"Forensic Fisheries Science": Literature Review and Research Suggestions

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ABSTRACT—Recent years have seen a dramatic increase in litigation against the National Marine Fisheries Service, NOAA. Litigation may affect personnel throughout the agency, including scientists, whose work is often directly or indirectly influenced by complex legal requirements, but who may not be in a position to comment or engage in public dialogue. It may be helpful for scientists and other agency personnel to join the ongoing discussion in the legal community regarding the interface of science and law. This paper provides a starting point with a selected introduction to relevant legal literature in this area. It uses the phrase "forensic fisheries science" to describe the application of science to legal requirements in the fishery management context. It concludes with suggestions for future research that could assist NMFS scientists as they grapple with the challenge of using science to help the agency meet its complex legal requirements.

Forensic: belonging to, used in, or suitable to courts of judicature or to public discussion and debate; argumentative, rhetorical; relating to or dealing with the application of scientific knowledge to legal problems (Merriam-Webster Online Dictionary, http://www.mw.com/home.htm).

Introduction and Background

Recent years have seen a substantial increase in concern about the condition of U.S. living marine resources, accompanied by a surge of litigation against NOAA's National Marine Fisheries Service (NMFS). Since the mid 1990's, litigation against NMFS has risen tenfold, and the agency's early record of success in defending its actions has dropped dramatically to below 50% (NAPA, 2002). Recreational and commercial fishermen once initiated more than half the cases, but environmental group filings have increased markedly in recent years. Litigation by other plaintiffs, such as states, tribes, and nonfishing industrial groups, has increased as well (NAPA, 2002). Lawsuits brought under the National Environmental Policy Act (NEPA)[1], the Endangered Species Act (ESA), and the Regulatory Flexibility Act (RFA) have increased markedly, along with a smaller increase in lawsuits brought under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).

In response, NMFS has undertaken a series of initiatives designed to reduce litigation losses on process issues. For example, NMFS now employs regional NEPA coordinators who work to 1) ensure national and regional consistency, 2) facilitate early, active participation of NMFS and the fishery management councils in the NEPA process, 3) coordinate NEPA training programs, and 4) provide advice on environmental compliance.[2] It has also conducted a number of internal reviews, consultations, workshops, and strategy sessions aimed at improving its management and budget processes.[3] Nevertheless, given that "adversarial legalism"[4] (Kagan, 2001) is the prevailing paradigm for conflict resolution in the United States, we can expect that stakeholders will continue to use litigation as a blunt yet effective instrument for influencing the system.

Whether litigation is ultimately beneficial to the fisheries management process is a matter of strongly diverging opinion (Panelists, 2001). On one hand, some

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[1] See *American Oceans Campaign* v. *Daley*, (2000) (holding that environmental assessments on essential fish habitat amendments failed to include sufficient evidence or analysis to determine whether an environmental impact statement should have been prepared); *Greenpeace* v. *NMFS*, 55 F.Supp. 2d 1248 (W.D. Wash. 1999) (holding that the supplemental EIS failed to thoroughly analyze cumulative effects of changes to FMP's, requiring a programmatic EIS); *Metcalf* v. *Daley*, (2000) (finding inadequate NMFS' FONSI/EA concluding that the Makah tribe's whaling proposal would not significantly affect the environment). NEPA implementation has become such a problem that the Fishery Management Council Chairs asked Congress to legislatively exempt the fishery management process from NEPA. Under this proposal, NMFS and the Councils would still be required to engage in the NEPA planning process, but losing a NEPA challenge in court would result merely in judicial guidance rather than an injunction on the fishery. Testimony of David Benton, Senate Hearing, 9 May 2002.

[2] Testimony of William T. Hogarth, Senate Hearings 2002.

[3] NMFS contracted with Ray Kammer to perform a major study of adequacy of funding, the ability of NMFS to comply with its mandates, and the impact of litigation on NMFS operations. This study is often informally referred to as "The Kammer Report."

[4] "Adversarial legalism" refers both to the prevailing American practice of resolving disputes through adversarial litigation-oriented processes, as well as the legal institutions and rules that facilitate and encourage it.

agency employees contend that excessive litigation inhibits effective management by diverting scarce resources, allowing scientifically inexpert judges to manage fisheries, polarizing participants, and hindering collaborative and innovative approaches. On the other hand, environmental plaintiffs argue that lawsuits are the only way for them to gain a meaningful voice in an industry-dominated fishery management council system and to ensure that NMFS complies with the law (Panelists, 2001).

Although the agency's attorneys manage the nuts and bolts of responding to these lawsuits, agency scientists and managers are also affected by this litigious climate.[5] Environmental laws often mandate scientifically-based regulatory decisions, and thus play a major role in defining the agency's research agenda. But although science is clearly a necessary component of the regulatory decision process, it is often not sufficient by itself. Environmental regulatory issues tend to be "trans-scientific" (Weinberg, 1972): they raise questions that cannot be answered solely by recourse to science, because of intractable scientific uncertainty and difficulties in translating legal requirements into concrete scientific standards. Agencies must address these mixed questions of science and law by relying on scientifically informed expert professional judgment in accordance with a reasonable interpretation of legal requirements (Jasanoff, 1990). In other words, agency scientists and managers must learn to work at the interface of science and law to assist in the production of legally robust environmental documents.

This paper uses the term "forensic fisheries management" to refer to issues at the boundary of law and science in the fisheries context.[6] Although the term "forensic" conjures up images of criminal investigations, the term has a much broader application. Forensic science is simply the application of science to the law; "[t]he problems for the field have been set by the law's demands for peculiar sorts of knowledge" (Mashaw, 2003). Thus, the term "forensic fisheries science" refers specifically to the science questions that are asked and answered primarily for the purpose of meeting the agency's legal requirements.

Agency scientists are tasked with addressing these forensic fishery science questions by conducting research and providing data to develop management decisions that comply with legal mandates. Yet they labor with the uncomfortable knowledge that, in the event of a lawsuit, lawyers and judges will scrutinize their work for legal shortcomings. Legal requirements may seem especially arcane to scientists and managers, whose professional expertise lies in science rather than law. It would, of course, be both unreasonable and unnecessary to expect scientists and managers to undertake rigorous legal training. However, it may be highly beneficial for them to join the ongoing conversation among the legal community on issues surrounding the application of science to the law. Such discussions could serve a boundary-spanning function by improving communications among scientists, managers, and legal counsel, thereby allowing agency personnel to work more effectively towards the common goal of producing legally compliant environmental documents. This paper seeks to serve as a starting point for such discussions with its selected review of recent legal literature containing useful theories and concepts regarding the intersection of law and science in the regulatory agency context.

Literature Review

My initial literature search encompassed both legal and fishery science periodical databases. However, it quickly became apparent that articles containing the targeted subject matter appeared almost exclusively in the legal literature. In other words, it seems that lawyers are writing about scientists, but not vice versa. And because legal periodicals are rarely indexed on science-oriented databases, it is unlikely that scientists would encounter such articles in their regular professional activities. The unique format of law review articles may pose an additional barrier to interdisciplinary learning. Law review articles are written with an audience of lawyers in mind. They tend to be extremely lengthy, heavily footnoted, and freighted with legal concepts and terminology. This is unfortunate, because the legal literature contains many instructive insights regarding the science-law interface. Accordingly, this review of the legal literature was written with regulatory scientists in mind.

This paper does not attempt to describe the comprehensive realm of literature on the interface of science and law. Rather, it provides a selection of recent materials, primarily from the legal and policy literature, chosen for their relevance and utility in helping scientists understand key issues and concepts in U.S. forensic fisheries management. Articles focusing primarily on international fisheries issues[7], fishery science, and tools for fishery management were excluded. In addition, the sizeable body of literature concerning the admissibility of scientific expert testimony at trial is only briefly discussed because it is rarely at issue in NMFS fishery cases.[8] The selected literature is broadly organized under two related categories: 1) legal-institutional and 2) sociocultural, with subcategories under each. Because the issues are so tightly interwoven, these subcategories are not entirely discrete; however, the subcategories should assist the reader in parsing the literature.

