individual uses in some way impacts the resources and environment of the LME;[39] cumulatively, the effect of these uses may be magnified. Consequences may be direct and relatively easy to observe, such as through the rapid decline of desired fish species due to overfishing, or more indirect and insidious, such as through the effects of nonpoint pollutants on the LME food chain.

Numerous gaps in knowledge exist in regard to the human use of the LME and problems associated with collecting data on human activities impacting LMEs. Some users have strong motivation to hide or to disguise activities; in other situations, it is simply very difficult or costly to obtain data. Yet in many LMEs, human activities and uses have substantial significance for the continued health and productivity of the natural environment.

To the extent that human activities in the LME are watched by governments, they are monitored by different agencies with specific functional areas of responsibility, such as fisheries or energy. An up-to-date inventory of current uses is needed for planning and management purposes, and data needs to be used to consider the LME holistically, taking into account not only particular uses but also the synergistic and cumulative impacts of the totality of uses as well. Significant questions that need to be addressed include: What activities are taking place? How much activity? Where is the activity occurring? What is the interplay of the various human uses with each other and with the natural environment? What are the ultimate effects of such uses on ecological balances of human uses of ecosystems?

In addition to knowing *how* people use the ocean environment and its resources, it is imperative to comprehend *why* they use them as they do.[40] Answers to the "why" question may be crucial to altering behavioral patterns that damage natural systems. It is understandable that people fish to feed themselves and their families. But can they feed their families by using less environmentally destructive capture methods? Do they fish with the use of dynamite, for example, out of habit or custom? Or do they do so because of a lack of understanding of the longer term implications of their practices, or simply due to the absence of effective enforcement? Is waste dumped into coastal waters out of ignorance of the consequences or because of the high cost of alternative

disposal? Different answers to the "why" question may suggest alternative approaches to ecosystem use management.

### *Establishment of Goals, Objectives, and Priorities for Resources and the Environment of the LME, Taking into Systematic Account Scientific Data and Socioeconomic Considerations*

All societies are faced with mutually exclusive choices regarding the use of resources. In line with the concept of opportunity costs, the use of a limited resource obviates its alternative uses. Accordingly, some values must be given a higher, and others a lower, priority. Should greater weight, for example, be given to long- or short-term considerations? Should the emphasis be on conservation of resources or should it be on utilization? How should balances be drawn? Such decisions may have profound political, economic, and social consequences associated with them. It is also important to recognize that goals, objectives, and priorities are subject to change over time and that their determination and reassessment are part of an ongoing management effort.

Scientific data and analyses that promote understanding of the natural world and its essential processes may indicate important parameters for society. They can warn of the approach of limits that, if ignored or exceeded, could result in significant damage to the natural systems upon which human activities and well-being depend. Such damage, which may or may not be reversible, would provide constraints on future human options.

At the same time, policy is not made in a vacuum or as an intellectual exercise taking into account only scientific analyses. Indeed, the fact that these analyses are often at variance with one another or may be selectively utilized or even blatantly misused to promote particular policy outcomes serves to limit or distort the impact of science in decision making.[41] But, additionally, socioeconomic considerations, that is, human needs, values, and motivations, and associated political pressures must be recognized as powerful inputs into governance systems.[42] Failure to understand and to address these considerations will undercut efforts to protect essential features of LMEs.

### *Regulation of Activities Affecting the LME So That Activities Conform to Choices and Priorities*

Once goals and priorities have been established for the use of LMEs and their resources, it is essential that human activities be consistent with these objectives. A system of regulations, whether based in law or in social conventions, is required to delineate what is allowable and what is prohibited so that those whose activities may affect the LME understand what they may or may not do and what is expected of them.

Further, a monitoring system is needed to ensure that expected behavior is adhered to and, also, to provide feedback that should be used to modify management policy in an effort to better serve goal achievement. In some cases, actual practice may indicate that goals which have been set are unrealistic or unobtainable or that priorities may have to be reevaluated.

Finally, there is a need for some type of enforcement system which will serve to deter or end behavior that is inconsistent with management strategies and rules. The monitoring and enforcement system must be effective in promoting objectives, yet must also meet requirements of efficiency and cost-effectiveness, while avoiding the character of harassment of legitimate users of LMEs and their resources.

### *Shaping of Suitable Institutional Machinery and Governance Arrangements for Policy Making and Administration of LME Uses*

Ecosystem-based management, by its very nature, must have the capacity to comprehend and to act upon the fact that a particular ecosystem is subject to a multiplicity of uses and that some of those uses have negative externalities associated with them. Consequently, it is important to provide for policy integration, that is, a means of assessing and incorporating into decision making the implications of particular uses for other uses and for the physical environment. For example, waste disposal may damage the environmental quality of estuarine areas that serve as nursery grounds for commercially fished species, and thereby severely damage the fishery.

As noted by Underdal,[43] coastal and marine policy integration requires coordination among governmental agencies (horizontal consistency), between different levels of government (vertical consistency), and, in states with federal governmental systems such as the United States, among the federal, state, and local governments. Likewise, there must be linkages between planning and implementation.[44] Varied organizational and institutional approaches have been proposed and undertaken to meet such needs.[45]

### *Oversight, Evaluation, Monitoring, and Assessment of Activities in an Effective Manner So as to Allow for Needed Changes in Management Efforts and Objectives*

lf management efforts are to be improved, it is vital that experience be used as a guide to determine what works and what does not. Clearly, oversight involving monitoring, analysis, and feedback must address the questions of whether adopted policies and practices promote intended results and whether modifications would lead to improved outcomes. But objectives themselves might require modification in light of changing knowledge of natural systems and human behavioral patterns, as well as changing human values and expectations. In this context, policy is modified in a continuing series of successive approximations, with each measure taken based on changing circumstances and an increasing base of knowledge and experience.

A willingness to accept change is needed with each effort being viewed as subject to modification rather than being seen as final and definitive in character. Such an approach, however, runs counter to the human tendency toward habitual practice and the organizational impulse toward maintaining the status quo.[46] And while monitoring and assessment have been made part of environmental and resource management programs at the international, national, and local levels, questions may remain as to the character and quality of the monitoring, analysis, and use of collected data. In a result-effective system, data quality will be high and its analysis will contribute to governance efforts in a timely and appropriate fashion.

In enumerating seven governance elements, it is necessary to note, first, that they are not meant to be seen as discrete steps which are performed sequentially, with a particular step completed before the next is taken. In fact, it is necessary to view them as elements of a dynamic system with constant interplay among them. For example, advances in the understanding of how a particular ecosystem works which suggest that two uses are truly incompatible may well require a change in priorities and regulation. Such modifications underscore the key role of learning from experience, incorporating lessons learned in future actions, and, generally, understanding the dynamic quality of needed governance.

Second, while each of the elements may be achieved in different ways, it is necessary that each of them somehow be undertaken and accomplished. No single institutional model will fill the needs, culture, and values of all societies. Variations in governance practices should be expected.

Third, and related to the last point, in developing governance systems to accommodate effectively the concept of LMEs, it is imperative to note that there is an existing governance status quo and not a blank slate on which to draw. The best developed plans and schemes will remain unimplemented if they do not take into account political realities. While change is possible and does come about, achieving it may require substantial effort, patience, and persistence.

## From Theory to Reality

The concept of LMEs provides a framework for the study of how the natural world operates and the effects of human actions on natural systems. If the concept is valid and is explanatory in terms of cause and effect, then it is desirable to utilize it as decisions are made relating to the use of the environment and its resources. How do we get from the theory of LMEs to its implementation and use in decision making?

### *Perceptions*

It is typically easier to describe desired change than it is to effectuate it. Yet it is obvious that change occurs. People act in accordance with their perception and cognition of the world around them; as their understanding evolves, behavioral changes may be expected. Ongoing events may make it possible to overcome inertia and the general acceptance of what has been done in the past and how it was done as the pattern for the indefinite future. When old ways of doing things no longer produce anticipated results, opportunities for reassessment may present themselves; traditional frameworks of thought may come to be questioned and paradigm shifts may occur.[47]

In terms of fisheries, for example, the decline in catch per unit of effort (CPUE) of desirable species may lead to a new conceptualization of fisheries. Are fisheries inexhaustible or are they not? Does human fish catch alter the future availability of fisheries? Does it make a difference if the shoreline is altered, if rivers are dammed, or if estuaries and wetlands are polluted or otherwise damaged? There may be no need to contemplate or to answer such questions in the absence of a perceived decline of fisheries; in such a situation the existing paradigm, whatever it may be, does not need to be reconsidered. When, however, the customary manner of conducting business no longer appears to allow continued patterns of exploitation at growing or even existing levels, then the opportunity for a paradigm shift emerges.

The question of why similar expenditures of effort yield different results over a span of time may cause consideration of commonly held assumptions, such as the belief once held that marine fisheries were inexhaustible. Empirical evidence may be sought and observation and evaluation, rather than belief, may lead to a new understanding of how natural systems work.[48] The role of science and the scientific method is extremely important in this regard, helping to explain the interactions of the parts of natural systems and the impacts of human behavior on those systems.

To the extent possible, it is necessary to discern whether events are simply random or if there are direct or indirect cause and effect relationships among them. An awareness of such relationships makes it possible to contemplate a phenomenon in the context of

systems involving the interplay of its parts and a deeply needed understanding that what happens here, either immediately or ultimately, has an effect there. This view of "system" provides the model that guides behavior and, given the need to include human activities in the system, it is important that there be, at least in general terms, a shared perception among the scientific community, decision makers, and stakeholders as to how things work. The model that underlies the present effort is that of large marine ecosystems.

In his research on the Regional Seas Programme in the Mediterranean,[49] and more generally on international regime development, Peter Haas has emphasized the concept of "epistemic communities," defined as "a network of professionals with recognized expertise and competence in a particular domain and an authoritative claim to policy-relevant knowledge within that domain or issue-area."[50] These professionals, drawn from a variety of disciplines, can provide information, advice, and conceptualizations that are useful to policymakers faced with uncertainty with respect to matters of cause and effect and issue linkages and, accordingly, may serve as significant agents of change. It is apparent that a transnational body of specialist advocates for the concept of the LME has emerged and begun to influence thinking at both the national and international levels,[51] offering yet another case study of the Haas thesis.

### *Emerging Principles and Practices of Ecosystem Use Governance*

A basic precept of ecosystem use governance is the need to analyze events in the context of systems, that is, to understand the relationship of particular events or uses to the wider environment. In terms of human uses, a key concept is that of externalities or the unintended effects of particular actions on the system. Disposal of wastes into the oceans may serve as a solution to the problem of waste disposal but, at the same time, may create significant and unintended problems for the physical survival of fisheries and the economic well-being of fishermen.

The 1969 report of the Stratton Commission recognized the need for more holistic analysis of the coastal and ocean environment—a more integrated approach to the uses of that environment.[52] But, as the Stratton Commission observed, the U.S. government was fragmented functionally, with each department and agency considering only a piece of the total picture. That problem of fragmentation and associated attempts at bureaucratic "turf" protection appear to be typical in governments, and among international organizations as well, rather than unique to the United States.[53] Overcoming the difficulties associated with such sectoral fragmentation provides a basic problem in advancing ecosystem-based management.[54]

An ever-growing body of literature on coastal and ocean management as well as a growing body of law, both nationally and internationally, point to a number of principles and approaches that need to be incorporated into a regime for the management of marine resources and the coastal and ocean environment in an ecosystem context. Some of the heavily cited principles and approaches are listed below.

*Integrated Management.* Agenda 21 calls upon states to commit themselves to "integrated management" of coastal areas and the marine environment.[55] Integrated, as opposed to sectoral, management is generally seen as providing for a more holistic, encompassing approach to environmental or resource management. As noted by Cicin-Sain, integrated management or policy is not an either-or proposition, but rather one that may be evaluated along a spectrum ranging from total fragmentation to complete integration.[56] Given this reality, a variety of incremental measures may be advanced, as the alternative of institut-

ing a whole new governance structure at once is likely to be unachievable. In this regard, Ehler has noted that "[d]eveloping an integrated management approach does not take place quickly; it evolves over time based on incremental gains that build one upon another."[57]

There are several interrelated dimensions to "integrated management" that merit attention, including the three listed below.

