The Use of Science in Marine Resource Management: Can We Reconcile the Paradigms of Science, Law, and Policy?

by

Professor Richard Hildreth
University of Oregon School of Law

Professor M. Casey Jarman
University of Hawai'i School of Law

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The Use of Science in Marine Resource Management: Can We Reconcile the Paradigms of Science, Law, and Policy?*

Professor Richard Hildreth, University of Oregon School of Law (541-346-3866)
Professor M. Casey Jarman, University of Hawai'i School of Law (808-956-7489)

Abstract - **To make sound marine resource management decisions, agency personnel needs and the law require reliance on accurate and timely scientific data. However, agencies face a multitude of difficult decisions regarding use of scientific data, such as what and how much data to use, what weight to give the data, how to determine when they have enough data, and how to proceed with incomplete data. The answers to those questions can and do affect the policy decisions of agencies, which in turn affect the economic situations of people who make a livelihood from harvesting the ocean's resources and the ability of a host of marine creatures to survive. The answers to those questions often differ depending upon whether you are viewing them as a scientist, a policymaker, or a court. This paper explores the differing paradigms of science, law, and policy in marine resource management decision making and looks at how they can be reconciled to improve ocean policy decisions.**

I. INTRODUCTION

In the United States, the president, Congress, federal and state courts, state governors, state legislatures, coastal local governments, ports, and federal and state marine, environmental, and resource agencies all play important roles in establishing and implementing marine policy. As marine resources have become more scarce and competition for these resources has increased, the demand for scientific knowledge to help resolve these conflicts is on the rise. Congress and state legislatures are requiring more and more that resource allocation decisions be based upon "the best scientific evidence available" or similar standards. Even without such specific standards, marine resource managers regularly use scientific information when making decisions. The roles science plays in marine policymaking vary tremendously both with the particular issue and with the institution making the policy decisions (Jarman et al. 1994).

For purposes of this paper, *policy* is defined as public sector articulation of general principles for and specific decisions regarding the conservation and development of both privately and publicly owned marine resources (Hildreth 1994, 164). *Science* is defined broadly to include the methodologies of both the natural and the social sciences (NRC Committee to Review the Outer 1992). Using a dichotomy developed by Tuohy (1993, 115) and based on prior work by Jasanoff, science includes "research science" subjected to the traditional peer review and other standards of scientific research, as well as "regulatory science" performed principally to comply with legal requirements such as statutory timetables, with the resulting studies often being unpublished, thereby becoming part of the large body of gray literature. We

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suggest a third category, "agency research science," which is either conducted or funded by the regulatory agency to develop data to assist in decision making. Agency research science goes through the traditional peer review process, but the data and conclusions are available to the decision makers before peer review and publication have occurred.

More succinctly, "[s]cience is a method, generally accepted at the core although disputed at the margins, designed to arrive at what is right, or true, or correct. But science cannot tell us what is better" (Huffman 1991, 1098). What is "better" is debated and decided in policymaking processes, including those focused on marine policy:

> Conclusions from scientific research do not, however exact and reliable they may be, in themselves have any clear-cut policy "implications." . . . Research can help clarify possible criteria and the dilemmas and trade-offs involved, and it can help compute the score of alternative options on whatever criteria are adopted. But the basic question of what shall be considered "good" or "bad" cannot be answered by science. [Underdal 1989, 257].

While the goal of making marine policymaking more scientific deserves support, there are limits to how scientific marine policymaking can become because the roles of scientists and policymakers are different. In addition, substantive and procedural legal rules imposed by legislatures and courts impact the role of science in agency decision making. Both scientists and marine policymakers need to bear these facts in mind as they proceed with the important task of improving the management of national and global marine resources.

II. THE DISTINCTIONS BETWEEN SCIENCE AND VALUES IN POLICYMAKING

At bottom, most marine policy decisions are resource allocation decisions, either through direct allocation of publicly owned or controlled resources, such as seabed minerals or fish, or through indirect allocation through regulation of private resource utilization. However, it hardly makes sense to proceed with such "allocative or distributive choices without first factoring in the contributions of the scientific community" (Young 1989, 15). But it is unwise to allow science alone to drive marine policy decisions:

> Science, when it is accepted as a justification for policy, becomes a tool for circumvention of the democratic process. . . . The tendency to justify policy decisions on the basis of science is pervasive in the U.S. regulatory system. . . . The challenge is to preserve the objectivity of the scientific process while avoiding scientific domination of the policy-making process. [Huffman 1991, 1101, 1104].