[5] Penny Dalton, former director of NMFS, testified that "Life at NMFS was a little like being on the F/V *Andrea Gail* in the "Perfect Storm"; you constantly felt that the next wave might well be the one that would capsize the boat." Senate Hearing, 9 May 2002.

[6] Thanks to Professor Marc Hershman, University of Washington, Seattle, for pointing out this underutilized definition of "forensic."

[7] Carr and Scheiber (2002), for example, analyze initiatives to establish effective global conservation standards and institutions to govern marine fisheries and argue that the main problems are related to scientific uncertainty.

[8] The landmark case on this issue is *Daubert* v. *Merrell Dow Pharmaceuticals, Inc*., 509 U.S. 579 (1993). In that case, the U.S. Supreme Court held that trial courts must apply a two-part test in determining admissibility of scientific expert testimony: 1) whether the testimony reflects scientific knowledge, derived from the scientific method, and amounting to good science; and 2) whether the testimony will assist the trier of fact to determine facts at issue in the case. A Westlaw search of NMFS cases decided after 1993 found only 3 cases mentioning *Daubert*, out of a total of 283 cases involving NMFS.

Legal and Institutional Issues Governing the Integration Of Scientific Information in the Policymaking Process

Complex and Contradictory Statutory Mandates

Perhaps the most obvious and commonly cited problem is the difficulty of managing marine resources under multiple and sometimes contradictory statutory mandates (Heinz Center, 2000; Fletcher, 2002; Halpern, 2002; NAPA, 2002; Pew Oceans Commission, 2003; Christie, 2004; U.S. Commission on Ocean Policy, 2004). The NMFS must simultaneously manage sustainable fisheries and conserve protected species under the statutory framework defined by the MSFCMA, ESA, NEPA, the Marine Mammal Protection Act (MMPA), and other applicable laws. Each of these laws arose in response to different problems, and accordingly they have different statutory mandates and different mechanisms for accomplishing their objectives. The twin goals of managing for sustainable fisheries and conserving protected species are not mutually exclusive; however, unifying the current statutory framework could make the job easier.

Ecosystem-based management could serve as a useful organizing concept for statutory reform. The ESA and other resource management laws were not expressly designed with ecosystem management in mind, and these laws may not provide an adequate framework for taking into account all facts and values pertinent to solving broad complex resource management dilemmas (Flournoy, 1994). Craig (2002) advocates expressly incorporating ecosystem management and restoration principles and to actively pursue restoration goals based on historical ocean productivity. But while NMFS is not expressly precluded from incorporating ecosystem management principles into the decision-making process, the lack of an express statutory mandate institutionalizing management at an ecosystem level means that such attempts will tend to remain fragmentary and procedural (Keiter, 1994).

Macpherson (2001) argues that the 1996 amendments to the MSFCMA and NMFS interpretive guidelines provide some statutory basis for managing fisheries using ecosystem principles by increasing information, facilitating consideration of interrelated impacts, and improving managers' ability to learn from experience. However, at this time there is no statutory mandate favoring ecosystem management over other approaches.

The passage of the Oceans Act of 2000, which established the U.S. Commission on Ocean Policy "to make recommendations for coordinated and comprehensive national ocean policy," has renewed calls to overhaul and integrate the current fragmented marine resource management regime (Heinz Center, 2000; Fletcher, 2002; Halpern, 2002; NAPA, 2002; Pew Oceans Commission, 2003; Christie, 2004; U.S. Commission on Ocean Policy, 2004). Perhaps the recently released report from the U.S. Commission on Ocean Policy (2004) will spark a legislative response.

The "Science Charade"

However helpful a well-integrated suite of ocean management laws might be, the integration of science, law, and policy in resource management will always present thorny challenges. One of the most important recurring ideas in the legal literature is the realization that complex environmental problems invariably present mixed questions of science and policy, and that ignoring this fact presents regulatory pitfalls.

Using the example of toxic risk standard setting at the Environmental Protection Agency (EPA), Wagner (1995, 1999) argues that agencies intentionally or unintentionally exaggerate the contributions made by science to avoid accountability for the underlying policy decisions—a phenomenon she calls "the science charade." Toxic risk problems are trans-scientific; because science cannot establish definitive quantitative standards for protecting human health from toxic risks, policy considerations must fill the gaps left by scientific uncertainty. There are powerful political, legal, and institutional incentives for agencies to conceal policy choices under a veneer of science.

For example, the public insists on near absolute safety from toxic risk while also demanding a strong economy and reduced governmental regulations. This creates strong political pressure on agencies to disguise the unavoidable policy choices as purely scientific. Individuals may also intentionally engage in the science charade to retain personal control over the policy and research agenda. Congress also perpetuates the science charade by promulgating laws that put too much emphasis on scientific data in the mistaken belief that science alone can provide the solution to environmental problems. It is politically appealing to pass responsibility for making politically unpopular decisions to the agencies and to assume that "sound science" will resolve controversies in an objective manner. Scientific uncertainty allows legislators to impede environmental programs by insisting that more or better studies are needed.

Wagner argues that the science charade creates substantial costs in the form of complicated and ineffective laws, delays in implementation, damage to democratic values, and demoralized agency personnel, and that regulatory reform efforts will not be successful unless they address it directly. Some options include: educating legislators and their staffs about the science charade; having Congress state policy choices explicitly in the text of legislation or requiring agencies to disclose their policy decisions; delegating toxic standard-setting to an administrative task force composed of scientists and policymakers from academia, government, and stakeholders; or amending the Administrative Procedures Act (APA) to require agencies to explicitly separate science from policy.

The science charade and its consequences can arguably be observed in any science-policy issue plagued with high levels of scientific uncertainty. Doremus (1997) examines the science charade in ESA implementation to explain why better science doesn't always lead to better policy. The ESA requires that the threshold decision to add a species to the endangered or threatened list be made "solely on the basis of the best available scientific information." But science alone cannot answer all the relevant questions, such as what risk of extinction society should tolerate. Agencies are thus forced to pretend that their decisions were based solely on science without reference to policy judgments. Consequently, agencies have an incentive to conceal the true bases for their decisions. Calls for "better science" only serve to reinforce the science charade. Doremus (1997) concludes that ESA critics should focus on the process by which listing decisions are made and communicated to the public. Congress should separate the scientific aspects of listing determinations from the value judgments, either making those decisions itself or delegating them to agencies free of the "strictly science" mandate. Agencies should remain free to rely on the best available data, even if they are relatively weak.

Halpern (2002) examined NMFS management of Steller sea lions, *Eumetopias jubatus,* as a case study regarding the effects of multi-statute administration on the role of science in environmental management. Halpern argues that NMFS does not consider each statutory mandate separately, but rather weighs them all together along with outside interests, economics, and science, in attempting reasonable management solutions (the "gestalt effect"). He further contends that NMFS uses science to define an acceptable range of management strategies (the "bookends effect"), but ultimately reacts to legal and political pressures in choosing a management strategy within that range (the "reactivity effect").[9] He argues that these effects demonstrate the subservience of scientific information to other considerations in administrative thinking, transforming NMFS from an objective expert to a political decision maker. Halpern does not place all the blame on NMFS for this state of affairs; he also questions the extent to which Congress should be able to shunt politically difficult decisions to agencies. Interestingly, Halpern's analysis bears a distinct resemblance to Wagner's (1995) science charade concept, although he never utilizes that term.