1. *The need to address externalities through more holistic institutional arrangements and management strategies.* Coastal and ocean areas are recognized as being areas of multiple use; inevitably, conflicts occur among the uses. Calls for integrated management, in which efforts in different sectors are coordinated or harmonized, result from the desire to limit the negative externalities that result when each use is governed by a separate authority and when governance occurs without sufficient reference to other uses which may be managed by other entities. Integrated management, by providing for consideration of the effect a particular use of the marine environment has on other uses and on the marine environment itself, could serve to minimize negative externalities and to promote an equitable and sustainable balance of uses that would meet multiple needs. As noted by Kenchington and Crawford, the concept of integrated management "involves combining, co-ordinating or integrating, at a number of scales, values, interests and goals, many of which are in competition."[58] Not only must each individual activity in or use of a given area be considered in relation to other particular uses or with respect to environmental effects, but the collective, cumulative effects of all such uses and activities need to be contemplated.[59]

Describing a system of integrated management for coastal and ocean areas is difficult enough;[60] implementing such a system presents a host of additional problems. Among other things, there is a need to get the different parts of the governance structure to interact more effectively. Intragovernment coordination is needed to compensate for the narrow, sectoral focus that is often typical in government agencies. Further, meaningful exchange of information and perceptions between the government and the public in both the development and implementation of governance decisions must be developed. Given the existing divisions of authority and interests among and within countries, governments, and stakeholders, the development of a fully integrated policy may be politically and administratively, if not technically or intellectually, unachievable. Nonetheless, various and worthwhile, incremental steps could be taken to advance needed policy integration.

2. *The need to incorporate and integrate natural and social science perspectives and insights into governance processes.* Integration involves more than simply getting agencies, governments, and nongovernmental interests to work together. It also requires effective integration of science and the insights of a variety of disciplines into the public policy process.[61] No matter what particular political interests want to achieve, there are physical and ecological parameters that need to be recognized;[62] the "need" for the production of 200 metric tons of high-value fishery species in capture fisheries each year may exist in a certain sense, but those with expertise in the science of fisheries must impress upon the wider public that such a level of production is not a possibility. Relevant science must be accessible and understandable to those shaping policy whose background is not in the biological or ecological sciences. Ecosystem management efforts require that science and the data and analytical techniques it provides be utilized in the decision-making process. Therefore, scientists must go beyond discovering knowledge and be willing to discuss the implications of their findings for societal interests.[63] In this regard, a recent study by the National Research Council on science and coastal management concludes that

> [t]o be helpful to policymakers, science must provide timely and credible information that is responsive to policy-relevant questions. Scientists must identify the significance of their findings and the limitations inherent in the information they provide, as well as the additional questions that are raised by their research and the potential cost of addressing those questions.[64]

Social scientists also have an essential role to play in the governance process since ecosystem-based governance addresses human behavior.[65] Economists, for example, can point to the increasing marginal cost of additional fish capture, the benefits of alternative uses of scarce capital, and the effects of government subsidies on fishing practices which may impact ecosystem balances.[66] Anthropologists can provide needed awareness of cultural and social values and structures that need to be acknowledged to advance management efforts.[67] And political scientists and lawyers can address a multitude of questions relating to public policy, institutions, representation, and law as a tool for effective management.

The work of the scientific community in studying natural processes and human interactions, in informing decision makers and the wider public, in analyzing and commenting upon alternative courses of action, and in assessing the consequences of decisions and policies provides essential contributions to governance efforts. Such contributions would be enhanced by closer interaction with policy makers than has been the case in the past[68] and will necessitate consideration of the often observed clash of cultures between science and policy.[69]

3. *The need to recognize the connection between coastal management and fisheries or ocean management.* Historically, coastal and fisheries management efforts have emerged separately, addressing different needs. Yet, a growing body of evidence indicates that farming, industrial, transportation, recreational, and development activities can negatively impact marine ecosystem integrity either directly or indirectly.[70] Direct damage to fishery resources can result, for example, from toxic waste disposal; indirect damage can occur through destruction of habitat or reduction of availability of elements in food chains. Impacts such as these present yet another type of externality that must be addressed and encourage consideration of integrated coastal and ocean management efforts. Ecosystems spill over from one medium (land) to another (water), and if they are to be the subject of effective governance, they need to be treated together as appropriate.

The Global Programme of Action for the Protection of the Marine Environment from Land-based Sources,[71] adopted in November 1995 at an intergovernmental conference with representatives from over 100 states and the European Union, serves as an indicator of awareness of the coastal-ocean interplay. In unequivocal terms, the Programme acknowledges that most of the pollutants in the ocean result from land-based activities. Accordingly, it is not surprising that the Programme calls for harmonization of coastal area management with river basin and land use planning.[72] Further, in recognition of the basic linkages between freshwater and marine environments, it points to the need to utilize watershed management approaches to protection of the marine environment.[73] More directly to the point with respect to fisheries, the Food and Agriculture Organization (FAO) Code of Conduct for Responsible Fisheries notes as one of its general principles that

> States should ensure that their fisheries interests, including the need for conservation of resources, are taken into account in the multiple uses of the coastal zone and are integrated into coastal area management, planning and development. [74]

*Sustainability.* The concept of sustainable development emerged from attempts to reconcile the goals of economic development and environmental protection.[75] To the extent that the two are seen as mutually incompatible, support for the latter will be undermined, particularly in developing states whose living standards are far below those in developed countries.[76]

In the report of the World Commission on Environment and Development (Brundtlandt Commission), great emphasis is given to the concept of sustainable development. In the view of the Commission, this refers to the ability to "meet the needs of the present without compromising the ability of future generations to meet their own needs."[77] While the concept does recognize that the biosphere has limited capacity to absorb the effects of human activities, the commission expressed the view that "technology and social organization can be both managed and improved to make way for a new era of economic growth."[78]

How exactly is "sustainable development" to be understood? Critics have suggested that it is "the environmental cliché of the 1990s," representing empty rhetoric that is inadequate as a guide to policy choice since it is subject to a multitude of understandings.[79] The point has been made that "[c]hoosing what to sustain is not only a biological question but also a question of human values."[80] It has been noted that the Brundtlandt Commission's definition does not address key questions such as what should be sustained and for whose benefit.[81] Accordingly, Fernandes et al. recommend the use of the term "sustainable use," rather than sustainability. Sustainable use refers to "the maintenance of the functions of the natural environment at those optimal levels that sustain (or improve) the contribution of natural resources to the welfare of society indefinitely."[82] While this approach still leaves open the question of what is meant by "the welfare of society," its focus is on the natural ecological processes that provide the basis for resource availability.

Considering sustainability from an ecosystem rather than a development perspective, Boyce and Haney note with concern that "sustainability is generally taken to mean that yield of goods and services from an ecosystem will not decline over time."[83] As noted by Franklin, if sustainability of natural systems is the goal of ecosystem management, then it is not possible to stipulate some particular level of output such as fish catch since it is the capacity of the ecosystem that determines what levels of output are consistent with sustainability of the system.[84] A report by a committee of the Ecological Society of America came to a similar conclusion, indicating that

> [s]ustainable strategies for the provision of ecosystem goods and services cannot take as their starting points statements of need or want such as mandated timber supply, water demand, or arbitrarily set harvests of shrimp or fish. Rather, sustainability must be the primary objective, and levels of commodity and amenity provision must be adjusted to meet that goal.[85]

In such a view of sustainability, it is the ecosystem that is the key and independent variable, while human-desired resources extracted from that ecosystem are the dependent variables; the fulfillment of human needs is dependent on functioning ecosystems, and those ecosystems can provide limited quantities of what may be desired before they break down.

Contemplating the pattern of resource exploitation in the United States dating to colonial times, Hanna sees a pattern of sequential development of single resources rather than use based in a balanced ecosystem approach; such use accorded with market needs

rather than those of ecosystem sustainability and has led to resource depletion and ecosystem degradation. In this "frontier" mentality new lands and resources were available and resource exploiters could always move on. Hanna maintains that the expanse of the oceans and their extensive resources allowed the "frontier" period to operate in the ocean context until well into the 20th century. However, as the limits of fisheries development were reached, the need to understand fisheries in the context of ecologically linked systems became more evident.[86]

If sustainability of fish stocks is an important goal of governance, and if ecosystem management is the governing paradigm, then not only will it be necessary to consider limits to catch levels, but attention will also have to be given to land-based, as well as sea-based, activities that have detrimental effects on those stocks. For example, harmful effects resulting from land-based pollutants or coastal development must be addressed, clearly necessitating closer interplay between coastal and fisheries management. Evidence of such an understanding is increasing both nationally in the United States and internationally.

*Public Participation.* If human behavior is of substantial significance to ecosystem health, then it is imperative that groups and individuals whose actions affect those ecosystems be involved in ecosystem protection.[87] While some type of command system of enforcement may always be needed, effective protection efforts will require that appropriate behavior patterns be understood, appreciated, and internalized by the vast majority of ecosystem users. Public participation in relevant decision making may fulfill three absolutely key functions: education, legitimization, and the building of political constituencies to support needed efforts. All are essential to the long-term protection of ecosystem health.

Education addresses the conceptual framework in which decisions are made, providing an understanding and a context for what needs to be done and why it needs to be done.[88] It is important that education be understood as involving a mutual exchange of information, one in which the valuable, first-hand experience of the local population,[89] as well as the data and conceptualization of a scientific or bureaucratic elite, is brought to bear on decision making. At the same time, public participation lends legitimacy[90] to adopted policy since those affected have had an opportunity to be heard and to influence decisions and policies. If key players do not "buy into" the approach being suggested, the likelihood of success is surely reduced and the potential willingness of people to cooperate will be replaced with indifference or hostility.[91] Finally, for an effective attempt at ecosystem-based management, there is a need to develop a political constituency which believes in the effort and which will provide the needed support for required governance mechanisms and measures.

*Equity.* Policy or management schemes are more likely to prove successful if those affected believe that what is being done has the fundamental quality of being "fair." Management efforts may not only affect resource availability and sustainability, but may also have significant allocative implications among the members of a society and internationally as well.[92] Economic development generates benefits but often environmental costs as well. Yet those who pay the costs are often not those to whom benefits accrue.

With respect to fisheries management, it is generally accepted that fishing effort needs to be reduced in the name of resource sustainability.[93] Questions then arise with respect to how such effort reduction is to be achieved. The social and economic effects

of measures such as license fees, transferable quotas, or gear restrictions will have differential impact on the various segments of the fishing community, and those who believe themselves disadvantaged by particular approaches will oppose them.

In addition to being allowed to participate in the making of decisions, stakeholders and the wider public must conclude that costs and benefits of the efforts being undertaken are apportioned in appropriate fashion—namely, that what Franck terms "distributional justice"[94] is done. The absence of such justice is likely to promote resistance and ultimately raise questions about the legitimacy of the process, while its perceived presence will serve to encourage voluntary compliance. Equity is a complicated concept; its quality is highly subjective and multidimensional (e.g., as between groups within states, as between states, as between generations), and yet the issues it presents must be considered and addressed if needed actions are to be taken and made effective.[95]

*Precaution.* It is often noted that governance efforts are reactive rather than proactive.[96] The concept of precaution reflects the attempt to move toward a more proactive mode of management.[97] The use of environmental impact statements to assess the possible effects of some action provides an example of considering the implications of that action in advance of taking it and is a manifestation of planning. However, given existing knowledge and analytical capabilities, it is not always possible to understand the implications of what is planned.

Precaution suggests that when the consequences of an action on, for example, the ocean environment are not clearly understood, greater weight should be given to caution, with the burden of proof shifted from those who oppose the action to those who favor it.[98] In the words of one writer, the precautionary principle "embodies a large degree of skepticism on the level of understanding of environmental processes and our ability to rectify damage after it has occurred."[99]

The concept of precaution has gained a significant degree of international support, as reflected in the 1992 Rio Declaration of the United Nations Conference on Environment and Development, which stipulates that

> [i]n order to protect the environment, the precautionary approach shall be widely applied by States according to their capability. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmentalist degradation.[100]

The section of Agenda 21 that addresses oceans and coasts makes several references to precaution,[101] and the 1995 United Nations Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks provides for party states to "apply the precautionary approach widely" to conservation and management decisions so as to protect living marine resources and the marine environment.[102] The 1995 Global Programme of Action on Land-based Pollution[103] and the 1996 Protocol to the London Convention on Dumping[104] also endorse the application of the precautionary approach.