In reality, marine policy decisions are not made solely on the input of scientists. They also involve the personal values and beliefs of those making the decision and those affected by the decision. A principal goal of any marine policymaking process that purports to be scientifically based should be to maintain as clear a separation of science from values as possible. "The distinction . . . between science and values . . . is fundamentally important to legitimate public decision making" (Huffman 1991, 1097). The science/values dichotomy is further complicated because science can be value-laden in itself. For example, the act of

deciding which scientific questions to ask involves value choices. Non-peer-reviewed scientific studies are more likely to reflect the biases/values of the scientific researcher than peer-reviewed studies.

The separation of science and values presents a significant challenge to decision makers. Some provisions of the U.S. Endangered Species Act demonstrate a clear attempt by Congress to rely at times solely on scientific truth (such as listing endangered species "solely on the basis of the best scientific and commercial data available" [16 U.S.C. § 1533(b)(1)(A)]) while other times permitting other values to modify the science-based decision making (such as requiring economic factors be taken into account in designating critical habitat [16 U.S.C. § 1533(f)]). But even if we can be sure that the scientific data used to determine whether a species should be listed as "endangered" are free from bias, questions remain as to what and how much data to use to make that determination, what weight to give the data, how to determine when we have enough data, and how to proceed with incomplete data. These questions are inherently value laden.

III. ACHIEVING TIMELY SCIENTIFIC INPUT

A significant challenge facing agencies that rely on science for informed decision making is timeliness of the scientific input. A National Academy of Sciences report highlights the problem:

> Although . . . how much science is enough, can be defined for scientific purposes . . . decisions must be related to scientific uncertainty in assessing risks and in making predictions. How much uncertainty is acceptable is related to the state of the science, the perceived value of the resource or activity being considered, the nature of the risk, and public concern. The issue is how to balance the need to reduce uncertainty against the increased costs in time and money of doing the science required. [NRC Committee to Review the Outer 1991, 8-9].

What approach should agencies take when the scientific information needed to make informed decisions is either insufficient or incomplete? Four norms of environmentally responsible conduct have emerged from the 1992 UN Conference on Environment and Development. They emphasize sustainability, biodiversity, the polluter pays principle, and a precautionary approach to resource use. Public ownership of most marine resources supports a thoughtful, go-slow, or precautionary approach to marine resource use that reflects the latest scientific thinking. Even so, the timetables for marine policy decisions do not always mesh well with those of scientific research, resulting in marine policy decisions without significant scientific input. The rates and processes of scientific discovery are not always predictable, so the amounts of time and money required to generate information relevant to a pending marine policy decision cannot always be known in advance. In addition, policymakers sometimes ignore preliminary conclusions resulting from agency research science even though that information directly addresses the problem they are confronted with. For example, National Marine Fisheries Service (NMFS) staff, in making recommendations for lobster harvest in the Northwestern Hawaiian Islands, essentially refused to consider the results of a study they had funded that concluded that lobsters are an important part of the endangered monk seals' diet because the study's findings were only preliminary (Greenpeace Foundation 2000b).

A related issue involves delineating the roles of scientists in policymaking. Marine resource allocation decisions could benefit from scientists becoming more engaged in the policymaking process. Despite the legitimate concern for maintaining at least a conceptual separation between facts and values, in the end, for the increased use of science in marine policymaking, scientists themselves need to accept more temporary or part-time involvement with the policymaking bodies. In other words, natural and social scientists must be willing to serve on boards and commissions and participate in other forums that make marine policy decisions. Nonscientists such as attorneys (Symposium 1992; Loevinger 1992) and politicians are willing to make policy decisions and exercise their judgment and influence based on whatever information is available; scientists should be willing to contribute their judgment to marine policy decisions, even on issues where more research clearly is needed. In the end there are no clear solutions to the dilemmas faced by scientists seeking to influence marine policy and operating at the interface between scientific research and political decision making. At a minimum, scientists need to consider and communicate more carefully and understandably the policy implications of their work, and policymakers need to recognize the need for a better understanding of the scientific basis of their policy prescriptions (Rogers 1991). The treaties and legislation implementing marine resources management policies discussed below illustrate these considerations.