Best Available Scientific Information

Innocuous though it may seem to the uninitiated, the notion of "sound science" has become a major battle cry among competing stakeholders. NMFS is often the target of lawsuits claiming that its management decisions were not based on the best available science. The MSFCMA, ESA, and MMPA mandate that agencies use the "best available science" in making certain management decisions, but because the term remains undefined, there is a great deal of uncertainty as to its meaning and application.[10] The question of how to define and apply best available science in fisheries management is a classic example of the difficulties inherent in translating between legal and scientific evidentiary standards, burdens of proof, and treatments of uncertainty.

Invoking the mantra of "sound science" is politically appealing because of the common perception that science is objective and infallible (Coglianese and Marchant, 2004). Some stakeholder groups have been pressing Congress to legislate a rigid definition of the term, arguing that implementation will be improved if agency actions are based on strict research methodology and peer-reviewed empirical evidence. But many scientists and managers contend that this is a thinly veiled attempt by special interests to paralyze decision making and delay protective actions by ruling out the only available data (Mooney, 2004).

Wagner (2003) argues that so-called "good science" reforms, which are designed to rectify purported problems with the quality of agency science, miss the mark and may actually damage administrative processes. She contends that the real problem is not with the quality of agency science, but rather the quantity of science needed to justify regulation. Rather than fixating on peer review, reform efforts should focus on overcoming what she calls "the rebuttal problem"—deciding when the cumulative weight of the evidence is enough to first justify, then rebut, a protective policy. Clarifying these rebuttal criteria, she says, will improve regulatory outcomes by enhancing transparency of agency decisions, properly isolating the underlying issues for judicial review, and focusing decision-making criteria on statutory goals.

Courts continue to struggle with best available science issues. Brennan et al. (2003) explored the role played by scientific uncertainty in implementing the ESA, focusing on judicial efforts to apply the best available science standard in ESA cases, and recent legislative attempts to modify the standard. Agencies and courts are plagued by the ESA's lack of definitional terms and the fact that endangered species data are often vague, ambiguous, and uncertain. As a result, judicial guidance has been equally inconsistent and ambiguous; too often the court either disregards the legislative best available science requirement, or intrudes too far into the agency decision-making process. The authors suggest that courts take a "hard look" to determine whether the agency considered the scientific information available to it, identified the information used in its decision, and clearly explained its determination.

Doremus (2004) offers an in-depth review of the purposes and effects of the ESA's best available science mandate. She argues that Congress included the best available science mandate in an attempt to ensure that trained experts would make strictly technical decisions in an objective, value-free manner. In practice, however, science alone cannot fully answer all ESA decisions. Questions such as how to define the problem or how much risk of extinction society should tolerate are inescapably political in nature.

Doremus (2004) contends that the ESA's best available science mandate does not play a major role in constraining agency decision making because it adds

[9] Halpern's hypotheses regarding the "bookends" and "reactivity" effects seem to play down the inescapable nature of scientific uncertainty. In the face of high scientific uncertainty, decision makers cannot base their decisions solely on science. Policy judgments are required to fill the gap between the "bookends."

[10] See http://www.usm.maine.edu/~rieser/workshop%20goals. References to "best available science" can be found in the following statutes: 16 U.S.C. §§ 1533(b), 1536(c), 1537a(c) (1994); 16 U.S.C. §§ 1851(a) and 1881d (1997); 16 U.S.C. §§ 1362(19) and (27), 1371(a), 1373(a), 1374, 1378, 1383b(a), 1386(a) and (b) (1994).

little beyond the general requirement to avoid being "arbitrary and capricious" by showing a rational connection between the decision and the available information. She argues that the primary effect of the mandate is in limiting the agency's ability to openly rely on nonscientific factors in the decision process, rather than exerting a major substantive effect on the substantive treatment of science. The ESA is not broken; however, agencies could improve their use of science in the ESA context by 1) openly acknowledging the limits of science, including the scope of scientific uncertainty and the nonscientific aspects of decisions, 2) actively seeking ways to obtain new scientific information and put it to use, and 3) building public trust and acceptance of ESA decisions by overcoming "project-specific myopia." This could be accomplished by separating the scientific aspect of decisions from the political aspect, and explaining the role of uncertainty.

In 2001, a prominent group of scientists and lawyers convened a workshop to examine recent litigation and associated agency actions regarding application of the best available science standard.[11] Key themes included how to reconcile law and science for protection of biodiversity; the nature and sources of scientific information available to agencies; the processes by which agencies determine best available science; the treatment of uncertainty in these processes; and the interpretation of scientific theories and data in litigation. Rather than coming to an agreed set of conclusions, the workshop served as an important forum for lawyers and scientists to exchange their perspectives and to brainstorm ideas.

Three years later, the NRC Ocean Studies Board conducted a study on "Defining Best Scientific Information Available in Fishery Management" (NRC, 2004) .The study brought together scientists, policymakers, and legal experts with the stated goal of "produc[ing] recommendations for more uniform application of best available scientific information in preparation of fishery management plans."[12] The NRC committee found that the best available science standard in the MSFCMA "embodies the idea that decisions…should be made in a timely and effective fashion with available information despite recognized data gaps" but that there are no uniform guidelines for applying the standard. The committee also found institutional and regional differences in the way the standard is applied. But the committee did not advise amending the MSFCMA to include a statutory definition of best available science because it could impede the incorporation of new scientific information and would be difficult to amend if more flexibility was needed. Instead, the committee advised that the NMFS establish regional guidelines to govern the production and use of best available science in fisheries management. This would enhance accountability and credibility while allowing for flexibility when warranted under the circumstances (NRC, 2004).

Scientific Uncertainty and the Politicization of Science

Policymakers increasingly rely on scientists to provide scientific predictions as a guide to decision making (Sarewitz et al., 2000). Science's apparent predictive capacity seems to promise an objective basis for difficult decisions. But the appeal of scientific prediction is based in part on confusion about the nature of prediction for policy making. Prediction in science has been traditionally used to validate reductionist theory, yet prediction for policy making is quite different. It has political elements because it offers to reduce the contentious, subjective elements of the decision process. The ability of predictive research to improve policy outcomes may depend on a variety of social, economic, and political factors, as well as scientific uncertainty (Sarewitz et al., 2000).

Paradoxically, in the context of science intensive resource management disputes, science may feed political controversy rather than foster consensus (Sarewitz, 1996). Sarewitz (2004) argues that "scientific inquiry is inherently and unavoidably subject to becoming politicized in environmental controversies." This is because 1) science provides stakeholders with different sets of legitimated facts about nature which can be used to support desired policy outcomes, 2) competing disciplinary approaches to understanding the science basis of environmental problems may be tied to competing ethical positions, and 3) scientific uncertainty can be viewed as "a lack of coherence among competing scientific understandings" rather than a mere dearth of knowledge. Scientific disunity and political conflict combine to create conditions of scientific uncertainty.

The typical response is to call for more research, but new data often increases uncertainty or provides more "ammunition" to fuel the ongoing political conflict (Pielke, 2004). Additional scientific data can result in what Sarewitz (2004) terms an "excess of objectivity," in which competing stakeholders pick and choose the data that support their preferred value-based policy outcomes. This is the phenomenon underlying the common refrain that "our science is sound science and their science is junk science" (McGarity, 2004). Scientists themselves may also politicize science by using it to negotiate for specific desired political outcomes (Pielke, 2004). Sarewitz (2004) contends that progress in addressing environmental controversies is unlikely to occur without advances in political process.