While the principle of precaution is seen increasingly in international declarations and treaties relating to environmental protection and fisheries, its implementation does raise significant questions. How much precaution should there be, what should trigger it, and how do the benefits weigh in relative to the socioeconomic costs that may be incurred as a consequence of its use? And, most importantly, what should be the objects of precaution: About what should we be "precautious?"[105]

Among other things, precaution implies the shifting of the burden of proof from those opposed to a particular use or activity on the basis of potential harm to the environment or the resource, to those seeking to undertake, and thereby benefit from, an activity. Freedom of action would thus be made subject to constraints absent evidence that significant harm would not result from a desired use or activity.

In his consideration of the "burden of the proof" question as applied to fisheries management, Dayton distinguishes between two types of errors: Types I and II. Type I is consequent to the adoption of proposals, such as those to restrict trawling to protect benthic habitat, that do not accomplish their objectives. Type II errors result from the failure to adopt suggested proposals, which would have been effective if adopted, with consequent damage occurring to the environment or the resource. Current management approaches, Dayton maintains, focus on reducing Type I problems since such errors interfere with efforts to maximize fish catch and are opposed by politicians and the fishing industry. Type II errors, it is said, are virtually ignored because the effects of such errors are not immediately obvious, even though serious and long-term damage could result to the fisheries or the environment. For Dayton, Type II errors are seen as more serious because of the lag time in recovery of ecosystems or fish populations; Type I errors are seen as resulting "only in short-term economic costs."[106] But as Dayton implies, such economic costs often translate into significant political pressures on policy makers and interfere with the adoption of what otherwise would be viewed as rational policy.

*Market-Based and Other Economic Incentives.* Self-interest is a powerful motivator. As market-based economic systems spread worldwide, use of market and economic incentives may provide powerful and efficient complements to traditional command and control efforts to influence human behavior.[107]

In the past, the waste products of civilization have been released into the ocean and air with little restraint. From an economic perspective this made perfect sense, because such disposal afforded the cheapest and easiest alternative for those seeking to be rid of waste. No cost was associated with the use of the absorptive capacity of the air or water. As the substantial environmental costs of this unrestricted disposal became increasingly evident, efforts to regulate disposal became ever more pronounced. When damage to the economic interests of individuals or countries resulted from pollutants, provision was made for liability and compensation; damage to property or goods through the action of others has long been recognized as a basis for damage claims.[108] The establishment of liability and requirements for compensation, if implemented effectively, can serve to affect behavior by inducing consideration of externalities in an attempt to control costs.[109]

But compensation for damage to the broader environment and natural processes is a newer concept. Contributing to the development of such actions is the attempt to recognize the economic value of the environment and associated processes.[110] Increasingly, the recognition of the negative impact of pollutants on these processes has encouraged the thought that environmental costs need to be internalized in economic decisions. And, to this end and in the name of equity, it is the polluter, the one who uses the environment, who must be made to pay for its degradation.[111] The use of the "polluter pays" principle, as well as concepts of liability and compensation, bring the economic force of the marketplace to bear on the problem of environmental protection, providing an incentive for considering alternative and more socially acceptable methods of waste disposal.[112]

*Adaptive Management.* New knowledge and the benefits of experience must be integrated in governance systems and their policies and practices on a continuing basis. Ecological conditions and ecosystems are dynamic; accordingly, governance, too, must be dynamic in nature, employing newly acquired insights regarding the natural world and human interplay with it.

Adaptive management has been described by Lee in the following manner:

> Adaptive management applies the concept of experimentation to the design and implementation of natural-resource and environmental policies. An adaptive policy is one that is designed from the outset to test clearly formulated hypotheses about the behavior of an ecosystem being changed by human use. . . . If the policy succeeds, the hypothesis is affirmed. But if the policy fails, an adaptive design still permits learning, so that future decisions can proceed from a better base of understanding.[113]

From this perspective, policy is seen as an ongoing experiment. Walters maintains that such a management approach replaces management learning by trial and error, an "evolutionary process," with learning by careful tests, a process of "directed selection." Having said this, he is well aware of the many obstacles to successful employment of adaptive management approaches.[114] Will stakeholders, particularly if they are not adequately consulted, willingly allow their interests to be made subject to the outcomes of policy experiments?[115] Further, questions may arise relating to the problem of time and effort investment: How long must an "experiment" last before a judgment can be made as to a policy's success or failure? Have sufficient resources been dedicated so that a valid test has occurred? One clear point that emerges from discussions of adaptive management is that the focus of management efforts should not be on some preconceived plan, but rather on the process that allows for appropriate data collection, analysis, and policy adaptation as indicated by experience and changing circumstances.[116]

As governance efforts proceed, the question occurs as to what constitutes success and effectiveness. A variety of perspectives are possible.[117] It would appear that governance effectiveness would be characterized by the ability to influence and modify behavior in directions conducive to goal achievement in a cost-effective manner, with cost-effectiveness understood not only in terms of economics but also in sociocultural, political, and legal terms as well.[118] Effectiveness so defined often will be difficult to achieve given the need to define and prioritize goals and the need for society, domestically or internationally, to sacrifice present for future benefits and to apportion the direct and indirect costs and benefits of governance policies among its members in a widely acceptable, equitable manner. Given these needs, it is clear that governance cannot avoid politics and simply be managerial or administrative in nature. Further, in evaluating effectiveness, judgments must be made as to how much "improvement" in outcomes must be achieved to qualify a policy, effort, or arrangement as being successful. Finally, efforts at evaluation will have the often difficult task of considering whether what has been done is causative or correlative in nature with respect to outcomes.[119]

In concluding this section, the author suggests that the seven broad principles discussed above, and often cited and noted, need to be considered carefully and made operational if they are to be applied and, indeed, reconciled with one another. While theoretical discussions proceed, however, concrete, incremental steps can be made to advance a more holistic, ecosystem-based approach to management. Several mechanisms and institutional devices that may be of use to this end are noted below.

### *Mechanisms and Institutions that May Be Useful in Advancing Ecosystem-Based Management*

The literature on resource management contains recurrent references to certain practices that are said to contribute to more effective management[120] Such devices contribute to a more holistic, multiuse perspective and provide for the incorporation of considerations of externalities. Briefly discussed below are several of these practices, which are variously employed domestically and internationally.

*Environmental Impact Analyses.* Environmental impact analyses are associated with planning and, in general terms, provide for consideration of the implications of utilizing the environment for some particular purpose before that utilization occurs. The requirement of the use of an environmental impact statement (EIS) was mandated in the United States, in certain circumstances, by the National Environmental Policy Act (NEPA) of 1969.[121] An EIS is to utilize "a systematic, interdisciplinary approach," calling for wide input from both inside and outside the government, which would consider externalities associated with particular courses of action and contribute to more coherent and integrated policy making.[122] The use of the environmental impact analyses in various forms has been adopted and promoted by a number of governments around the world.[123]

At the international level, too, the use of environmental impact analyses is in evidence. The 1991 United Nations Convention on Environmental Impact Assessment in a Transboundary Context stresses the need to develop anticipatory policies for the purpose of "preventing, mitigating and monitoring significant adverse environmental impact" and calls upon states to establish environmental impact assessment procedures.[124] The Madrid Protocol on Environmental Protection to the Antarctic Treaty emphasizes the need for prior assessments of the possible impacts of activities in the Antarctic and mandates the use of environmental impact assessments, the nature and requirements of which are detailed in a separate treaty annex.[125] The prepared assessments are to be circulated to all party states and made available to the public at large for comments, which are to receive responses in a final evaluation.[126] Decisions on proposed activities to which environmental assessment applies are to be based on that assessment "as well as other relevant considerations."[127] While this latter wording provides flexibility, the public availability of the environmental assessment will force sensitivity to environmental needs and attendant political pressures and, thus, the environmental assessment process should serve to protect ecosystem values.

*Coordinating Governmental Arrangements and Mechanisms.* The sectoral, functionally based organization of governments can be a significant impediment to attempts to provide for spatially based ecosystem management, since responsibility within a given ecosystem may be spread among a variety of authorities, each with a different focus of concern. It is recognized in both theory and practice that sectoral approaches can generate important negative externalities with deleterious implications for ecosystem functioning.[128]

Accordingly, there is growing recognition of the need for coordination within and among governmental units. Increasingly, use is made of coordinating bodies that bring together representatives of governmental agencies to discuss the interplay of the sectoral policies they each generate. Such interdepartmental, interagency bodies can serve an information function and, more importantly, can serve as mechanisms for the mitigation of negative externalities as well as for the assessment of cumulative effects of departmental or agency policies. For the purposes of ecosystem governance it would be

important to study the operation of such bodies, their strengths and weaknesses, and the conditions under which they succeed.

A more radical approach involves the development of superdepartments that would incorporate a larger number of governmental actors in the hope that through such structures, more integrated and coherent policies would emerge; in regard to the oceans, for example, arguments have been made in the United States for the creation of a single cabinet-level department in which nonmilitary ocean programs and agencies would be located.[129] For a variety of reasons this department has not been established, though some countries have experimented with centralized ocean governance institutions.[130]

A recent study of marine area management in the United States by the National Research Council suggests the need for a "federalist" approach toward governance, one in which authority is shared between central and local levels, and calls for the creation of a National Marine Council and regional marine councils (RMCs).[131] In this system the federal government, through the National Marine Council, would set the broad priorities and attempt to engage local interests and skills to solve problems. The RMCs would have representation from federal and state agencies, as well as from other stakeholder groups. They would have multiuse perspectives and responsibilities for whole coastal ecosystems, regardless of political boundaries. A basic principle of the proposed approach would be that "authority belongs at the lowest point in the organization that has the capability and information to get the job done."[132]

On November 13, 1997, the Senate of the United States approved a bill entitled the "Oceans Act of 1997," which would create a National Ocean Council, chaired by the secretary of commerce, with representation from a variety of government departments and agencies, for the purpose of developing and implementing a comprehensive and coherent national ocean and coastal policy.[133] Further, a 16-member commission with membership from federal and state government, industry, public interest organizations, and academia would be established to provide recommendations for that policy; in effect, this would be Stratton Commission II. The 105th Congress, however, did not pass needed legislation.

A more modest approach is embodied in provisions in domestic laws for required interdepartmental or intergovernmental consultations.[134] The need to consult before actions are taken could have the effect of forcing the incorporation of more systemic concerns; this requirement, together with those for public disclosure, could serve to force explicit consideration of externalities and appropriate modifications of sectoral policies. In conjunction with the use of environmental impact analyses and public participation, meaningful consultation requirements that allow for input from all of the stakeholders, governmental and nongovernmental, could provide a significant element in the emergence and implementation of ecosystem-based policy.

At the international level, too, the need for cooperation among UN bodies, for example, is recognized, widened by the creation in 1993 of a Subcommittee on Oceans and Coastal Areas by the Administrative Committee on Coordination. This subcommittee's membership includes representation from the United Nations, the World Bank, the FAO, the United Nations Educational, Scientific, and Cultural Organization (UNESCO), the Intergovernmental Oceanographic Commission (IOC), the World Meteorological Organization (WMO), the International Maritime Organization (IMO), and the International Atomic Energy Agency (IAEA).[135]

*Comanagement Systems.* Interest in the concept of comanagement reflects an awareness that avoidance of "the tragedy of the commons"[136] may be accomplished other

than through either privatization or central government control. Communities that are dependent on ecosystems and their resources may themselves adopt institutional arrangements for needed management, and these arrangements may or may not be part of "nested relationships" involving a sharing of power between governments and local communities.[137]

The Canadian National Round Table on the Environment and the Economy has suggested that comanagement may be broadly defined as "systems that enable a sharing of decision-making power, responsibility and risk, between stakeholders, including but not limited to resource users, environmental interests, experts, and wealth generators."[138] In the context of oceans, the Round Table conceives of comanagement as

> an arrangement by which responsibility for resource management and ocean stewardship is shared between governments and stakeholders who are applying an integrated approach to management with the objective of maintaining the ecological integrity of the oceans.[139]

Comanagement seeks, explicitly, to incorporate stakeholders and communities into the governance system and, by doing so, to obtain the benefits identified earlier in this study in the observations on public participation, namely, the utilization of local knowledge and experience, enhancement of legitimacy and respect for adopted policy, and increased likelihood of adherence to that policy since stakeholders will have had input into its making.