IV. SCIENCE AND MARINE RESOURCES LAW

In reviewing the scientific underpinnings of recent marine resource management treaties and legislation, several trends are discernible: (1) the introduction of precautionary and adaptive approaches to decision making, (2) greater internalization of the externalities of marine resource exploitation, and (3) increasing respect for biodiversity preservation. Marine resource management decisions have become more holistic and sensitive to ecosystem context through recognition of the habitat and food web impacts of human marine resource use (Greenpeace 2000; Greenpeace Foundation 2000a, 2000b). Nowhere are these trends more apparent than in the design of the 1996 U.S. Sustainable Fisheries Act and its implementation together with the U.S. Marine Mammal, Endangered Species, and National Environmental Policy Acts. These trends are less obvious but still discernible in the administration of other U.S. laws relevant to marine resource use such as the Clean Water, Ocean Dumping, Coastal Zone Management, and Marine Sanctuaries Acts. The above trends are not so discernible in the U.S. management regimes for outer continental shelf (OCS) oil, gas, and minerals and for deep seabed minerals.

The 1996 Sustainable Fisheries Act (SFA) (16 U.S.C. §§ 1801 et seq.) requires the U.S. regional fishery management councils to not allow fishing above a species' maximum sustainable yield, to develop plans to rebuild the species that are below their long-term sustainable yield, to minimize fisheries bycatch, to identify essential fish habitats (EFHs) and take measures to protect them, and to determine the effects of fishing on the environment (Wallace and Fletcher 2000). In addition, the Act mandates a study of the extent to which ecosystem principles are used in U.S. fisheries management and how such principles could be further implemented (Macpherson 2001; NMFS Ecosytem 1999). To achieve these management policies, section 1851(a)(2) of the SFA requires that "best scientific information available" be used, words that are not otherwise defined in the Act. Regulations implementing the SFA state that such information includes the "peer-reviewed literature, data reports and 'gray' literature, data files of government resource agencies, and any other sources of quality information" (50

C.F.R. § 600.815(a)(2)(i)(B)). Similar information mandates are included with specific management policies throughout the Act and its implementing regulations.

Other SFA information mandates are more subtle, such as section 1853(a)(11)'s mandate that fish bycatch be minimized "to the extent practicable," and section 1851's mandate that fisheries management goals such as efficiency, safety, and minimized adverse community impacts (Blue Water Fisherman's Ass'n 2000) be achieved where "practicable." The information produced by council and agency staff and advisory committees pursuant to these mandates are examples of "regulatory science" and "agency research science." Given the relatively modest personnel and research budgets of the regional councils and NMFS, the vast majority of fisheries management decisions reflected in council fishery management plans (FMPs) approved and implemented by the Commerce Department are based on this kind of science (Grimes 2001). Periodically, specific questions of management policy may be mandated by Congress for investigation with timetables and budget support that result in scientific analyses which meet standards closer to those used in traditional peer review processes. Examples would be the National Research Council report on the use of individual fishing quotas as a fisheries management technique (NRC Committee to Review Individual 1999) and the National Academy of Sciences review of a NMFS endangered Steller sea lion biological opinion requested in 2000 under Public Law 106-554 as part of a $43 million study of the impacts of commercial fishing on Steller sea lions.

Beyond the above requirements, data and analyses—predominantly environmental, social, and economic—are also required in support of fisheries management decisions under the Small Business Act, the Regulatory Flexibility Act (Blue Water Fisherman's Ass'n 2000), the National Environmental Policy Act (American Oceans Campaign 2000; Conservation Law Foundation 2001), and presidential Executive Order 12866: Regulatory Planning and Review.