Heazle (2004) examines the treatment of scientific uncertainty at the International Whaling Commission (IWC) to show how scientific uncertainty can be interpreted and manipulated in relation to its perceived political utility. Scientific uncertainty was once used to argue against lower whaling quotas on the grounds that there was no proof that increased whaling would harm stocks. But today, anti-whaling nations use scientific uncertainty to support the current whaling moratorium. More scientific information has failed to force consensus on the underlying value-based disagreements between whaling and nonwhaling nations. Heazle (2004) argues that the likelihood of an individual to oppose a given action or policy by invoking scientific uncertainty

[11] Available at http://www.usm.maine.edu/~rieser/workshop.html (accessed 16 January 2004).

[12] See http://nationalacademies.org/osb/ (accessed 6 February 2004).

is dependent upon the extent to which the action may satisfy a recognized need and the extent to which it is perceived not to conflict with an already established need. Scientific uncertainty can be quite useful when used to invoke the precautionary principle (regulate absent proof of safety) or its polar opposite (do not regulate absent proof of harm). Thus, "it is not uncertainty itself that determines or influences policy making so much as how we choose to use it" (Heazle, 2004).

The Influence of Institutional Structures and Functions on the Environmental Decision-making Process

Even the best scientific information will be of little use unless it is successfully integrated into the decision-making process. The success or failure of this integrative process is highly dependent on the institutions that bring together scientists and policymakers. Commentary in this area focuses on decision-making structures and functions: how they shape the issues and the research agenda; how they legitimate data; and how they mediate between the competing forces of technocracy (science) and democracy (public participation).

Institutions can play a powerful role in mediating the impact of scientific assessments on environmental policy. Cash et al. (2003) found that the most influential assessments are simultaneously perceived by a broad array of actors to possess three attributes: saliency (whether an actor perceives the assessment to be addressing relevant issues), credibility (whether an actor perceives the assessment's arguments to meet standards of scientific plausibility and accuracy), and legitimacy (whether an actor perceives the assessment as unbiased). Efforts to bolster one of these attributes usually come at the expense of another.

Institutions shape the influence of assessments largely by balancing the tradeoffs between saliency, credibility, and legitimacy. Important factors include 1) the embeddedness of an assessment (the degree to which it is carried out within or under the control of the organization that will subsequently use it), 2) the weakness or strength of boundary spanning arrangements (bridging the gap between experts doing the assessment and the decision makers who use it), and 3) provisions for learning and critical self-reflection (to balance the benefits of cumulative experience with the need to track changing conditions). Information alters behavior not by directly altering deep-seated values and goals, but by indirectly altering the beliefs actors have about what their interests are and the best ways to pursue them.

Flournoy (1991) argues that the traditional decision-making structure embodied in many environmental protection statutes, such as the ESA, fails to provide an effective mechanism for resolving factual disputes in the face of scientific uncertainty. This process is based on a "binary structure" that requires decision makers to resolve a single issue with a yes or no answer. The burden of meeting the standard of proof is allocated to a given party, typically the proponent of regulatory action. Because scientific uncertainty cannot be completely eliminated, a process that predicates regulation on affirmative proof of harm tends to amplify the burden of proof and discourage protective regulation. And because the binary system tends to sort facts based on their ability to pass the certainty threshold, it tends to encourage the parties to mask the uncertainty and value judgments which are bound up in their conclusions.

Fluornoy (1991) suggests that Congress increase uniformity and clarity in statutory provisions; clarifying fundamental policy choices; explicitly allocate burdens of proof; require agencies to assess the adequacy of the record before making decisions; and develop a decision-making process that permits more than two possible outcomes and provides agencies with a range of responses based on a sliding scale of standards of proof.

Why do Federal scientific advisory committees often fail to produce consensus or reduce conflict, even though they are composed of supposedly rational, independent experts? In a pathbreaking book, Jasanoff (1990) examines this question using case studies of decision making at the EPA and the Food and Drug Administration (FDA) and grounds her analysis in a framework drawn from extensive theoretical and empirical research on the relationship between science and the regulatory process. She challenges two commonly accepted assumptions regarding the use of science by regulatory agencies: the technocratic view that policy choices can be validated by independent experts relying on sound science, and the democratic view that broad public participation is the antidote to abuses of expert authority.

Noting that regulatory science questions are inherently mixed with policy and unavoidably entail a high level of scientific uncertainty, she questions the ability of scientists to remain neutral while certifying results as valid. She also argues against the strict separation of science and politics on the grounds that it is impossible to restrict the science advisory process to purely technical issues.

Courts, too, play a significant role in the way that scientific information is defined, legitimated, and applied in the policy process. Some argue that scientifically illiterate judges exacerbate agencies' litigation woes, but Jasanoff (1982) argues that proposals for judicial reform aimed at enhancing the technical competence of courts fall short because these problems are not solely attributable to a lack of judicial competence. Scientific uncertainty is inescapable and policy problems often arrive at the court disguised as purely scientific questions, which cannot be resolved by technical debates.

Some commentators, including former EPA Administrator William Ruckelshaus, argue that fundamental tensions between science and democracy pose a major obstacle to science-policy integration.[13] Policymakers ask scientists to resolve complex regulatory problems, but science is not a democratic institution. Policymakers may use science as a "fig leaf" to legitimize a political decision, and scientists may also dabble in policymaking—the "mutual corruption of science and policymaking." The result is that

[13] Ruckleshaus, W. "Science and Public Policy: The Twain Must Meet", Transcript of the Wolfle Lecture at the University of Washington, 16 May 2002.

science is delegitimized in the public eye, and policymaking is paralyzed.

Ruckelshaus argues that we lack institutions where democratic powers can be exercised in concert with the application of the best science, and suggests "resolution by collaboration," whereby interest groups and government agencies at all levels with a stake in some local issue come together to solve problems that no single one of them could solve alone. Rather than trying to completely separate science and management, we need constant feedback between the two. The science effort must focus closely on the specific needs of managers, and the managers must absorb new information and learn to ask intelligent questions that science can actually try to answer.

Similarly, Karkkainen (2002a) discusses a new model of collaborative ecosystem governance that recognizes the need for integrated ecosystem management emphasizing regional solutions within broader structures of coordination and accountability, and allows for continuous experimentation and adjustment. These challenges are addressed through public-private governance structures which emphasize information sharing, monitoring, and collaborative problem solving among diverse interests on multiple spatial scales.

But Karkkainen (2002a) sees potential pitfalls in the lack of fit between collaborative ecosystem governance institutions and conventional governance structures; law prefers tidy, permanent rules, whereas ecosystem management is "messy, elaborate, cumbersome, ad hoc, and defiantly unconventional."

Adler (2002) advocates the use of a consensus-building strategy known as environmental conflict resolution (ECR), which uses strategic cooperation in an attempt to address science-intensive resource management challenges by seeking solutions that maximize mutual gains. Based on extensive interviews, focus groups, and case studies, Adler offers five intriguing hypotheses for determining conditions likely to enhance the success of ECR. ECR is more likely to succeed if: 1) political issues are discussed before technical issues, 2) scientific aspects of a decision are explicitly examined by all parties, 3) scientific uncertainties are openly acknowledged, 4) participants work together on scientific modeling, and 5) participants confront their own inherent assumptions and biases, and acknowledge the validity of other participants' perspectives. In ECR, the thorny question of "how much science is enough" must be negotiated. Thus, one test of ECR is whether it can successfully facilitate the integration of the best science with the best of what the politics and policies of a given conflict can allow.

Tarlock (2002) argues that the failure of science to satisfactorily answer environmental questions posed by society has led to the contested "ownership" of science. Scientists once owned science in the sense that they controlled both the production and use of scientific knowledge. But when scientists could not provide all the answers that society posed, nonscientists asserted a right to participate in the application of science to public policy choices.