But important questions arise with respect to comanagement. For example, how are comanagement systems institutionalized? For what geographic areas and activities do they have responsibility? How is the work of different comanagement units to be coordinated? How is influence to be distributed within the comanagement units? And, do such systems allow needed action to be adopted in a time-relevant fashion, given the need implicit in such governance arrangements for consultations and consensus building? There is, however, a growing body of experience with comanagement systems that may be consulted and that may provide valuable guidance in addressing the questions that have been raised.[140]

*Science and Socioeconomic Advisory Bodies.* Science advisory bodies have been used in conjunction with the management of marine living resources and coastal areas, but questions have been raised about their effectiveness in influencing policy decisions.[141] In the making of decisions on catch quotas, for example, scientific data have been treated as but one, and not necessarily the dominant, factor to be considered. Experience in the management of the groundfish stocks in the Georges Bank/Gulf of Maine region provides such an example.[142] This may reflect limited confidence in the state of scientific knowledge and the understanding of cause and effect relationships, but also may be due to the need to recognize social and economic imperatives. A growing understanding of the importance of science, however, is reflected in recent changes in the United States' Fishery Conservation and Management Act, which revised the definition of "optimum yield" in a manner that emphasizes the importance of scientifically based maximum sustainable yield and limits the impact of social and economic factors.[143]

While the reality is that socioeconomic concerns will always factor into policy decisions, reliable scientific data remains essential to effective ecosystem management. A scientific advisory body that provides systematic, rather than anecdotal, data to aid in rational decision making is a necessity. Accordingly, it is worth the effort to consider

carefully the conditions under which scientific advisory bodies have proven effective and ineffective and to learn from these experiences; indeed, a number of suggestions have been made on improving their utility and effectiveness.[144]

*Educational Efforts.* Educational efforts are needed with at least two target populations in mind: the experts and technical people who are responsible for developing and administering programs and interacting with the wider public, and the wider public, which comprises the users of the natural environment. It is the first group that is typically referred to in the context of "capacity building," and it is this group that provides the basic human infrastructure needed to effectuate ecosystem-based management.

While the education of the second group may be less formal and detailed, it is essential if ecosystem-based management is to succeed. It is helpful if people understand why they are being asked to behave in particular ways and how their behavior contributes to the greater good. Increasingly, educational efforts are seen as meaningful parts of plans and programs for environmental protection and resource management because they can contribute very significantly to program success.

*Remote Sensing and Use of Geographical Information Systems.* Modern technological capabilities provide new opportunities for data collection and analysis. Two such technologies are remote sensing and GIS. The advent of remote sensing capabilities through the use of satellites is important both because of the wider perspective these capabilities provide and the information that they generate. From a distance, the interrelationship of land and water over large areas may be better appreciated and may contribute to new modes of thought about natural processes and the impact of human activities on those processes. Remote sensing may also enhance enforcement capabilities as attempts are made to protect resources and the environment.[145]

As information becomes available in greater quantities, the problems of organizing and digesting are presented. The development of GIS provides a new and important tool for efforts in ecosystem-based management through its ability to display data in a format that enhances human understanding and by furthering analyses of the spatial relationships among resources, human populations and activities, and physical features of the area concerned.[146] GIS provides a tool that can promote integrated analysis through its ability to convert data from a variety of formats into one that is standard and to overlay that data in a spatial context. Further, the display of data from different time periods can demonstrate the nature of change over time and assist in developing an understanding of interactions and interrelationships. It may also be useful in discerning cumulative and synergistic effects of human and natural activity. And it may prove to be a very useful tool in explaining policies and practices at public meetings.[147]

*Economic Incentives.* Interest in economic well-being may encourage the use of appropriate incentives to advance ecosystem management goals. Such incentives may have negative results, such as higher costs to individuals or corporate entities, or they may be positive in nature, leading to increased benefits. User fees, for example, may be employed, attaching a cost to the use of resources, such as freshwater, which in the past had been free. Their use, in turn, would be expected to lead to a reassessment of how a resource is used, with consideration given to encouraging greater efficiencies, thereby reducing pressure on the natural environment. Additionally, tax incentives or subsidies may be used to encourage behavior patterns conducive to ecosystem goals. The substantial literature and growing body of experience on the use of economic incentives and market mechanisms to achieve environmental objectives may be studied and applied as contextually appropriate.[148]

*Government Regulation and Command and Control Rules.* To some degree, government regulation and command and control rules involving detailed, legally enforceable requirements and conditions will probably always be needed, as self-regulation may be lacking or ineffective.[149] Enforcement capability will be required because some people will not respond adequately to other inducements for behavioral change. Having said this, it is important to understand that government regulation is but one of many approaches available to influence behavior.

The effectiveness of regulations depends upon a variety of factors, including reasonableness, degree of public understanding and support, monitoring, enforcement, appropriate sanctions, and evaluation efforts that continually assess their efficacy. In the United States, the use of "negotiated rule making" is one device designed to enhance the effectiveness of government regulation by making the rule-making process less adversarial in nature between the government and the regulated population or between different nongovernmental interest groups.[150] The process of rule negotiation, in which the parties who will be affected by the regulation are actively involved in rule making from its origin, may allow substantive rules to be developed through agreement. Consequently, it might be expected that the adopted rule will have a greater degree of acceptability among stakeholders, be of improved substance because of the active input of interested and knowledgeable parties, and be less likely to be challenged in the courts.[151] Negotiated rule making will involve mutual education, public participation, and considerations of equity. And while the consideration of matters of equity is often difficult, it cannot be avoided; indeed, the process of negotiation may lead to accommodations that are widely acceptable.

## Conclusions

The emergence of ecosystem concepts and the growing realization of their relevance to human well-being is a driving force, encouraging new ways of viewing natural resources, the natural environment, and the impact of human activities. That realization needs to be given due recognition and be reflected in governance arrangements.

If resources are to be managed in the context of ecosystems, governance systems will have to adapt their institutions, procedures, and policies. Recognition will have to be afforded to the growing degree of human capability to alter the workings of the ecosystems on which human well-being is dependent. Customary behavior patterns, values, and institutional arrangements may no longer prove functional in this context. Governance systems based on an earlier ethic and grounded in theories of nation state sovereignty or traditional governance practices are displaying inadequacies and, not surprisingly, new governance arrangements are being sought in the light of contemporary experience, knowledge, and understanding.

In a variety of locations and at different levels of human organization, attempts are being made to make governance responsive to the need for ecosystem-based management efforts. This study has examined some of the basic considerations in seeking to make necessary adaptations and has suggested some of the fundamental functional prerequisites of such management systems, exploring a variety of principles and practices that may be relevant to ecosystem-based management. It is clear that many difficulties lie ahead as attempts continue to be made to develop governance systems that are relevant, effective, and politically acceptable.

While substantial change may be necessitated in toto, it may well be that a number of site-specific, incremental steps could be taken that would have substantial cumulative effects in advancing needed governance arrangements. As always, change will be rendered more difficult to accomplish by those who benefit from the present way of doing

things. In general, what is needed is patience, persistence, education, experimentation, learning, adaptation, integration of new data, understanding, and acceptance of governance efforts as a continuing, dynamic process. In particular, it would be useful to analyze a number of detailed, comparative studies of efforts at ecosystem-based management that could provide indications of what works, in what circumstances, and under what conditions. At the same time, it must be recognized that socioeconomic and governance measures that work in one location may not be effective in others; the local context and human motivation must be understood if change is to be effectuated.

## Notes

1. Kenneth Sherman, "Sustainability, Biomass Yields, and Health of Coastal Ecosystems: An Ecological Perspective," *Marine Ecology Progress Series* 112 (1994): 279 and Lewis M. Alexander, "Large Marine Ecosystems: A New Focus for Marine Resources Management," *Marine Policy* 17 (1993): 186. Alexander indicates that the figure of 200,000 square kilometers is equivalent to some 60,000 square nautical miles, with each square nautical mile equal to 1.325 square statute miles.

2. See the contributions of the many authors in *Variability and Management of Large Marine Ecosystems*, ed. Kenneth Sherman and Lewis M. Alexander (Boulder, CO: Westview, 1986); *Biomass Yields and Geography of Large Marine Ecosystems*, ed. Kenneth Sherman and Lewis M. Alexander (Boulder, CO: Westview Press, 1989); *Large Marine Ecosystems: Patterns, Processes, and Yields*, ed. Kenneth Sherman, Lewis M. Alexander, and Barry D. Gold (Washington, DC: American Association for the Advancement of Science, 1990); *Food Chains, Yields, Models, and the Management of Large Marine Ecosystems*, ed. Kenneth Sherman, Lewis M. Alexander, and Barry D. Gold (Boulder, CO: Westview Press, 1991); *Large Marine Ecosystems: Stress, Mitigation, and Sustainability*, ed. Kenneth Sherman, Lewis M. Alexander, and Barry D. Gold (Washington, DC: American Association for the Advancement of Science, 1993); *The Northeast Shelf Ecosystem: Assessment, Sustainability, and Management*, ed. Kenneth Sherman, Norbert A. Jaworski, and Theodore J. Smayda (Cambridge, MA: Blackwell Science, 1996); *Large Marine Ecosystems of the Indian Ocean: Assessment, Sustainability, and Management*, ed. Kenneth Sherman, Ezekiel N. Okemwa, and Micheni J. Ntiba (Malden, MA: Blackwell Science, 1998); and *The Gulf of Mexico Large Marine Ecosystem: Assessment, Sustainability and Management*, ed. H. Kumpf et al. (Malden, MA: Blackwell Science, 1999).

3. See, for example, Interagency Ecosystem Management Task Force, *The Ecosystem Approach: Healthy Ecosystems and Sustainable Economies*, 3 vols. (Washington, DC: The Task Force, 1995–1996); General Accounting Office, *Ecosystem Management: Additional Actions Needed to Adequately Test a Promising Approach*, GAO/RCED-94-111 (Washington, DC: GAO, 1994); Norman Christensen et al., "The Report of the Ecological Society of America Committee on the Scientific Basis for Ecosystem Management," *Ecological Applications* 6 (1996): 665–691; Mark S. Boyce and Alan Haney, eds., *Ecosystem Management: Applications for Sustainable Forest and Wildlife Resources* (New Haven, CN: Yale University Press, 1997).

4. P. A. Larkin, "Concepts and Issues in Marine Ecosystem Management," *Reviews in Fish Biology and Fisheries* 6 (1996): 141.

5. See, for example, *Report of the United Nations Conference on Environment and Development (Rio de Janeiro, 3–14 June 1992)*, UN Doc. A/CONF.151/26, 5 vols. (1992), of which Agenda 21 is a major component. In particular, see Chapter 17 of Agenda 21 (in vol. 2), which addresses protection of oceans and coastal areas, and see Food and Agriculture Organization of the United Nations, *Code of Conduct for Responsible Fisheries* (Rome: FAO, 1995) [hereafter cited as FAO *Code of Conduct for Responsible Fisheries*], which was adopted at the 28th session of the FAO Conference in October 1995.

6. Biliana Cicin-Sain and Robert Knecht note that most state coastal zone programs in the United States "focus primarily on the management of shore land use and, so far at least, less so

on coastal water-related issues." Biliana Cicin-Sain and Robert W. Knecht, *Integrated Coastal and Ocean Management: Concepts and Practices* (Washington, DC: Island Press, 1998), 33. On the distinctive development of coastal and ocean management, see Paolo Fabbri, "From Coastal to Ocean Management: Policies and Planning Issues," in *Ocean Management in Global Change*, ed. Paolo Fabbri (London: Elsevier Applied Science, 1992), 169–183.