NMFS' obligation to carry out regulatory science to meet its responsibilities for protected marine species under the Marine Mammal Protection Act (MMPA) (16 U.S.C. §§ 1361 et seq.) and the Endangered Species Act (ESA) (16 U.S.C. §§ 1531 et seq.) further illustrates the challenges facing marine resource agencies in integrating science into policymaking. Under the ESA, federal agencies must consult with NMFS to ensure that any actions authorized, funded, or carried out by them are "not likely to jeopardize the continued existence" of any endangered or threatened marine species (16 U.S.C. § 1536). In approving the otherwise illegal unintentional takings of listed species by nonfederal parties, NMFS must determine that "the taking will not appreciably reduce the likelihood of the survival and the recovery of the species in the wild" (16 U.S.C. § 1539). These mandates apply to significant injuries to habitat as well as to the species themselves. The fisheries management challenges created by these mandates are illustrated by the impacts of ground fishing off Alaska and Hawaii on endangered Steller sea lions and monk seals (which also are protected by the MMPA) and the impacts of longline fishing in the Pacific and shrimp fishing in the Gulf of Mexico on endangered and threatened sea turtles. Federal courts have issued injunctions restricting those fishing activities when NMFS has been judged not to have met those statutory responsibilities adequately (Greenpeace 2000; Greenpeace Foundation 2000a, 2000b; Louisiana 1988). Congress has responded with revised fisheries management directives and significant funding for both compensation to affected communities and regulatory and peer-reviewed research science focused on those disputes. A recent critique of U.S. fisheries management finds that those forms of congressional intervention sometimes unnecessarily consume scarce research funds in disputes where the adequacy and accuracy of research are not the primary bone of contention (H. John Heinz III Center 2000, 136, 141).

Administration of the MMPA is centered on restoration and maintenance of all marine mammal species at their optimum sustainable population (OSP), which is defined as "the number of animals which will result in the maximum productivity of the . . . species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem . . ." (16 U.S.C. § 1362(18)). When data are insufficient to determine a species' OSP or the potential impacts of ocean uses such as fishing on a marine mammal species, federal courts again have restricted fishing to avoid possible risks to protected marine mammals (Kokechik Fishermen's Ass'n 1988). In response, Congress has revised the standards applicable to the unintended taking of marine mammals in fishing operations. Significant regulatory and agency research science has been necessary to implement those standards and prepare the marine mammal take reduction plans required by section 1387 of the Act (Bache 2001). Difficult regulatory science issues also have arisen in connection with the potential impacts on marine mammals of undersea acoustic research (Gardner 1999) and the Makah Tribe's hunting of gray whales (Metcalf 2000).

Marine pollution and nonliving marine resources are managed under statutes that also emphasize regulatory rather than peer-reviewed research science. The information mandates of the Outer Continental Shelf Lands Act (OCSLA) could be the subject of renewed attention under President Bush's energy supply initiatives. Mismanagement of the OCSLA's information processes in connection with possible offshore oil and gas development near North Carolina's Outer Banks resulted in a recent U.S. Supreme Court decision entitling various oil companies to the return of $158 million that they had bid for seabed leases in that area (Mobil Oil 2000).

Generally under the OCSLA, assessment and management of the impacts of OCS oil and gas development on living marine resources incorporate the MMPA and ESA processes described above, with potential conflicts with fishing handled on a relatively loose and ad hoc basis by the Secretary of the Interior under the OCSLA and the National Environmental Policy Act (Tribal Village of Akutan 1988; Massachusetts 1979). Here and elsewhere under the OCSLA, the precautionary approaches to scientific uncertainty now being built into U.S. living marine resources management could be expected to play a much greater role than they have in the past.

As discussed above, most uses of U.S. ocean waters are managed under single sector statutes such as the SFA and the OCSLA. Less than 1 percent of U.S. ocean waters are managed on an integrated, comprehensive multiple-use basis as marine protected areas (MPAs) under the Marine Sanctuaries Act. Under that Act, a regulatory science approach is used to carry out multiple-use management within the thirteen sanctuaries currently designated (Burger and Leonard 2000; Personal Watercraft 1995). There seems to be a consensus among marine scientists that the MPA concept including "no take zones" can be used to prevent overfishing, prevent damage to sensitive habitat areas from certain types of fishing gear, and support ecosystem-based approaches to marine resource management (NRC Committee on Evaluation 2000). To implement adaptive management, MPA managers can organize data gathering, analysis, and monitoring on a consistent basis over time.