Although scientists are the primary "owners" of science, they cannot exclusively control it because the issues are framed by legislators and regulators, forcing the scientific community to adapt its protocols of inference and standards of proof to answer them. Tarlock (2002) suggests several approaches for bridging this gap: 1) reject the false dichotomy between "sound" and "junk" science in favor of a credible scientific foundation; 2) utilize the precautionary principle as a basis for legitimate decisions, provided that a reasonable evidentiary threshold for invoking it has been established, mid-course correction mechanisms are created, and the needs of adversely affected parties have been considered; 3) create open-ended decision processes that allow for progressive stages of decision making as knowledge is acquired; and 4) the scientific community must accept the need to redirect research to questions deemed relevant by society; in other words, "scientists must learn to think like lawyers." (It would also seem prudent for lawyers to learn to think like scientists!)

Noting that scientists have become more actively engaged in the policymaking process, Clark et al. (1998) discuss how Canada, the United States, and Mexico approach science-policy integration. Although the countries' approaches often differ in their specifics, common prerequisites to successful science-policy integration include clarity of objectives, clarity of roles and responsibilities, quality control through peer review, and effective stakeholder involvement. They emphasize that political and legal issues cannot be solved by more or better science, and caution against a "tyranny of small decisions," whereby manageable issues are not dealt with until they create a major crisis.

Integrating New Scientific Thinking Into the Existing Legal Structure

When well-meaning scientists and managers attempt to introduce innovative strategies such as ecosystem management and adaptive management into the decision-making process, they may be shocked and dismayed at the legal and institutional roadblocks they encounter.

Many environmental laws were passed decades ago, during a time when our understanding of the environment was based upon outdated notions of equilibrium and the balance of nature (Tarlock, 1994, 2003; Scheiber, 1997; Bosselman, 2002). Ecologists once assumed that ecological systems were relatively uniform, closed, and self-sufficient, but they now see ecosystems as open and susceptible to outside influences. This shift has created a disconnect between new ecological theories and environmental laws based on the old theories (Tarlock, 1994). The nonequilibrium paradigm's emphasis on constant flux and change has exacerbated the problem of environmental decision making under high scientific uncertainty because it heightens the tension between traditional strict standards of legal causation and the limits of science's ability to provide definite answers (Tarlock, 1994).

Sustainable management of living marine resources requires development of management institutions, such as adaptive management, that will effectively produce, identify, and integrate new scientific knowledge into natural resource decisions (Tarlock, 1994;

Doremus, 2001). Adaptive management remains influential as an idea, but it has thus far had limited success as a practical conservation method (Lee, 1999). It challenges the legal system's efforts to promote settled expectations and finality of decisions. It requires flexibility, yet legal and political institutions seek long-term certainty. The flexibility demanded by adaptive management leaves decisions open to political pressure. Agencies may seek out any discretion they can find in the ESA and use it to reduce the protection of biological resources under political pressure (Doremus, 2001). Adaptive management has been called "an elaborate accomodationist and incrementalist tactic for reducing the visibility and consequent political vulnerability of management innovation" (Scheiber, 1997). And although adaptive management could be a useful tool for structuring the dialogue between policy and science, there has been little willingness or ability to use large-scale ecosystem experiments to probe scientific uncertainties (Volkman, 1999). Endangered species listings may offer incentives to learn through adaptive management, but they also create opportunities for stakeholders to perpetuate their defensive positions (Volkman, 1993).

Despite these challenges, there may be ways to make adaptive management more feasible and acceptable to stakeholders. Lee (1999) suggests that adaptive management may be more successful if a collaborative structure is in place before adaptive management approaches are implemented, rather than the common approach of adopting experimentation during the planning process. Otherwise, adaptive management can become "a way to justify trial and error in the midst of a political free-for-all" (Lee, 1999).

Ecosystem management and ecosystem revival efforts face similar roadblocks, as they are a radical departure from environmental laws favoring quick technological fixes rather than sustained management of functioning ecosystems. And extensive stakeholder participation favored in laws such as NEPA may not be compatible with ecosystem experiments that are fundamentally informed by science (Tarlock, 2003).

Doremus (2001) argues that if adaptive management is to work, we must develop institutions capable of permitting flexibility while strengthening the agency's resolve in the face of strong political pressure. Tarlock (1994) suggests that the legal system can balance individual fairness with environmental protection by applying concepts that provide for the continuous integration of science and policymaking. This would include reducing data gaps and paying close attention to implementation and monitoring so that policies can be continually modified as necessary. He favors science-based decision making with public accountability as a checking mechanism and concludes that environmental laws must be revised to provide new statutory foundations for ecosystem revival (Tarlock, 2003). Bosselman (2002) suggests strategies for better incorporating ecological data into management processes, such as facilitating access to large-scale ecological information; developing performance standards for alteration of ecological processes; and requiring large-scale environmental impact analyses. Governments must proactively think in advance about how they will react to likely ecological disturbances and work to counteract or avoid unidirectional environmental change.

Legal reforms may be necessary to address these problems. Keiter (1994) examines the ecosystem management concept from a legal perspective, documenting its fragmentary emergence into the common law via piecemeal judicial rulings and administrative initiatives. He identifies legal barriers to ecosystem management, including statutory mandates favoring resource production, court cases favoring property owners who argue that burdensome regulations entitle them to just compensation (the "takings" doctrine), and decisions hostile to citizens' right to sue (the "standing" doctrine). He also points to bureaucratic resistance to change; the political pitfall of local opposition to ecosystem management; and the difficulties of integrating science and policy. He argues that Congress should enact statutory reforms to institutionalize ecosystem management.

The Double-edged Sword of NEPA: Planning Tool and Source of Litigation

Although NEPA compliance can sometimes seem to be a costly and burdensome procedural task, there is an increasing recognition that NEPA can serve as a strategic planning tool and as a "framework for collaboration between federal agencies and those who will bear the environmental, social, and economic impacts of their decisions" (CEQ, 1997). Since the enactment of NEPA, several other laws have been passed that echo NEPA's requirements for environmental analyses, consultation, and documentation. NEPA can serve as an organizing tool by 1) using scoping and tiering to prevent duplication of analyses, 2) preparing environmental studies under NEPA and other laws concurrently, 3) combining documents under NEPA and other laws, and 4) combining public participation under NEPA and other laws (CEQ, 1997).

NEPA can serve as a tool for integrating ecosystem management principles into agency decision making via the cumulative impacts analysis. Cumulative impacts analysis is particularly challenging because of the difficulty in defining geographical and temporal boundaries. If the boundaries are set too narrowly, significant issues may be missed, but if set too broadly, the analysis becomes overwhelming. However, "an ecosystem approach to strategic planning through NEPA can provide a framework for evaluating the environmental status quo and the combined cumulative impacts of individual projects, thereby enhancing the attainment of environmental quality objectives on a broader, more cost-effective scale" (CEQ, 1997).[14]

There is also increasing interest in using NEPA as a tool for adaptive management. Typically, the NEPA process ends when an Environmental Impact Statement (EIS) is released, in which case

[14] For a discussion of analytical tools for cumulative impact analysis, see Larry Canter, "Cumulative Effects and Other Analytical Challenges of NEPA" in Clark and Canter, "Environmental Policy and NEPA: Past, Present and Future" (1997).

adequate environmental protection depends partially on the accuracy of the predicted impacts and expected mitigation results.[15] Adaptive management allows agencies to analyze and approve a plan with an uncertain outcome, monitoring the status of the resource to make corrective changes to the project or mitigation plan if necessary (CEQ, 1997).[16]

Caldwell (1998) champions the original intent and unrealized potential of NEPA as an "umbrella policy that integrates purposes and objectives and provides for choice where agency missions and environmental quality may conflict." This approach may be especially helpful for NMFS, which is confronted with the dilemma of carrying out the primary objective of fisheries management while accommodating a host of other environmental statutory mandates.