7. Note, for example, the general conceptualization of the LME in Kenneth Sherman, "Sustainability of Resources in Large Marine Ecosystems," in *Food Chains, Yields, Models,* 1–34.

8. Roger B. Griffis and Katharine W. Kimball, "Ecosystem Approaches to Coastal and Ocean Stewardship," *Ecological Applications* 6 (1996): 708–712.

9. Cicin-Sain and Knecht, *Integrated Coastal and Ocean Management*, 37–38. These authors note that experience has demonstrated the "seamless web" that ties together ocean and coastal activities.

10. See the Sustainable Fisheries Act, Public Law 104-297, *U.S. Statutes at Large* 110 (1996): 3559–3621 and, in particular, the attention given to the matter of essential fish habitat in §§ 101, 108, and 110.

11. Kenneth Sherman, "Achieving Regional Cooperation in the Management of Marine Ecosystems: The Use of the Large Marine Ecosystem Approach," *Ocean & Coastal Management* 29 (1995): 165–185 and Kenneth Sherman, "Large Marine Ecosystems: Assessment and Management from Drainage Basin to Ocean" (Paper presented to the Joint Stockholm Water Symposium/EMECS Conference, in Stockholm, August 1997).

12. On this theme, see Susan S. Hanna, "Institutions for Marine Ecosystems: Economic Incentives and Fishery Management," *Ecological Applications*, suppl., 8, no. 1 (1998): S170–S174. J. M. McGlade and R. McGarvey note that fisheries management needs to consider the dynamics of both the harvested populations and the human populations exploiting them. They assert, however, that "to date, fisheries models have dealt almost exclusively with fish population dynamics, treating fishing effort and the behaviour of fishermen and processors as exogenous variables in the calculation of specific harvesting yields." For management strategies to succeed, "it is critical that the underlying rationalities of the various actors in the system be exposed and some attempt made to create a system in which these behaviours can be made to converge." J. M. McGlade and R. McGarvey, "Integrated Fisheries Management Models," in *Advances in the Science and Technology of Ocean Management*, ed. Hance D. Smith (London: Routledge, 1991), 196–197.

13. James Rosenau underscores the differences between governance and government, writing that

> [b]oth refer to purposive behavior, to goal-oriented activities, to systems of rules; but government suggests activities that are backed by formal authority, by police powers to insure the implementation of duly constituted policies, whereas governance refers to activities backed by shared goals that may or may not derive from legal and formally prescribed responsibilities and that do not necessarily rely on police powers to overcome defiance and attain compliance. Governance, in other words, is a more encompassing phenomenon than government. It embraces governmental institutions, but it also subsumes informal, non-governmental mechanisms whereby those persons and organizations within purview move ahead, satisfy their needs, and fulfill their wants.

James N. Rosenau, "Governance, Order, and Change in World Politics," in *Governance Without Government: Order and Change in World Politics*, ed. James N. Rosenau and Ernst-Otto Czempiel (Cambridge: Cambridge University Press, 1992), 4.

On this subject, Oran Young notes that governance

> is a social function whose performance is crucial to the viability of all human societies; it centers on the management of complex interdependencies among actors (whether individual, corporations, interest groups, or public agencies) who are engaged in interactive decisionmaking and, therefore, taking actions that affect each other's welfare. Governments, by contrast, are organizations—complex material entities possessing offices, personnel, equipment, budgets, and legal personality and often

> professing political ideologies—that we commonly take for granted as vehicles for the provision of governance because we are so accustomed to their efforts to perform this role in domestic societies. . . . Yet there is nothing sacred about the connection between governance and government.

Oran Young, "The Effectiveness of International Governance Systems," in *Global Environmental Change and International Governance*, ed. Oran R. Young, George J. Demko, and Kilaparti Ramakrishna (Hanover, NH: University Press of New England, 1996), 2.

14. See, for example, Grant J. Hewison, "The Role of Nongovernmental Organizations in Ocean Governance," in *Ocean Yearbook 12*, ed. Elisabeth Mann Borgese, Norton Ginsburg, and Joseph R. Morgan (Chicago: University of Chicago Press, 1996), 32–51; Thomas Princen and Matthias Finger, *Environmental NGOs in World Politics: Linking the Local and the Global* (London: Routledge, 1994); and Kevin Stairs and Peter Taylor, "Non-Governmental Organizations and the Legal Protection of the Oceans: A Case Study," in *The International Politics of the Environment: Actors, Interests, and Institutions*, ed. Andrew Hurrell and Benedict Kingsbury (Oxford: Clarendon Press, 1992), 110–141.

15. See, for example, Svein Jentoft, "Fisheries Co-management: Delegating Government Responsibility to Fishermen's Organizations," *Marine Policy* 13 (1989): 137–154 and Robert S. Pomeroy and Michael D. Pido, "Initiatives Towards Fisheries Co-management in the Philippines," *Marine Policy* 19 (1995): 213–226.

16. A listing of and a map showing 49 areas identified as LMEs is found in Kenneth Sherman, "Achieving Regional Cooperation in the Management of Marine Ecosystems: The Use of the Large Marine Ecosystem Approach," *Ocean & Coastal Management* 29 (1995): 171 and in Alexander, "Large Marine Ecosystems," 188.

17. Sherman, "Sustainability, Biomass Yields, and Health of Coastal Ecosystems."

18. For examples, see the references in note 2 above.

19. This analysis builds upon the approach developed in Lawrence Juda, "The Exclusive Economic Zone and Ocean Management," *Ocean Development and International Law* 18 (1987): 305–331.

20. General Accounting Office, *Ecosystem Management*.

21. Richard Haeuber, "Setting the Environmental Policy Agenda: The Case of Ecosystem Management," *Natural Resources Journal* 36 (1996): 6.

22. U.S. House Committee on Natural Resources, *Ecosystem Management: Sustaining the Nation's Natural Resources Trust*, 103d Cong., 2d sess., 1994, Committee Print No. 6, 2.

23. Public Law 92-583, Title III, *U.S. Statutes at Large* 86 (1972): 1280–1289. For a discussion of differing conceptualizations of the coastal zone, see Jens C. Sorensen and Scott T. McCreary, *Institutional Arrangements for Managing Coastal Resources and Environments*, 2d rev. ed. (Washington, DC: National Park Service, U.S. Dept. of the Interior, 1990), 3–19.

24. Public Law 92-583, § 304(1).

25. Organisation for Economic Co-operation and Development, *Coastal Zone Management: Integrated Policies* (Paris: OECD, 1993), 10.

26. United Nations, *Oceans and the Law of the Sea: Law of the Sea: Report of the Secretary-General*, UN Doc. A/52/487 (1997), para. 354; Food and Agriculture Organization of the United Nations, *Integration of Fisheries into Coastal Area Management*, FAO Technical Guidelines for Responsible Fisheries, no. 3 (Rome: FAO, 1996); and Agenda 21, ch. 17, para. 17.29. Note, too, the evolving ecosystem governance system for the Great Lakes, which not only focuses on the waters of those lakes but also extends to their entire drainage basins, which are more than twice the size of the lakes themselves. Marcia Valiante, Paul Muldoon, and Lee Botts, "Ecosystem Governance: Lessons from the Great Lakes," in *Global Governance: Drawing Insights from the Environmental Experience*, ed. Oran R. Young (Cambridge, MA: MIT Press, 1997), 197–225.

27. On the jurisdictional zones of ocean space and the rights and duties of states in these zones, see the 1982 United Nations Convention on the Law of the Sea, *International Legal Materials* 21 (1982): 1261–1354. With respect to innocent passage, see arts. 17–32.

28. Ibid., arts. 55–75.

29. On the traditional status of the high seas, see R. R. Churchill and A. V. Lowe, *The Law of the Sea* (Manchester: Manchester University Press, 1983), 144–154. The classic statement of the freedom of the seas by Hugo Grotius is found in that author's *The Freedom of the Seas*, trans. from the Latin by Ralph van Deman Magoffin and ed. James Brown Scott (New York: Oxford University Press, 1916).

30. On this matter, see Yann-huei Song, "The Canada–European Union Turbot Dispute in the Northwest Atlantic: An Application of the Incident Approach," *Ocean Development & International Law* 28 (1997): 269–311.

31. Note that the 1982 United Nations Convention on the Law of the Sea, in Article 63, expresses recognition of problems associated with straddling and transboundary stocks.

32. In broader terms, Kenneth Boulding observed that "[a] great problem of the human race . . . is that the world is becoming a single ecosystem, but is not a single community." Kenneth Boulding, "Commons and Community: The Idea of a Public," in *Managing the Commons*, ed. Garrett Hardin and John Baden (San Francisco: W.H. Freeman and Company, 1977), 288.

33. In what may be seen as an extreme case within a country, the National Research Council found that in 1984, in the Puget Sound region, a total of 454 public entities exercised jurisdiction over water quality and related ecosystem management. National Research Council, Committee on Wastewater Management for Coastal Urban Areas, *Managing Wastewater in Coastal Urban Areas* (Washington, DC: National Academy Press, 1993), 395.

34. See, for example, Robert J. Bailey, "The Oregon Ocean Resources Management Program: A State-Level Ocean Management Initiative," *Ocean & Coastal Management* 34 (1997): 205–224; Marc J. Hershman, "Ocean Management Policy Development in Subnational Units of Governments: Examples from the United States," *Ocean & Coastal Management* 31 (1996): 25–40; and Jon L. Jacobson and Glenn Boledovich, "Ocean Governance Policy Coordination in the United States," in *Ocean Governance: Strategies and Approaches for the 21st Century: Proceedings, the Law of the Sea Institute Twenty-eighth Annual Conference, Honolulu, Hawaii, July 11–14, 1994*, ed. Thomas A. Mensah (Honolulu: Law of the Sea Institute, William S. Richardson School of Law, University of Hawaii, 1996), 458–497.

35. General Accounting Office, *Ecosystem Management*, 51–54. Agenda 21, in its Chapter 17, which addresses issues relating to oceans and coastal areas, underscores the need for coastal states to collect and analyze information for the sustainable use of resources and the environmental impacts of activities on coastal and marine areas (para. 17.8).

36. For one example of the attempts to provide a structured marine ecosystem model, see David Pauly and Villy Christensen, "Stratified Models of Large Marine Ecosystems: A General Approach and an Application to the South China Sea," in *Large Marine Ecosystems: Stress, Mitigation, and Sustainability*, 148–174.

37. National Research Council, Committee on Wastewater Management for Coastal Urban Areas, *Managing Wastewater*, 84–85.

38. See, for example, Agenda 21, ch. 17, paras. 17.15–17.17. M. J. Peterson points to the need for both resources and skills. M. J. Peterson, "International Organizations and the Implementation of Environmental Regimes," in *Global Governance*, 122. See also volume 22, number 3 (1998) of *Marine Policy*, which is dedicated to the issue of marine capacity building. In particular, note Gunnar Kullenberg, "Capacity Building in Marine Research and Ocean Observations: A Perspective on Why and How" (pp. 185–195) and John C. Pernetta, "An Overview of the Role of the Global Environment Facility in International Waters with Reference to Marine Capacity Building" (pp. 235–246).

39. See, for example, R. Goñi, "Ecosystem Effects of Marine Fisheries: An Overview," *Ocean & Coastal Management* 40 (1998): 37–64.

40. A study prepared by the World Bank has concluded that "[n]o topic in fisheries research is more important, and studied less, than the interactions between people and the resources they use." World Bank, *Fish for the Future: Summary Report: A Study of International Fisheries Research* (Washington, DC: World Bank, 1993), 13.

41. Michael Healey and Timothy Hennessey note that scientific evidence is rarely clear and uncontested and, accordingly, "individuals with strongly held policy positions will exploit the scientific uncertainty to find scientific and political support for their position." Michael C. Healey and Timothy M. Hennessey, "The Utilization of Scientific Information in the Management of Estuarine Ecosystems," *Ocean & Coastal Management* 23 (1994): 168. See also Sonja Boehmann-Christiansen, "Black Mist and Acid Rain—Science as a Fig Leaf of Policy," *The Political Quarterly* 59 (1988): 145–160 and Frieda B. Taub, "When Ecology Doesn't Play Straight," in *Saving the Seas: Values, Scientists, and International Governance*, ed. Anathea Brooks and Stacy D. VanDeveer (College Park, MD: Maryland Sea Grant College, 1997), 131–148.