According to a recent report of the Pew Oceans Commission (2001), adaptive management involves periodic reevaluation and adjustment of the management response based on careful observation of outcomes. An example is in-season fisheries closures based on accumulating catch statistics. Monitoring outcomes should be linked legally to adaptive management responses by statute, agency regulation, or permit conditions as appropriate. Adaptive management also depends heavily on careful comparison of monitoring outcomes to scientific predictions. But ecosystem science is both relatively new and complex:

> The goal of sustainability is obviously desirable. . . . That it may more easily be applied to renewable rather than stock resources such as minerals is self-evident. Management for sustained yields of single renewable resources such as fisheries or forestry—as opposed to a more general notion of sustainable development—found its way into the practice of renewable resource use much earlier. If sustainability is extended from a single resource to the ecosystem(s) on which that resource relies, great difficulties are introduced. Ecosystem functions and components may change at different rates and in different directions while they are also influenced by forces outside the system. Simultaneous control or mastery over all of them is usually not attainable for physical, social, or economic reasons. [Bardach 1991, 71].

Due to these scientific uncertainties, ecosystem-based management poses special challenges for the judicial review process discussed in the next section (In re the Water Use Permit Applications 2000). Many MPA management decisions will most likely use the precautionary approach discussed further below.

With all of these considerations in mind, the Western Pacific (64 Fed. Reg. 32,210), North Pacific (65 Fed. Reg. 39,342), South Atlantic, and Pacific fishery management councils have developed proposals for incorporating MPAs into FMPs. In 2000 the Gulf of Mexico council designated two such areas to prevent overfishing, and the North Pacific council for several years has designated relatively small six- to twenty-mile-diameter MPAs surrounding endangered Steller sea lion rookeries. Similarly, NMFS, in 2001, closed federal waters off the mouth of Delaware Bay to horseshoe crab fishing in order to prevent overfishing and provide declining migratory shorebirds with sufficient crab eggs to feed on. Much larger MPAs have been included in the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve created by President Clinton in January 2001, pending designation of the reserve as a national marine sanctuary by the Secretary of Commerce; in the Palmyra Atoll National Wildlife Refuge; and in the Oculina Bank Coral Habitat area off Florida's east coast. These federal initiatives represent the most significant use of the MPA concept outside the sanctuary system. Within the Channel Islands and Florida Keys national marine sanctuaries, special protected areas to control fishing are also being considered. Pending legislation to reauthorize the SFA would require the regional councils to prepare fisheries ecosystem plans (FEPs) for each major ecosystem within their jurisdiction (H.R. 2570, 107th Cong., 1st Sess. (2001)). All FMPs would be required to be consistent with the relevant FEP. These uses of MPAs are consistent with a precautionary approach to scientific uncertainty in the management of fisheries.

V. JUDICIAL REVIEW OF REGULATORY SCIENCE

Marine resource management decisions with potentially significant economic or environmental consequences frequently are challenged in court under the laws mentioned in the previous section. In reviewing such agency decisions, courts base their decision on the record that was developed by the agency in making its decision. Under administrative law doctrine, courts will typically defer to agency decisions that have a scientific basis unless they find the agency interpretation to be arbitrary and capricious (Administrative Procedures Act, 5 U.S.C. § 706; Massachusetts *ex rel*. 1999). Under the arbitrary and capricious standard, courts generally

require agencies to be comprehensive in their choice of scientific studies used to reach a decision (Scenic Hudson 1965). In developing its record, an agency might rely on research science, regulatory science, and/or agency research science. It might also choose to ignore scientific studies that might otherwise be relevant to the decision making. For example, an agency that has available preliminary results of agency research study might refuse to consider the data because of the preliminary nature of the conclusions (Greenpeace Foundation 2000b). It may also overlook studies that are repetitive of ones they are relying upon or that it believes are outdated. Or it will refuse to act because of its belief that it lacks sufficient information to make an informed judgment (Greenpeace Foundation 2000b). Because of the courts' bias towards comprehensiveness, an agency that ignores relevant research must put into the record its reasons for doing so or risk having its decision overturned by the court (Motor Vehicle Manufacturers Ass'n 1983). Even if the agency justifies its decision, the court could choose to reject the explanation and require the agency to re-decide, taking the ignored research into account (Greenpeace Foundation 2000b).