Caldwell (1998) believes NEPA has had a positive impact on government policies, but maintains that agencies have not fully internalized the substantive goals of NEPA due to "bureaucratic and judicial conservatism and equivocal political support." He favors legal reform to reinvigorate NEPA's substantive mandate, as well as a constitutional amendment for the environment.

Karkkainen (2002b) argues that NEPA is often criticized as weak, procedural, and costly because its "ex ante predictions are inevitably inexact and contestable." He argues that agencies try to protect themselves against legal challenges to the adequacy of EIS's by producing large yet uninformative documents. They may also seek to avoid the EIS process by making a finding of no significant impact (FONSI) and relying on mitigation measures to reduce expected impacts below threshold levels (mitigated FONSI). However, because NEPA does not require follow-up monitoring, actual impacts remain unknown. Karkkainen (2002b) recommends retooling NEPA by requiring follow-up monitoring, adaptive mitigation, and implementing an environmental management-systems approach.

The programmatic EIS can be a useful planning tool, but a recent NEPA Task Force report on "modernizing NEPA implementation" (CEQ, 2003) suggests that the Preliminary Environmental Impact Statement (PEIS) process is not always meeting agency and stakeholder needs. Ideally, the PEIS improves agency decision making by forcing a "systematic and comprehensive consideration of environmental matters early in the planning stage" (Cooper, 1993). However, NEPA task force study participants cited challenges in determining how to define the proper scope and depth of programmatic analysis; how to use it effectively; how to determine the "shelf life" of the document; and how to integrate adaptive management principles. The process can become particularly contentious when stakeholders ask for greater specificity in the PEIS than agencies believe is required.

While agencies can always improve their NEPA implementation processes, some guidance from CEQ might be very helpful in this area. An illustrative example can be found in *Greenpeace* v. *NMFS*, 55 F.Supp.2d 1248 (W.D. Wash. 1999). In that case, the presiding Judge Thomas Zilly held that the supplemental EIS for the North Pacific groundfish FMP (NMFS, 1998) was inadequate because it only addressed impacts related to total allowable catch (TAC) determination. The court remanded the Supplemental Environmental Impact Statement (SEIS) to the agency and ordered it to prepare a "programmatic EIS analyzing the impacts of the FMP's as a whole on the North Pacific ecosystem."

Preparing a programmatic supplemental EIS on this scale has proven to be an extremely challenging task. There are also nagging questions about the proper scope and content of the alternatives, with the environmental community demanding a high level of action-forcing detail and NMFS opting for a broad comparison of management frameworks. The resulting document (NMFS, 2004) is approximately 6,000 pages in length and took five years to prepare. It seems reasonable to ask whether more guidance from CEQ could reduce legal uncertainties regarding scope and content of a PEIS and thereby improve efficiency.

NMFS can also learn from the experience of agencies such as the U.S. Forest Service, which endured a similar litigation crisis a decade ago, related to conflicts over the recovery of the northern spotted owl and the potential impact of logging old growth forests. Ackerman (1990) describes the "co-evolution" of NEPA and the Forest Service over the first 20 years of NEPA implementation, asserting that the Forest Service has integrated NEPA into its basic decision-making process but cautioning that the high complexity, cost, time constraints, and public debate regarding Forest Service decisions warrant changes in the way those decisions are made.

Many of the Ackerman (1990) observations are relevant to NMFS. For example, he asserts that NEPA's procedures are "better suited to discrete projects than to the continuous and dynamic land management programs implemented by the Forest Service." Whereas failure to act on a proposed project merely preserves the status quo, failure to act on a new land management policy serves to perpetuate past practices, which may be harmful. Furthermore, the multiple layers of required analyses require huge amounts of time, money, and manpower, yet they are never finished and must be continually updated. And because of the political nature of complex resource allocation decisions, the final decision is never permanent or easily defensible. Ackerman (1990) questions whether NEPA can be efficiently and effectively applied to broad, complex, dynamic, and ongoing programs, and suggests that Congress should provide clearer policy guidance.

Mattix and Becker (2002) review issues of scientific uncertainty under NEPA. Since 1986, CEQ regulations have required agencies to obtain incomplete and unavailable information in an EIS when it would not be exorbitantly expensive, and it would be relevant to reasonably foreseeable significant

[15] Of course, the degree of environmental protection will be largely dependent upon the agency's final choice of alternatives. Agencies may choose the environmentally preferable alternative, but are not required to do so (Bass et al., 2001).

[16] See also R. A. Carpenter, "The Case for Continuous Monitoring and Adaptive Management under NEPA," in Clark and Canter (1997).

adverse impacts. However, NEPA regulations do not specify when and under what conditions scientific uncertainty mandates preparing an EIS rather than an Environmental Assessment (EA). These issues are intensified when stakeholders point to scientific information that seems to conflict with the agency's science. Mattix and Becker (2002) observe that court decisions are inconsistent on this issue, and suggest that regulatory guidance from CEQ is needed.

Sociocultural Issues

Ultimately, successful fishery management relies on effectively changing human behavior. This includes the people managing the resource as well as those harvesting it. Therefore, it may be useful to examine the agency decision-making process in light of nonscientific social and cultural factors. The literature summarized in the following section highlights misunderstandings that arise from different goals, incentive structures, and ways of legitimizing knowledge. This body of literature is particularly helpful in understanding why within the same agency different people, such as scientists and lawyers, may have radically different interpretations of the same situation, and what might be done to improve communications.

Science and Law: The Culture Clash

Science, law, and politics represent radically different modes of legitimating public decisions. Schuck (1993) argues that the science-law-politics conflict is fundamentally cultural. It lies near the center of important public debates, even when it goes unrecognized. Schuck (1993) analyzes the cultures of science, law, and politics by examining the central values to which members of the culture subscribe, the incentive structures that motivate the culture's members and the decision techniques they employ, and the characteristic biases and orientations of the culture.

Science Scientific facts are constructed and validated through a social process dominated by those in the scientific community with the authority to do so, and shaped by the scientific paradigms of the period. Although science is socially embedded, its culture is not as flexible, indeterminate, and relativistic as that of law and politics. Science is committed to a conception of truth reached through a conventional methodology of proof based on the testing of falsifiable propositions. Scientists subscribe to rigorous standards of empirical observation and proof. Principles of peer review enforce a norm of extreme caution.

Law Unlike science, legal principles are rooted in propositions about how things should be, not how the world actually works. Law seeks legitimacy by generating outcomes that are perceived as just and morally correct by the general public, not just the experts. Law operates under pressure to resolve disputes quickly and conclusively, and its findings are treated as final and authoritative. Science, in contrast, seeks to develop a professional consensus on the truth of its propositions. This often takes a long time, and even then it can be open to revision. Yet the law's demand for immediate and conclusive dispute resolution may force legal decision makers to choose prematurely among competing scientific theories.

Politics Important process values include participation, accountability, and conflict management. Politicians are driven by the need to build and maintain a winning electoral coalition. Political decisions tend to be "spasmodic and impulsive." The preferred decision technique is bargaining to a consensus, a process that is complex and continuous. Compromise of principle is inevitable. Political culture embraces many populist premises that science and (to a lesser degree) law repudiate.

Science, politics, and law commonly converge at their peripheries in the context of a multicultural issue. This demands a complex decision-making structure that can somehow integrate the conflicting values. Society must negotiate the relative weights of the conflicting values in an ad hoc fashion; this is messy and indeterminate, but it is a condition of liberal-democratic-technocratic society that we simply must learn to live with and manage better. Schuck (1993) argues that the culture with the ultimate decision-making authority in any given situation should infuse into its decision process the relevant values of the other cultures.