42. For example, in their consideration of fisheries management, D. Ludwig, R. Hilborn, and C. Waters refer to a "ratchet effect" in which investment in fisheries increases during good years, leading to excess capacity. When catches decline, the industry turns to government for assistance and that assistance has the effect of encouraging continued overharvesting. "The ratchet effect is caused by the lack of inhibition on investments during good periods, but strong pressure not to disinvest during poor periods. The long-term outcome is a heavily subsidized industry that overharvests the resource." D. Ludwig, R. Hilborn, and C. Waters, "Uncertainty, Resource Exploitation, and Conservation: Lessons from History," *Science* 260 (1993): 17, 36.

43. Arild Underdal, "Integrated Marine Policy: What? Why? How?" *Marine Policy* 4 (1980): 159–169.

44. This point is made, for example, in Chua Thia-Eng, "Essential Elements of Integrated Coastal Zone Management," *Ocean & Coastal Management* 21 (1993): 85.

45. For a review of different approaches, see Sorensen and McCreary, *Institutional Arrangements*, 87–111 and 155–162.

46. This frequently made point is noted, for example, in Peterson, "International Organizations," in *Global Governance,* 135. In its consideration of adaptive management, the federal government's Interagency Ecosystem Management Task Force noted that what is required is "a willingness to undertake prudent experimentation, consistent with sound scientific and economic principles, and to accept occasional failures. This contrasts with the strongly risk-averse nature of most agencies and managers." Interagency Ecosystem Management Task Force, *The Ecosystem Approach*, 1:7–8.

47. On the concept of paradigm shifts and the role of anomalies in such shifts, see Thomas S. Kuhn, *The Structure of Scientific Revolutions*, 2d ed. (Chicago: University of Chicago Press, 1970).

48. For an examination of the changing perception of the exhaustibility of marine fisheries from the 17th century to the present, see Lawrence Juda, *International Law and Ocean Use Management: The Evolution of Ocean Governance* (London: Routledge, 1996).

49. Peter M. Haas, *Saving the Mediterranean: The Politics of International Environmental Cooperation* (New York: Columbia University Press, 1990).

50. Peter M. Haas, "Introduction: Epistemic Communities and International Policy Coordination," *International Organization* 46 (1992): 3. See also Peter M. Haas, "Epistemic Communities and the Dynamics of International Environmental Cooperation," in *Regime Theory and International Relations*, ed. Volker Rittberger (Oxford: Clarendon Press, 1993), 168-201.

51. See, for example, Intergovernmental Oceanographic Commission, "IOC-IUCN-NOAA Ad Hoc Consultative Meeting on Large Marine Ecosystems (LME), Paris, France, 23–24 January 1997," which reports on LME-related developments involving the IOC, FAO, UNEP, and the Global Environment Facility (GEF), including projects or proposed projects based in the LME approach in the Gulf of Guinea, the Yellow Sea, and the South China Sea.

52. Commission on Marine Science, Engineering, and Resources, *Our Nation and the Sea: A Plan for National Action* (Washington, DC: U.S. Government Printing Office, 1969). Most recently, this theme has been repeated in National Research Council, Committee on Marine Area Governance and Management, *Striking a Balance: Improving Stewardship of Marine Areas* (Washington, DC: National Academy Press, 1997) and H. John Heinz III Center for Science, Economics, and the Environment, *Our Ocean Future: Themes and Issues Concerning the Nation's Stake in the Oceans Developed for Discussion During 1998, the Year of the Ocean* (Washington, DC: The Heinz Center, 1998).

53. On this point, see, for example, Jean-Pierre Levy, "Towards an Integrated Marine Policy in Developing Countries," *Marine Policy* 12 (1988): 326–342 and United Nations Economic and Social Council, *Development of Marine Areas Under National Jurisdiction: Problems and Approaches in Policy-Making, Planning and Management*, UN Doc. E/1987/69 (1987). Agenda 21 points to the need to strengthen the coordination among UN organizations with marine and coastal responsibilities (ch. 17, para. 17.117). For a classic consideration of bureaucratic behavior and agency efforts to protect their share of "policy space," see Anthony Downs, *Inside Bureaucracy* (Boston: Little, Brown, and Company, 1967).

54. For an analysis of institutional problems in the U.S. government agency context, see Interagency Ecosystem Management Task Force, *The Ecosystem Approach*, 2:19–36.

55. Agenda 21, ch. 17, para. 17.5.

56. Biliana Cicin-Sain, "Sustainable Development and Integrated Coastal Management," *Ocean & Coastal Management* 21 (1993): 25–26. For a more detailed examination of the concept of integrated management, see Cicin-Sain and Knecht, *Integrated Coastal and Ocean Management*.

57. Charles N. Ehler, "Integrated Coastal Ocean Space Management: Challenges for the Next Decade," in *Coastal Ocean Space Utilization III*, ed. Norberto Della Croce, Shirley Connell, and Robert Abel (London: E & FN Spon, 1995), 183.

58. Richard Kenchington and David Crawford, "On the Meaning of Integration in Coastal Zone Management," *Ocean & Coastal Management* 21 (1993): 111.

59. On the problem of cumulative effects of multiple uses, see William Odum, "Environmental Degradation and the Tyranny of Small Decisions," *BioScience* 32 (1982): 728–729; Peter M. Douglas, Elizabeth Fuchs, and Charles Lester, "Managing the Cumulative Impacts of Development: An Opportunity for Integration?" in *Improving Interactions Between Coastal Science and Policy: Proceedings of the California Symposium, Irvine, California, November 11–13, 1992* (Washington, DC: National Academy Press, 1995), 184–205 and Frances H. Irwin and Barbara K. Rodes, *Making Decisions on Cumulative Environmental Impacts: A Conceptual Framework* (Washington, DC: World Wildlife Fund, 1992).

60. For one well-known and often cited attempt to lay out the requirements of integrated policy, see Underdal, "Integrated Marine Policy." A detailed attempt to consider integrated ocean management is found in Adalberto Vallega, *Sea Management: A Theoretical Approach* (London: Elsevier Applied Science, 1992).

61. See Robert W. Knecht, "On the Role of Science in the Implementation of National Coastal Ocean Management Programs," in *Improving Interactions Between Coastal Science and Policy: Proceedings of the Gulf of Maine Symposium, Kennebunkport, Maine, November 1–3, 1994* (Washington, DC: National Academy Press, 1995), 39–62 and Interagency Ecosystem Management Task Force, *The Ecosystem Approach*, 2:47–68.

62. Recognition of this perspective is reflected in changes made in the 1996 reauthorization of the Magnuson Fishery Conservation and Management Act in changing the definition of "optimum yield" to the level prescribed "on the basis of maximum sustainable yield from the fishery *as reduced by* any relevant social, economic, or ecological factor." Sustainable Fisheries Act, § 102(7) (emphasis added). The original corresponding wording was "*as modified by* any relevant economic, social, or ecological factor." Fishery Conservation and Management Act of 1976, Public Law 94-265, § 3(18)(B), *U.S. Statutes at Large* 90 (1976): 335 (emphasis added). The change in wording indicates that the maximum sustainable yield is to be treated as a ceiling rather than a floor in the determination of catch limits.

63. Note that this is not at all to say that the science community has been totally absent in this regard. Dahl notes, for example, that it was the science community that initially expressed concern over land-based sources of marine pollution and public health authorities who noted increased incidence of disease in coastal areas. Arthur Lyon Dahl, "Land-based Pollution and Integrated Coastal Management," *Marine Policy* 17 (1993): 562. More generally, Caldwell notes that attempts to inform the public and to influence policy in regard to increasing environmental risks have often been led by scientists. Lynton K. Caldwell, *Between Two Worlds: Science, the Environmental Movement, and Policy Choice* (Cambridge: Cambridge University Press, 1990), 22–23.

64. National Research Council, Committee on Science and Policy for the Coastal Ocean, *Science, Policy, and the Coast: Improving Decisionmaking* (Washington, DC: National Academy Press, 1995), 2.

65. This point is developed in Michael K. Orbach, "Social Science Contributions to Managing Ecosystems," in *Improving Interactions Between Coastal Science and Policy: Proceedings of the Gulf of Maine Symposium*, 27–37. The FAO *Code of Conduct for Responsible Fisheries* notes that to ensure sustainable management of fisheries, "sufficient knowledge of social, economic and institutional factors should be developed through data gathering, analysis and research" (art. 7.4.5). The National Research Council's Committee on Science and Policy for the Coastal Ocean strongly emphasizes the need for close interaction and attention to the insights of natural and social scientists in its report, *Science, Policy, and the Coast*, 42–50, noting that "[t]he human and ecological dimensions of coastal marine resources are inextricably linked, and their linkage creates a need for the integration of natural and social sciences." Ibid., 43–44.

66. The FAO has estimated that, on an annual basis, the worldwide total of government subsidies to the fisheries sector is in the range of $54 billion, since the fishing industry spends some $124 billion to capture fish with a total value estimated at $70 billion. WWF Endangered Seas Campaign, Press Release, June 2, 1997 (Available on the World Wide Web at http://www.panda.org/endangeredseas/pressrelease6.htm).

67. See Christopher Dyer, "Proaction versus Reaction: Integrating Applied Anthropology into Fishery Management," *Human Organization* 53 (1994): 83–88.

68. In its study of science and coastal policy, the National Research Council found that "[c]oncerted efforts are seldom made to foster interactions between scientists (social and natural) and policymakers (agency and legislative)." National Research Council, Committee on Science and Policy for the Coastal Ocean, *Science, Policy, and the Coast*, 9. See also L. S. Parsons, H. Powles, and M. J. Comfort, "Science in Support of Fishery Management: New Approaches for Sustainable Fisheries," *Ocean & Coastal Management* 39 (1998): 151–166.

69. A succinct characterization of the differences between approaches of science and management is found in Brock B. Bernstein, Bruce E. Thompson, and Robert W. Smith, "A Combined Science and Management Framework for Developing Regional Monitoring Objectives," *Coastal Management* 21 (1993): 185–195. See also Peter M. Douglas, "What Do Policymakers and Policy-Implementors Need from Scientists?" in *Improving Interactions Between Coastal Science and Policy: Proceedings of the California Symposium,* 15–32; Donald F. Boesch and Swantje-A. Macke, "Bridging the Gap: What Natural Scientists and Policymakers and Implementors Need to Know about Each Other," in ibid., 33–48; and Paul A. Sabatier, "Alternative Models of the Role of Science in Public Policy: Applications to Coastal Zone Management," in ibid., 83–95.

70. See, for example, John R. Clark, *Coastal Zone Management Handbook* (Boca Raton, FL: Lewis Publishers, 1996) and T. J. Done and R. E. Reichlet, "Integrated Coastal Zone and Fisheries Ecosystem Management: Generic Goals and Performance Indices," *Ecological Applications*, suppl., 8, no. 1 (1998): S110–S118.

71. *Global Programme of Action for the Protection of the Marine Environment from Land-based Activities*, UNEP(OCA)/LBA/IG.2/7 (1995). The Programme was adopted November 3, 1995, by the intergovernmental conference which met for that purpose in Washington, DC, October 23 to November 3, 1995. The text of this document appears on the World Wide Web at http://www.unep.org/unep/gpa/pol2a.htm.

72. Ibid., para. 19.

73. Ibid., para. 23(b).

74. FAO *Code of Conduct for Responsible Fisheries*, art. 6.9.

75. Note that prior to the utilization of the term "sustainable development," UNEP under the leadership of Maurice Strong, fostered the concept of "ecodevelopment," or ecologically sound development so as to promote environmental protection concerns in developing countries. United Nations Environment Programme, *Ecodevelopment*, UNEP/GC/80 (1976). See also Lawrence Juda, "International Environmental Concern: Perspectives of and Implications for Developing States," in *The Global Predicament: Ecological Perspectives on World Order*, ed. David W. Orr

and Marvin S. Soroos (Chapel Hill: University of North Carolina Press, 1979), 9–107. For a detailed consideration distinguishing among environmental, social, and economic sustainability, see Robert Goodland, "The Concept of Environmental Sustainability," *Annual Review of Ecology and Systematics* 26 (1995): 1–24.