Careful attention to judicial interpretation of statutory mandates is important in the agency's handling of science. For example, in an important interpretation of the SFA's restrictions on overfishing, a federal appeals court invalidated a NMFS summer flounder quota. The court found that the quota was insufficiently protective of the species' viability, despite evidence of significant economic effects of further reductions in the quota (Natural Resources Defense Council 2000). Although the SFA requires the agency to minimize adverse economic effects, the court held that the Act's provision directed at overfishing took priority. Similarly, an FMP which utilizes regulatory science to justify significant economic impacts in order to reduce bycatch is likely to receive judicial support (A.M.L. International 2000).

Litigation in Hawai'i over the impact of the lobster and bottom fisheries on the endangered Hawaiian monk seal demonstrates that science that is sufficient in one context may not be in another (Greenpeace Foundation 2000b). In that case, Judge King ruled that NMFS violated section 7 of the ESA when it, among other things, failed to evaluate the impact of the Crustacean Fishery Management Plan on prey availability for the monk seals. NMFS had declined to use preliminary data on the importance of lobsters in the diet of the seals: "NMFS cannot speculate that no jeopardy to monk seals or adverse modification of their critical habitat will occur because it lacks enough information regarding the impact of the fishery on seals. . . . Such a conclusion is arbitrary and capricious." However, Judge King found that the preliminary nature of the data did not support a claim for an illegal taking of monk seals by the lobster fishery under section 9 of the ESA.

The scientific information challenges faced in U.S. fisheries management are perhaps best illustrated by the 1996 SFA's mandate that all FMPs designate as EFH "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" as defined in section 1802(10). Given the limitations of existing habitat data and the relatively short statutory timetable for making EFH designations, the regional fishery management councils, with the approval of NMFS and the Department of Commerce, have tended to rely on broad generic habitat designations, which have been challenged both successfully (American Oceans Campaign 2000) and unsuccessfully (Conservation Law Foundation 2001) by environmental groups for their environmental inadequacy, and by commercial fishing groups fearing adverse habitat impacts (Cape Cod Commercial Hook Fishermen's Ass'n 1998). So far, in these EFH cases, the courts have accepted the use of quite primitive "regulatory sciences" to meet tight statutory deadlines. The overfishing cases discussed in the next section suggest that the courts

are less likely to be so deferential as council, NMFS, and Commerce Department experience with implementation of the SFA's EFH provisions grows. Pending legislation to reauthorize the SFA would require the use of the precautionary approach discussed in the next section in future EFH administration (H.R. 2570, 107th Cong., 1st Sess. (2001)).

Because marine resource agencies simultaneously implement a number of laws and, as illustrated above, the legal burdens under each law can differ, agencies must continually be aware of the statutory context in which their decisions to use or reject science are being made. To deal with situations of lack of adequate scientific data and to curb the chances that their decisions will be overturned by a court, many agencies are adopting the precautionary approach discussed in the next section.

VI. THE PRECAUTIONARY APPROACH AS A RESPONSE TO SCIENTIFIC UNCERTAINTY IN MARINE RESOURCES MANAGEMENT

As formulated in the 1995 UN convention for the management of straddling and highly migratory fish stocks (which the United States has ratified, but which is not yet in force), the precautionary approach instructs nations to "be more cautious when information is uncertain, unreliable or inadequate. The absence of adequate scientific information shall not be used as a reason for postponing or failing to take conservation and management measures" (Article 6.2). The precautionary approach is included in other important international agreements regarding marine resource management that the United States has signed, including the 1995 FAO Code of Conduct for Responsible Fisheries and the 1996 Protocol to the London Dumping Convention. For purposes of this paper, the precautionary approach switches the burden of scientific proof for initiating policy responses from those who want to restrict a potentially harmful activity to those who want to initiate or continue the activity. In the many resource management situations where the best available scientific information includes significant uncertainties, the precautionary approach steers decisions toward regulatory disapproval pending resolution of important uncertainties. Thus, whether to adopt a precautionary approach to decision making is in itself a key policy decision for legislators and agency policymaking staff.