Condlin (1999) observed a group of lawyers and scientists discussing a complicated interdisciplinary problem to study cultural tensions and communication problems. He found that lawyers converse in ways that are difficult for scientists to understand, thereby exacerbating the natural cultural tension between law and science. Condlin, himself a law professor, scathingly described the lawyers as "seemingly driven by a kind of disciplinary imperialism," looking at the issue solely from an insular and legalistic worldview which the scientists must adopt for communication to occur. They were combative, with a propensity to filibuster and unilaterally control the discussion. They expressed their views in an overstated and authoritarian manner. Condlin (1999) concluded that lawyers need to improve their conversational techniques and adopt a richer, multifaceted concept of their professional role outside the courtroom.

Antypas and Meidinger[17] synthesized scholarship on science-intensive policy disputes, drawing on literature from political science, sociology, and knowledge utilization regarding how such disputes occur, who is involved, and approaches for handling problems. They argued that because science is systematically applied to many policy arenas, it has become indispensable to social institutions. Yet because society imbues science with multiple, sometimes ambiguous, meanings, science-policy disputes "do not occur in a neutral social field." Topics include knowledge limitations, hidden values and conflicts, institutional cultures, societal views of science, science and advocacy, and sociology of science, among others.

Sociology of Science

The theory of sociology of science holds that "facts" are not purely objec-

[17]Antypas, A., and E. Meidinger. Science-intensive policy disputes: an analytic overview of the literature. May 1996. Unpublished report. Available at http://www.law.buffalo.edu/homepage/eemeid/scholarship/scipol.html (accessed 7 May 2004).

tive observations; rather, they achieve the status of fact only if produced according to socially derived agreements about the rightness of particular theories, methods, techniques, and review processes (Jasanoff, 1982; 1990; 1992; 1995). Perceptions of scientific "reality" are colored by contextual features such as scientists' professional, institutional, political, and cultural affiliations. Scientific claims are always contingent on factors such as the experimental or interpretative conventions that scientists have agreed to. The dominant scientific paradigm strongly influences how research questions are posed and shapes expectations as to the results. When disputes erupt, parties attempt to discredit each other's claims by assaulting these underlying contingencies and labeling the science as "junk." Scientists preserve their authority to set this agenda by engaging in "boundary work"—defining who has the prestige and authority to certify scientific results as legitimate.

These concepts do not apply solely to scientists. Jasanoff (1992) argues that courts should familiarize themselves with sociology of science in order to "dispel unrealistic and overly romanticized views" of the court's ability to reveal "truth." She argues that sociology of science offers a principled basis for evaluating legal rules of evidence and provides a more complete account of what really takes place when courts engage in scientific factfinding.

Jasanoff (1995) focuses on the role of courts in the development of what becomes accepted as scientific, technical, and medical knowledge. She acknowledges the science-law culture clash, but suggests that science and law also complement each other's shaping of scientific research and knowledge. She also argues that courts have played a positive role in democratizing science by forcing experts to explain their findings in terms understandable to laypersons. "Good science" alone cannot solve problems at the junction of law, science, and technology because science is not free from moral and policy choices. She examines the intersection of science, technology, and law in the legal system's construction of scientific knowledge and its management of technological change, using examples from case law to illustrate how courts construct their own version of scientific "truth."

Caudill (1999) discusses "science wars," the debate about the scope and authority of science in the legal arena. Critics of science emphasize its historical, social, rhetorical, political, moral, and gendered aspects, while defenders of science emphasize its linear and progressive nature, based on testable and falsifiable hypotheses. Caudill asks, "what is the appropriate response from lawyers, judges, legislators, and legal scholars?" One option is to simply ignore the critique of science and its institutions as too radical. If so, the law will reflect traditional notions of science as the arbiter of truth about reality. At the other extreme lies full-scale adoption of the social constructivist view of science. But law requires science to produce reliable knowledge about the natural world.

A third option was fashioned by the United States Supreme Court in the landmark case *Daubert* v. *Merrell Dow Pharm.*, 509 U.S. 579 (1993).[18] This approach upholds the importance of sound scientific methodology as it appears in scientific journals, but also encourages flexibility among gatekeeper judges by sometimes permitting unpublished theories which are well-grounded and innovative. Unfortunately, judges who naively idealize science may assume that if two experts disagree, one of them must be using "junk science." A more sophisticated view acknowledges the court's need to resolve the dispute at hand, while accepting that future revisions in scientific understanding are an essential aspect of the scientific method.

Radical critics of science have charged that scientifically derived "facts" are no better than opinion or conjecture in representing an objective "truth" (Caudill, 1999). This perspective seems extreme (because it ignores science's commitment to empirical data) and impractical (because even contingent science is superior to raw conjecture and superstitious belief). Nevertheless, when seen from a moderate perspective, sociology of science should be considered as a useful and valid theoretical lens for examining unspoken assumptions that may exert a powerful influence in the decision-making process.

Social Psychology and Law

This area of inquiry is a fascinating rising star in the field of interdisciplinary legal commentary. Blumenthal (2002) characterizes the use of social science, and psychology in particular, to inform legal theory and practice as "fast becoming the latest craze in the pages of legal academia."

Fishery managers and scientists are often confronted with the challenge of influencing stakeholder beliefs in an atmosphere of high uncertainty. Fox and Irwin (1998) advance a framework for organizing the six sources of information on which listeners rely when updating their beliefs under conditions of uncertainty: 1) the listener's prior beliefs and assumptions, 2) the listener's interpretation of the social and informational context in which the speaker's beliefs were formed, 3) the listener's evaluation of the speaker's credibility and judgmental tendencies, 4) the listener's interpretation of the social and motivational context in which the statement was made, 5) the listener's understanding of information conveyed directly and indirectly by the speaker, and 6) the listener's interpretation of the social context in which the statement was embedded. This study suggests that it may be useful to examine whether norms of scientific communication come across as unpersuasive from a legal perspective. For example, judges are accustomed to legal modes of discourse, which emphasize certainty and persuasiveness. In this light, the language used by scientists in environmental documents might seem weak, uncertain, and consequently unpersuasive.

Langevoort (1998) performed a comprehensive literature review applying behavioral psychology to law. He focused on the cognitive psychology literature on decision-making biases (i.e. the tendency to make judgments and

[18] See Jasanoff (1995) for a detailed analysis of this case and its impact on admissibility of scientific evidence in the courtroom.

decisions departing from economists' rational choice model). For example, the tendency to weigh losses more heavily than gains leads people to frame decisions in terms of potential wins/losses. This literature can be helpful for explaining agency behavior. Langevoort shows how new behavioral decision-making research is being applied by legal scholars.

Very few scholars have applied these ideas to the fisheries management arena; more work in this area is needed. One notable exception is provided by Thompson (2000), who applies empirical social psychology research to examine why dilemmas like "the tragedy of the commons" are so difficult to solve, and why it is so difficult for resource users to confront resource problems rationally.

First, resource users must reduce their current level of consumption in order to preserve the resource for future use. However, people tend to view this trade-off as giving up a current right, and social psychology research shows that most people are willing to risk huge future potential losses in order to avoid the certain, immediate loss incurred by temporarily restricting their current level of resource use. People tend to be overly optimistic about the future, believing that they will be able to avoid or ameliorate future risks. Second, in conditions of high scientific uncertainty, people faced with tough choices "engage in tremendous wishful thinking," overestimating the abundance of the resource and underestimating the threats. Third, in formulating rules for spreading the regulatory burden around, people egocentrically believe that the fairest rule is the one that benefits them the most. Thompson suggests ways to counter these problems, such as reducing uncertainty, reducing temporal discounting, focusing on present costs, finding acceptable solutions, and engaging in discussions about fairly allocating the burdens.