76. This point is implicit in the November 13, 1970, address of then Word Bank President Robert McNamara to the UN Economic and Social Council in which he noted the creation of an Office of Environmental Affairs in the Bank. McNamara stated that "[t]he problem facing development finance institutions, including the World Bank, is whether and how we can help the developing countries to avoid or mitigate some of the damage economic development can do to the environment, without at the same time slowing down the pace of economic progress." Quoted in Ibrahim F. I. Shihata, *The World Bank in a Changing World* (Dordrecht: Martinus Nijhoff, 1991), 137. For a critical assessment of the World Bank's record in environmental affairs through the 1980s, see Philippe G. Le Prestre, *The World Bank and the Environmental Challenge* (Selinsgrove: Susquehanna University Press, 1989).

77. World Commission on Environment and Development, *Our Common Future* (Oxford: Oxford University Press, 1987), 8. The World Commission on Environment and Development, also known as the Brundlandt Commission, notes that sustainable development "is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with future as well as present needs." Ibid., 9. Note that the Brundlandt Commission's view of sustainability is a variant of the International Union for the Conservation of Nature and Natural Resources' (IUCN's) definition of "conservation," which is seen as "the management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations." International Union for Conservation of Nature and Natural Resources, *World Conservation Strategy: Living Resource Conservation for Sustainable Development* (N.p.: IUCN, 1980), pt. 1. According to the IUCN, this view implies an ethical imperative based in the belief that "we have not inherited the earth from our parents, we have borrowed it from our children." Ibid.

78. World Commission on Environment and Development, *Our Common Future*, 8.

79. Caldwell, *Between Two Worlds*, 177.

80. National Research Council, Committee on Science and Policy for the Coastal Ocean, *Science, Policy, and the Coast*, 43.

81. H. Opschoor and L. Reijinders, "Towards Sustainable Development Indicators," in *In Search of Indicators of Sustainable Development*, ed. Onno Kuik and Harmen Verbruggen (Dordrecht: Kluwer Academic, 1991).

82. Leanne Fernandes et al., "A Conceptual Framework for Measuring the Sustainability of the Use of the North Sea," in *Ocean Yearbook 12*, 360. Caldwell indicates that "the importance of sustainability from an ecologic perspective is in the adoption of policies and processes that protect the integrity and continuity of natural ecosystems." Caldwell, *Between Two Worlds*, 178. For Caldwell, environmental concerns should not simply constitute a component of economic decisions but, more fundamentally, the context in which decisions are made. Ibid., 184–185.

83. Boyce and Haney, *Ecosystem Management*, 2.

84. Jerry F. Franklin, "Ecosystem Management: An Overview," in *Ecosystem Management: Applications for Sustainable Forest and Wildlife Resources*, ed. Mark S. Boyce and Alan Haney (New Haven, CN: Yale University Press, 1997), 28. In this vein, John Steele asserts that "we have certainly not achieved economic sustainability in fisheries. In part, this is because we regard fishermen as the endangered species, rather than the fish." John Steele, "Regime Shifts in Marine Ecosystems," *Ecological Applications*, suppl., 8, no. 1 (1998): S35. Note that the Bureau of Land Management and the U.S. Forest Service have been criticized because, it is said, their budgets and policies tend to encourage commodity production over ecosystem health. U.S. House Committee on Natural Resources, *Ecosystem Management*, 17. "Moreover, existing law allocates receipts from commodity extraction to local communities, creating significant pressures against shifting management from output targets to restoring the ecological health of the land." Ibid.

85. Christensen et al., "The Report of the Ecological Society of America," 666.

86. Susan S. Hanna, "The New Frontier of American Fisheries Governance," *Ecological Economics* 20 (1997): 221–233. Hanna distinguishes between the "frontier expansion" approach to resource utilization and management, based in conditions of surplus, and the "commons governance" approach, based in conditions of scarcity, and contrasts the characteristics of the two.

87. Principle 10 of the 1992 Rio Declaration on Environment and Development (Rio Declaration) emphasizes the need for public participation, asserting that "[e]nvironmental issues are best handled with the participation of all concerned citizens. . . ." Public availability of information and participation in the decision-making process is also stressed. The text of the Rio Declaration is found in *International Legal Materials* 31 (1992): 876–880. See also the report of the Independent World Commission on the Oceans, *The Ocean, Our Future* (Cambridge: Cambridge University Press, 1998), 119–137.

88. The significance of education is underscored in Principle 19 of the 1972 Declaration of the United Nations Conference on the Human Environment (Stockholm Declaration), which states, in part: "Education in environmental matters . . . is essential in order to broaden the basis for enlightened opinion and responsible conduct by individuals, enterprises and communities in protecting and improving the environment." For the text of the Stockholm Declaration, see *International Legal Materials* 11 (1972): 1416–1421.

89. John Kurien notes that "[h]uman communities with a historical continuity of resource use practices come to acquire a deep knowledge base about the complex ecological systems with which they interact." John Kurien, "Traditional Ecological Knowledge and Ecosystem Sustainability: New Meaning to Asian Coastal Proverbs," *Ecological Applications*, suppl., 8, no. 1 (1998): S2. He maintains that coastal fishing communities of Asia, unlike modern industrialized fishing, developed their fishing gear and practices to suit the needs of the ecosystem. Ibid., S3.

90. In political science and law, legitimacy, based in the idea of procedural fairness, is an important concept as a factor that affects willingness to comply with rules. According to Thomas Franck, who has given much consideration to the concept, legitimacy is, in part, "the perception of those addressed by a rule or a rule-making institution that the rule or institution has come into being and operates in accordance with generally accepted principles of right process." Thomas M. Franck, *The Power of Legitimacy Among Nations* (New York: Oxford University Press, 1990), 19. Franck maintains that in order for a decision-making system to be effective, "its decisions must be arrived at discursively in accordance with what is accepted by the parties as *right process*" (emphasis in original). Thomas M. Franck, *Fairness in International Law and Institutions* (New York: Oxford University Press, 1995), 7.

91. The key roles of public participation, stakeholder involvement, outreach, and consensus building are noted in Interagency Ecosystem Management Task Force, *The Ecosystem Approach*, 1:11–21 and 2:37–46. A World Bank Study on fisheries calls upon states to involve fishermen and their associations in the formulation and implementation of management measures. This is said to be especially important in small-scale fisheries in which governments themselves cannot effectively control access to resources. It is also urged that fishermen be involved in the collection and analysis of data for stock monitoring and developing methods for limiting fishing effort and investment. World Bank, *Fish for the Future*, 8.

92. William Burke notes, for example, that the idea of large marine ecosystems disappeared in the final version of Chapter 17 of Agenda 21, largely because of the allocative implications of ecosystem concepts. He observes that some states saw the LME concept as threatening coastal state control over stocks inside the exclusive economic zone (EEZ) by possibly giving some influence to high seas fishing states, while high seas fishing states saw the concept as providing an argument for coastal state control over fisheries beyond the limits of the EEZ. William T. Burke, "UNCED and the Oceans," *Marine Policy* 17 (1993): 522.

93. Larkin, "Concepts and Issues in Marine Ecosystem Management," 156.

94. Franck, *Fairness in International Law*, 7–9. This concept refers to the consequential substantive effects of laws and rules. Note, however, the recent study by M. C. Healey and T. Hennessey, which concludes that efforts to achieve "fairness" have served to undermine effective

fisheries management and that it may be necessary "to simplify the decision making process at the cost of some degree of 'fairness.'" M. C. Healey and T. Hennessey, "The Paradox of Fairness: The Impact of Escalating Complexity on Fishery Management," *Marine Policy* 22 (1998): 117.

95. The importance of equity in the governance and management of the oceans is stressed in Independent World Commission on the Oceans, *The Ocean, Our Future*, 55–73. For an examination of the concept of equity in the context of sustainable development, see Edith Brown Weiss, "Environmental Equity and International Law," in *UNEP's New Way Forward: Environmental Law and Sustainable Development*, ed. Sun Lin (Nairobi: United Nations Environment Programme, 1995), 7–21.

96. See, for example, Edward L. Miles, "Concepts, Approaches, and Applications in Sea Use Planning and Management," *Ocean Development and International Law* 20 (1989): 213–238. He characterizes marine policy, with some exception, as the "aggregation of haphazard responses to external demands and [it] is primarily reactive." Ibid., 216. H. D. Smith also notes the reactive, as opposed to proactive, approach to ocean use management. H. D. Smith, "The Development and Management of the World Ocean," *Ocean & Coastal Management* 24 (1994): 3–16.

LME-based management will seek to utilize multispecies fisheries management (MSM), as opposed to single species management, since MSM is believed to contribute to greater ecosystem stability. The two approaches, however, have different allocative consequences, and any reallocation of resources is likely to lead to political opposition and a questioning of the fairness of the suggested policy by those whose interests suffer. On this point see Per Ove Eikeland, "Distributional Aspects of Multispecies Management: The Barents Sea Large Marine Ecosystem," *Marine Policy* 17 (1993): 256–271.

97. For an exposition on the emergence of and issues related to the precautionary principle and approach, see David Freestone and Ellen Hey, eds., *The Precautionary Principle and International Law: The Challenge of Implementation* (Boston: Kluwer Law International, 1996); Harald Hohmann, *Precautionary Legal Duties and Principles of Modern International Environmental Law* (London: Graham & Trotman/Martinus Nijhoff, 1994); and John M. Macdonald, "Appreciating the Precautionary Principle as an Ethical Evolution in Ocean Management," *Ocean Development & International Law* 26 (1995): 255–286. In regard to the precautionary principle's application to fisheries, see S. M. Garcia, "The Precautionary Principle: Its Implications in Capture Fisheries Management," *Ocean & Coastal Management* 22 (1994): 99–125.

98. In the context of the Great Lakes, discussion has ensued on the "reverse onus" concept. Those requesting allowances to discharge substances into the environment would be required to prove that those substances are not harmful to the environment or to human health. Valiante, Muldoon, and Botts, "Ecosystem Governance," 212.

99. Adam Cole-King, "Marine Conservation: A New Policy Area," *Marine Policy* 17 (1993): 177.

100. Rio Declaration, Principle 15.

101. Agenda 21, ch. 17, paras. 17.1, 17.5, and 17.22.

102. The full text of the agreement is found in *International Legal Materials* 34 (1995): 1547–1580. See art. 6(1). The same wording is found in the FAO *Code of Conduct for Responsible Fisheries*, art. 7.5.

103. *Global Programme of Action*, para. 22(i).

104. 1996 Protocol to the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, art. 3(1). The text of the 1996 Protocol is found in *International Legal Materials* 36 (1997): 1–30.

105. On this point see Macdonald, "Appreciating the Precautionary Principle," who maintains that the concept of precaution is heavily value laden and value driven.

106. Paul K. Dayton, "Reversal of the Burden of Proof in Fisheries Management," *Science* 279 (1998): 821–822. On Type I and Type II errors, see also Kai N. Lee, *Compass and Gyroscope: Integrating Science and Politics for the Environment* (Washington, DC: Island Press, 1993), 74–76.

107. See Robert Stavins and Bradley Whitehead, "Market-Based Environmental Policies," in *Thinking Ecologically: The Next Generation of Environmental Policy*, ed. Marian R. Chertow and Daniel C. Esty (New Haven, CN: Yale University Press, 1997), 105–117.

108. See Philippe Sands, "Liability for Environmental Damage," in *UNEP's New Way Forward*, 73–93.

109. Gregory Rose and Richard Tarasofsky note that financial liability regimes serve several functions, encouraging the use of pollution prevention strategies by providing a disincentive to pollute, facilitating cleanup by requiring polluters to make reparations for damages, and ensuring that pollution-caused losses are paid by those responsible for the damage. Gregory Rose and Richard Tarasofsky, "Liability for Environmental Damage in International and Transboundary Settings," in *Protecting the Gulf of Aqaba: A Regional Environmental Challenge*, ed. Deborah Sandler et al. (Washington, DC: Environmental Law Institute, 1993), 419–459.