NMFS regulations and guidelines implementing the SFA tend to authorize a precautionary approach without mandating it. Specific NMFS and fishery management council decisions utilizing a precautionary approach to avoid overfishing are receiving judicial support (Southeastern Fisheries Ass'n 1991), while those that pose significant risks of overfishing are being judicially invalidated (A.M.L. International 2000; Natural Resources Defense Council 2000). Supported by most (NMFS Ecosystem 1999; NRC Committee on Ecosystem 1999; H. John Heinz III Center 2000; Stanford 2001) but not all recent studies and academic commentary on U.S. fisheries management as well as NMFS guidance documents, the precautionary approach can be expected to spread from overfishing (NMFS 1998) to bycatch reduction (50 C.F.R. § 600.350(d)), EFH, and management of the impacts of new fishing gear. Eventually, the precautionary approach may become a relatively routine part of council (Pacific States Marine Fisheries Commission 1999, 29), NMFS (NMFS 1997), and Commerce Department decision making pursuant to the statutory national standards for fisheries management in section 1851 (50 C.F.R. Ch. 600, Subpart D; 63 Fed. Reg. 24,212). Pending legislation to reauthorize the SFA would require its use (H.R. 2570, 107th Cong., 1st Sess. (2001)).

As reviewed above, the statutory frameworks and judicial decisions involving marine mammal (Brower 2000) and endangered species protection also incorporate a precautionary

approach favoring decisions protecting those species and their habitat where scientific uncertainty exists about possible adverse impacts on them. And we predict that over time, due in part to the influence of international marine resource agreements to which the United States is a party, U.S. legislation governing marine pollution, navigation (Hildreth et al. 2001), and the management of nonliving marine resources will become increasingly precautionary in approach.

While some resource user groups may be slow to embrace precautionary approaches, given the increased likelihood of delays in access to resources and decreased rates of exploitation when access is allowed, there may be offsetting benefits in the form of greater predictability and transparency (Bache 2001) in marine resource management decision making:

> The precautionary principle (or approach) is grounded in science and is not an ill defined concept with an arbitrary definition. There is sometimes a perceived lack of scientific integrity in the precautionary principle and critics site [*sic*] an absence of objectivity and a political nature that lies outside the bounds of good science. However, such criticism is based on a poor understanding of the purpose of the precautionary principle, which is to provide a holistic decision making process and not to pretend to provide a scientific "answer." Science is not rejected, and the need for as much sound scientific information as possible is recognized. In fact, the precautionary approach to environmental protection begins with science, but it also takes into account the limitations of that science and provides guidance for making decisions on the basis of both what is and what is not known, and what are the desired long-term results (environmental, human health, economic and social) of those decisions. [Thorne-Miller 1994, 26].

Furthermore, once implemented, precautionary approaches are not immune from political and judicial review. The United States Constitution does not mandate that public sector marine resource management decisions favor either environmental protection or resource exploitation. Irrational claims of scientific uncertainty will be judicially invalidated (Symposium 2000), and the switching of the burden of proof built into the precautionary approach can be changed either by a majority legislative vote, or by agency formal or informal rule making processes where precautionary approaches have been instituted as a matter of agency policy.

At this time we believe that the decidedly mixed track record of the United States in managing marine resources on a sustainable basis justifies the switch in the burden of proof inherent in the precautionary approach. Coupled with the related international environmental norms of fully internalizing the externalities of resource utilization while protecting biodiversity, the precautionary approach puts U.S. marine resource management on more sustainable paths supportable by the scientific, legal, policymaking, and marine resource user communities. Furthermore, implementation of precautionary approaches may encourage user group contribution to the cost of resolving or at least narrowing scientific uncertainty in particular management decisions, consistent with the "user pays" philosophy inherent in the norm of fully internalizing the externalities of resource use. Finally, the precautionary approach can give agency personnel a zone of comfort in dealing with scientific uncertainties involved in their marine resource management decisions.

VII. CONCLUSION

Science, law, and policy are integrally related in marine resource decision making. This paper has explored some of the issues raised by that integration. To improve the decision making, scientists, legal professionals, and policymakers must take the time to understand the limitations of the three paradigms. Scientists need to better educate themselves to the requirements of and involve themselves more effectively in the legal-political system. Lawyers and policymakers need to continually be aware of the limitations of science and to establish policies and procedures to guide agencies that have to make important management decisions in the face of incomplete data and scientific uncertainty. Agency staff charged with implementing science-based laws should adopt positions such as the precautionary principle to help ensure that they carry out their fiduciary duty in managing public resources in the face of scientific uncertainty and limited data. If so, we believe we will see greater progress in the task of improving marine resource management at both the national and global levels.

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