The Professional Role of Scientists in a Regulatory Agency

Scientists at regulatory agencies face a special set of professional challenges. Their research must be relevant to pressing policy questions and legal requirements. Their work is subject to strict legal time constraints. They are held accountable to Congress, courts, and the public as well as to their peers. Moreover, they must work within agency "culture"—institutionalized rules, rituals, and values a group produces to confront common problems (Vaughan, 1996)—which may carry its own political pressures. Thus, the role of agency culture deserves a closer look as a potential aspect of the litigation situation.

An ongoing topic of debate is the extent to which scientists should be segregated from decision makers in the policy process. It is commonly assumed that strict separation is essential to ensure that the scientists are not unduly influenced by political pressure from the decision makers. But many commentators argue that science advocacy is not necessarily inappropriate. Like Jasanoff (1990), Shannon et al. (1996) argue that the strict separation of science from administration is not the panacea it may appear to be.

Regulatory science intrinsically involves policy and values, and it is undesirable to pretend otherwise. Applied science does not just produce a "bucket of facts"; rather it has the potential to transform how society interacts with natural resources. Integrating scientists into the management process allows them to study the application of scientifically-based management approaches and provide the necessary critique of management. Furthermore, "managers gain the creativity of scientists in developing new solutions to complex problems and profit from the culture of critique and inquiry distinctive to scientists" (Shannon et. al., 1996). They advocate discussions among scientists, decision makers, and the public on what kinds of science advocacy are appropriate, and under what conditions.

Similarly, Clark et al. (2002) argue that conservation biologists should learn and apply "policy orientation," which encourages the integration of biological and social sciences to help managers, leaders, and the public make sound choices and solve problems effectively. A policy orientation can complement rigorous scientific methods and help achieve conservation goals without sacrificing scientific professionalism. Conservation biologists need to understand the policy process well enough to maximize opportunities for applying science-based recommendations. They must walk the narrow line between science and policymaking, addressing concerns raised by both. They must produce (or at least support) reliable research and participate in the socio-political context where that information is used. They should develop a useful "map" of the policy process and subsequently learn how to influence the process.

Mills and Clark (2001) argue that research scientists can and should contribute to natural resource management formulation; however, because working in the science-policy interface is inherently political, they must be very careful not to jeopardize their scientific independence. Some suggestions for accomplishing this difficult task include: understanding the political environment, learning how to translate management questions into science questions, clarifying uncertainty and risk, maintaining rigorous quality control, and refraining from advocating a particular policy outcome. They argue that science can be value-neutral and can help focus discussion on choices and consequences, thus increasing the likelihood of management success.

Lach et al. (2003) surveyed scientists and nonscientists, asking whether scientists should act as policy advocates and, if so, in what way. Most nonscientist respondents preferred scientists to "work closely with managers and others in integrating scientific results into management decisions." Scientists, while supportive of this role, preferred scientists to "report and interpret scientific results for others who are involved in natural resource science." There was much less support for allowing scientists to advocate for or make specific decisions. Many scientists expressed concern that their credibility would suffer if they became more involved in decision making. There were also different preferences for the way scientists should communicate information. Scientists preferred to communicate directly within the scientific community or the agency. Managers emphasized communication to themselves and the public through on-site demonstrations, but preferred to transmit and interpret the information to the public themselves. Lach et al. (2003) concluded that most scientists would support a more activist, integrative role in resource management, but that they would have to communicate more effectively with managers and non-scientist groups to effectively integrate scientific information in the decision process.

Wallace (2003) analyzed the decision-making behavior of agency personnel in five marine mammal recovery programs to discover what factors participants believe affect their recovery programs and how these factors influence decision making. He found that decision-making and participant interactions are strongly influenced by social factors such as leadership characteristics, communication, teamwork, the presence or absence of evaluation, and the development of prototype programs that incorporate and apply social factors to problem solving. Throughout the policy process, social behavior was influenced by the participants' values (power, wealth, knowledge, skill, respect, affection, well-being, and rectitude). If they could maintain or increase desired values while promoting species recovery, they did so; if not, species recovery suffered. Improved communication between agency leaders and staff members might reduce discord but is not likely to overcome the effects of political pressure. He argued that agency leaders should shun defensive decision-making strategies, focusing on species recovery. They need to recognize and support staff that provide data-based and problem oriented decision choices; these people are sometimes ignored or even reprimanded.

Mattson (1996) sees multiple barriers to the ethical practice of regulatory science. Applied research is designed to generate information directly relevant to resource decisions, which places political pressure on agencies and may make scientists partly responsible for management decisions. Researchers may become subsumed in management culture, which values cooperation, obedience, loyalty, and being a team player. Agency scientists may feel pressure when research results are at odds with prevailing political and social forces. And access to the research problem is controlled by the agency. Although most agency scientists do not behave unethically, these circumstances may make transgressions more likely. Mattson (1996) argued that ethical behavior can be promoted through institutional measures that affect personal incentives. These include keeping agency scientists in a separate administrative branch, alleviating monopolistic research arrangements, deemphasizing the importance of conformity, and using professional science organizations as mediators.

Suggestions for Future Research

Several key themes were repeated throughout this literature review. Interestingly, many of them run counter to conventional wisdom. Chief among them is the idea that more and better science does not automatically improve resource management and policy. The "science charade" is a consequence of inadvertent or deliberate attempts to pretend that trans-scientific problems can be solved by science alone, exacerbated by Congress's penchant for using broad, vague language to delegate thorny resource management policy decisions to agencies. Moreover, the complex network of laws governing marine resource management may sometimes hinder attempts to practice adaptive management or ecosystem management.

Many commentators find it instructive to examine the differing cultures and socially constructed aspects of law and science as a means of getting at pervasive, unstated assumptions that hamper communication. These themes suggest the following potential research questions that deserve closer scrutiny in an effort to shed light on the role of NMFS scientists and managers in the process of helping the agency meet its legal requirements.

1) A recent litigation review (NAPA, 2002) suggests that NMFS actually wins most science-based challenges, but its losses are often because it fails to provide a rational connection between the evidence in the administrative record and the action. Given that courts will defer to the agency's decision if it is adequately explained, why does NMFS fail to provide sufficient reasoning to support its decisions? This will require a deeper look at institutional factors governing science-policy integration at NMFS. What is the role of the "science charade"? Can scientists participate more actively in the management process without straying from the central values of their profession, and if so, how?

2) There is very little legal guidance on the proper depth and breadth of a PEIS, as well as how to tier site-specific analyses to the broad programmatic document. A recent CEQ study (2003) indicated that NEPA practitioners and affected stakeholders could benefit from a better understanding of how to do a programmatic analysis. It would be useful to review this issue in the fishery management context and to consider whether guidance is needed.

3) A focused, updated litigation analysis may be helpful. While the NAPA litigation analysis summarized recent cases and revealed general trends, more could be done. For example, the NAPA (2002) recommendations to NMFS tended to simply restate legal standards[19] and as such are not especially helpful in crafting strategies for courtroom success. What lessons can NMFS learn from the experience of other agencies such as the Forest Service and the EPA, which have extensive experience dealing with litigation crunches?

4) It may be useful to take a closer look at how emerging ecological theories clash with environmental laws. Current efforts to deal with this problem are focused on ways to introduce new ideas into the structure of existing laws, but there may be other ways to do this. For example, NEPA's requirement to assess cumulative impacts presents an opportunity to incorporate ecosystem management ideas into the environmental impact assessment process.

[19] NAPA recommended that "appropriate alternatives must be studied, developed, and described when preparing EA's and EIS's" and "threatened and endangered species must be listed under the appropriate legal standards."

5) The Steller sea lion dispute presents an excellent opportunity for a case study of resource management under high scientific uncertainty and legal complexity, focusing on the legal, institutional, and scientific factors that hampered efforts to reach consensus.

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