110. Robert Costanza et al., "The Value of the World's Ecosystem Services and Natural Capital," *Nature* 387 (1997): 253–260 and Richard Ambrose, "Ecological Value in Restored Coastal Ecosystems," in *Saving the Seas*, 67–86. The importance of valuation of ecosystem services is noted in Independent World Commission on the Oceans, *The Ocean, Our Future*, 97–116. On the evolving consideration of ecosystem services in the law of the United States, see James Salzman, "Valuing Ecosystem Services," *Ecology Law Quarterly* 24 (1997): 887–903.

111. Note, for example, the incorporation of the "polluter pays" concept in the 1992 Rio Declaration, Principle 16, and in the 1996 Protocol to the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter. Among the general obligations that states party to the Protocol accept is that "the polluter should, in principle, bear the cost of pollution, [and] each Contracting Party shall endeavour to promote practices whereby those it has authorized to engage in dumping or incineration at sea bear the cost of meeting the pollution prevention and control requirements for the authorized activities. . . ." 1996 Protocol, art. 3(2).

112. Note that Agenda 21 calls upon states to develop economic incentives and to encourage internalization of environmental costs. In this context, Agenda 21 encourages the use of the "polluter pays" principle (ch. 17, para. 17.22(d)). The use of the "polluter pays" principle has been incorporated in the law of a number of developing as well as developed states. See Peigi Wilson et al., "Emerging Trends in National Environmental Legislation in Developing Countries," in *UNEP's New Way Forward*, 198–200.

113. Lee, *Compass and Gyroscope*, 53.

114. Carl Walters, "Challenges in Adaptive Management of Riparian and Coastal Ecosystems," *Conservation Ecology* 1, no. 2 (1997): 1 (Available on the World Wide Web at http://www.consecol.org/vol1/iss2/art1/). For case studies involving the use of adaptive management approaches, see Timothy M. Hennessey, "Governance and Adaptive Management for Estuarine Ecosystems: The Case of Chesapeake Bay," *Coastal Management* 22 (1994): 119–145 and Joy B. Zedler, "Adaptive Management of Coastal Ecosystems Designed to Support Endangered Species," *Ecology Law Quarterly* 24 (1997): 735–743.

115. Writing of active adaptive management, Ray Hilborn notes that given uncertainty in fish productivity, long-term yields can usually be maximized by greatly reducing fishing for some period of time, thus allowing stocks to rebuild. Ray Hilborn, "Living with Uncertainty in Resource Management," *North American Journal of Fisheries Management* 7 (1987): 1–5. But, as he notes, such a policy results in reduced income to fishermen, and "[f]ishermen will not readily accept a short-term reduction in catch for possible increases in long-term catch, if they are struggling to meet mortgage payments." Ibid., 3.

116. In his consideration of coastal and ocean management, Ehler notes, for example, that too much time is spent on producing a "plan" that is frozen in time with a lack of adequate resources available for implementation and monitoring. "Coastal management must be a continuous process that should be constantly monitoring progress and feeding back information on performance to adjust management strategies to changing conditions." Ehler, "Integrated Coastal Ocean Space Management," 180. J. R. Schubel, J. Gulnick, and A. Conversi also stress the importance of process as opposed to a particular substantive plan for coastal management. See

J. R. Schubel, J. Gulnick, and A. Conversi, "Integrated Coastal Management (ICM)—An Idea Whose Time Has Come," in *Coastal Ocean Space Utilization III*, 253–261.

117. For consideration of different perspectives of effectiveness of international regimes, see John Vogler, *The Global Commons: A Regime Analysis* (New York: John Wiley & Sons, 1995), 152-182; Arild Underdal, "The Concept of Regime 'Effectiveness,'" *Cooperation and Conflict* 27 (1992): 227–240; and Young, "The Effectiveness of International Governance Systems," 1–27.

118. This characterization of effectiveness is closer to what Peterson terms "result effectiveness" rather than "compliance effectiveness." The former is associated with real environmental improvement, while the latter refers to the fact that actors obey regime prescriptions. Peterson, "International Organizations," 115–151.

119. This point is noted by Oran Young, "Rights, Rules, and Resources in World Affairs," in *Global Governance*, 12–15. On causation, see also Olav Schram Stokke, "Regimes as Governing Systems," in ibid., 27–63, particularly, pp. 33–35 and 43–46.

120. See, for example, Boyce and Haney, *Ecosystem Management*; D. Scott Slocombe, "Implementing Ecosystem-based Management," *BioScience* 43 (1993): 612–622; Interagency Ecosystem Management Task Force, *The Ecosystem Approach*; and Clark, *Coastal Zone Management Handbook*.

121. Public Law 91-190, *U.S. Statutes at Large* 83 (1970): 852–855. This legislation requires explicit consideration of environmental consequences and alternative courses of action in regard to "major Federal actions significantly affecting the quality of the human environment" (§ 102(C)).

122. It has been noted that in the minds of its congressional framers, NEPA was needed to help overcome "the disjointed and inconsistent manner in which federal agencies made decisions affecting the human environment." Richard N. L. Andrews, *Environmental Policy and Administrative Change: Implementation of the National Environmental Policy Act* (Lexington, MA: Lexington Books, 1976), 1. Caldwell notes that a basic aspect of NEPA is its integrative character, which cuts across a wide range of public issues. Lynton Caldwell, "Beyond NEPA: Future Significance of the National Environmental Policy Act," *Harvard Environmental Law Review* 22 (1998): 205. On the use of the EIS and its political as well as legal effects in one particular setting, see Lawrence Juda, "Ocean Policy, Multi-use Management, and the Cumulative Impact of Piecemeal Change: The Case of the United States Outer Continental Shelf," *Ocean Development and International Law* 24 (1993): 355–376.

123. On the widespread use of environmental assessment and analysis, see Alan Gilpin, *Environmental Impact Assessment (EIA): Cutting Edge for the Twenty-First Century* (Cambridge: Cambridge University Press, 1995) and Asit K. Biswas and S. B. C. Agarwal, eds., *Environmental Impact Assessment for Developing Countries* (Oxford: Butterworth-Heinemann, 1992).

124. The text of this treaty is found in *International Legal Materials* 30 (1991): 800–819. See the preamble and arts. 1 and 2.

125. 1991 Protocol on Environmental Protection to the Antarctic Treaty, arts. 3 and 8 and Annex I. The text of the 1991 Protocol is found in *International Legal Materials* 30 (1991): 1455–1486.

126. 1991 Protocol on Environmental Protection, Annex I, art. 3(3) and (6).

127. Ibid., Annex I, art. 4.

128. On the impacts of fisheries on marine ecosystems, for example, see Goñi, "Ecosystem Effects of Marine Fisheries."

129. See, for example, National Advisory Committee on Oceans and Atmosphere, *A Report to the President and the Congress: Eighth Annual Report* (Washington, DC: The Committee, 1979).

130. Stella Maris Vallejo, "New Structures for Decision-making in Integrated Ocean Policy," in *Ocean Governance: Sustainable Development of the Seas*, ed. Peter Bautista Payoyo (Tokyo: United Nations University Press, 1994), 71–94. On the French government's experiment with a "Ministry of the Sea," see Marie-Christine Aquarone, "French Marine Policy in the 1970s and 1980s," *Ocean Development and International Law* 19 (1988): 267–285.

131. National Research Council, Committee on Marine Area Governance and Management, *Striking a Balance*, 87–102.

132. Ibid., 4. Konrad von Moltke sees this principle, what he terms the principle of subsidiarity, as central to environmental management, recognizing that action is needed at different jurisdictional levels and assigning priority to the lowest level of action consistent with effectiveness. Konrad von Moltke, "Institutional Interactions: The Structure of Regimes for Trade and Environment," in *Global Governance*, 266–268.

133. S. 1213, 105th Cong., 1st sess. See also U.S. Senate Committee on Commerce, Science, and Transportation, *Oceans Act of 1997*, 105th Cong., 1st sess., 1997, S. Rept. 105–151.

134. See, for example, the Outer Continental Shelf Lands Act Amendments of 1978, Public Law 95-372, *U.S. Statutes at Large* 92 (1978): 629–698, which mandates consultations between the Department of the Interior, which administers the federal offshore oil leasing program, and coastal state governments, as well as with other federal government agencies. On how this development contributes to more holistic management of offshore areas, see Juda, "Ocean Policy, Multi-use Management."

135. United Nations, *Oceans and the Law of the Sea*, paras. 384–386.

136. A classic statement of this problem is found in Garrett Hardin, "The Tragedy of the Commons," *Science* 162 (1968): 1243–1248.

137. Fikret Berkes et al., "The Benefits of the Commons," *Nature* 340 (1989): 91–93 and Fikret Berkes, Peter George, and Richard J. Preston, "Co-management: The Evolution in Theory and Practice of the Joint Administration of Living Resources," *Alternatives* 18, no. 2 (1991): 12–18.

138. National Round Table on the Environment and the Economy, *Sustainable Strategies for Oceans: A Co-Management Guide* (Ottawa: The Round Table, 1998), xvi.

139. Ibid.

140. Note that there is increasing attention paid to and knowledge of traditional, local, and community-level institutions and arrangements for the management of common property resources. For an introduction to this subject and a number of case studies from around the world, see Fikret Berkes, ed., *Common Property Resources: Ecology and Community-Based Sustainable Development* (London: Belhaven Press, 1989). See also the references in note 15 above.

141. See, for example, Steiner Andresen, "Science and Politics in the International Management of Whales," *Marine Policy* 13 (1989): 99–117; M. J. Peterson, "International Fisheries Management," in *Institutions for the Earth: Sources of Effective International Environmental Protection*, ed. Peter M. Haas, Robert O. Keohane, and Marc A. Levy (Cambridge, MA: MIT Press, 1993), 267–272; and National Research Council, Committee on Science and Policy for the Coastal Ocean, *Science, Policy, and the Coast*.

142. See, for example, Healey and Hennessey, "The Paradox of Fairness," 109–118.

143. See note 62 above.

144. Boesch and Macke, "Bridging the Gap," 33–48.

145. James Bailey and Laurel Muehlhausen, "Marine Boundary Enforcement from Space: Satellite Technology and Fisheries Jurisdiction," in *The Peaceful Management of Transboundary Resources*, ed. Gerald H. Blake et al. (London: Graham & Trotman/Martinus Nijhoff, 1995), 413–425.

146. For an introduction to GIS and some of its capabilities, see Russell G. Congalton and Kass Green, "The ABCs of GIS: An Introduction to Geographic Information Systems," in *Wetland and Environmental Applications of GIS*, ed. John G. Lyon and Jack McCarthy (Boca Raton, FL: CRC Press, 1995), 9–24.

147. Ibid. On the potential uses and limitations of the use of GIS in coastal management, see Clark, *Coastal Zone Management Handbook*, 315–318.

148. A concise introduction to the use of economic incentives to achieve environmental goals is found in National Research Council, Committee on Wastewater Management for Coastal Urban Areas, *Managing Wastewater*, 404–413. See also Global Environment Facility, *Valuing the Global Environment: Actions & Investments for a 21st Century* (Washington, DC: GEF, 1998), 43–65.

149. For a critical examination of attempts by the U.S. Environmental Protection Agency to control pollution through industry self-regulation as an alternative to traditional rules, see Rena I. Steinzor, "Reinventing Environmental Regulation: The Dangerous Journey from Command to Self-Control," *Harvard Environmental Law Review* 22 (1998): 103–203.

150. See the Negotiated Rulemaking Act of 1990, Public Law 101-648, *U.S. Statutes at Large* 104 (1990): 4969–4977.

151. On negotiated rule making in practice, see Cary Coglianese, "Assessing Consensus: The Promise and Performance of Negotiated Rulemaking," *Duke Law Journal* 46 (1997): 1255–1349 and Siobhan Mee, "Negotiated Rulemaking and Combined Sewer Overflows (CSOs): Consensus Saves Ossification?" *Boston College Environmental Affairs Law Review* 25 (1997): 213–245.