Technocracy, Democracy and the Role of Scientists in Natural Resource Policy

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Abstract

The complexity of modern environmental problems has increased appeals for including scientific research and findings in natural resource policy decision making. Though scientists, resource managers, interest groups, and the general public support more science-based environmental policy, these preferences have been accompanied by growing calls for decentralization and democratization of policy decisions, where citizens and stakeholders would have an increased role in deciding official management strategies. This essay compares results from a recent study that targeted marine ecology scientists and other professionals with those from two previous studies that examined terrestrial ecology scientists, natural resource managers, interest groups, and the public concerning the role of science and scientists in natural resource policy processes. I find that though the two groups share similar beliefs regarding humans and the environment, significant differences exist between marine ecology scientists and the terrestrial ecology scientists from previous studies in terms of their beliefs about positivism, their favored role for scientists in public policy, and their perceived value of citizen participation in government processes.

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INTRODUCTION

The primary purpose of this essay is to explore the appropriate role of scientists in natural resource policy making processes, and additionally, to discern whether or not significant differences exist between marine ecologists and terrestrial ecologists regarding their opinions and beliefs about positivism and the relationship of humans to the environment. Likewise, this query lends further support to a controversial debate that is ongoing in the field of public policy and administration, namely the technocracy/democracy quandary, which involves reconciling the rightful role of experts and non-experts in public policy decision making arenas (Fischer, 2000). With regard to natural resource policy, this relationship is growing in importance, as nations attempt to enact optimal management strategies for potentially scarce natural resources in the context of accelerated global environmental changes.

Prior research and various studies have already addressed these themes and issues in great detail (e.g., Goggin, 1986; Pierce et al. 1992; Fischer, 2000); however, the results reported in this essay provide a new contribution to a specific body of comparable literature (Lach et al. 2003; Steel et al. 2004; Steel, Warner and Lach, 2008). The new data come from a survey administered to marine scientists, resource managers and others over the summer of 2010. This survey was conducted to aid an external review of the North Pacific Research Board (NPRB), which recommends marine research initiatives to the US secretary of Commerce and provides funding for research conducted in the North

Pacific Ocean. Potential respondents to the survey had either applied for an NPRB research grant over the past three years, or were likely to have conducted or used research products similar to those funded by the agency.

Overall, the results from this study suggest that significant differences exist between marine and terrestrial scientists. Marine scientists in our sample held significantly higher positivist orientations towards science than terrestrial scientists from previous studies. They were also more supportive than terrestrial scientists of an integrative role for scientists in natural resource management, where scientists would work closely with managers to make resource decisions instead of merely reporting or interpreting the results from their research. Marine scientists also appear to hold a higher opinion than most terrestrial scientists of elected officials, interest groups and the public in terms of their understanding of ecological science; however, they value citizen participation in policy processes significantly less than do terrestrial scientists. No significant difference between marine and terrestrial scientists was found with relation to their beliefs about the environment, where both groups tend to demonstrate high levels of agreement with modern environmental principles.

An overview of relevant literature is presented in the following review, beginning with a brief history of natural resource management. A discussion of positivism follows, as does an inquiry into the proper role of scientists in natural resource decision-making processes. The developments of more modern environmental paradigm shifts are discussed, after which the technocracy/democracy quandary is thoroughly examined. Two recently developed models of ecosystem management are compared before moving on to a relevant set of previously conducted studies. The approach and methods sections of this report are then addressed, followed by the study's findings and a discussion of the results. Finally, policy recommendations and the conclusion of this report are presented along with suggestions for future research.

LITERATURE REVIEW

Natural Resource Management

Natural resource management involves the decisions and actions of policy makers and resource managers in allocating and directing usage of natural resources within particular geographical jurisdictions (Davis, 1997). Natural resources include fresh water, mineral and fossil fuel deposits, forests, animal stocks, and various other forms of environmental wealth. Natural resources can be renewable or non-renewable, but even renewable resources such as forests can be exhausted when subjected to improper management, potentially resulting in scarcity, environmental degradation, or lost opportunities in terms of future usage.

As popularized by Garret Hardin in the 1960s (and followed by substantive revisions from others since then), unlimited access to a natural resource by an expanding population can lead to ruination of that resource when left unmanaged (Hardin, 1968; Diamond, 2005). To prevent this "tragedy of the commons" and limit the pursuit of personal maximum utility in a commons at the expense of other users, official public management structures (as opposed to communal agreements and more personalized community arrangements) have been developed under the pretext of preventing over-utilization of most natural resources, particularly in the US and other modern industrialized nations. These structures have often involved privatization of natural resources to encourage responsible usage practices; however, vast geographical areas and public goods remain under the direct authority of federal, state and local governments.

While natural resource issues involving water, energy, agriculture, timber harvesting, mining, fishing, and rangelands all have unique histories and challenges, regulation of these resources has generally shared a common initial purpose in that their "policies were originally developed within a distributive policy context to encourage industrial growth and provide economic opportunity" (Davis, 1997, p. 74).

More recently, the mission of managing these resources has fallen under a general collective principle, that of sustainability. While notions of sustainability reflect traditional principles of responsible resource management (which are by no means new), more recent applications of the concept have manifested, which specifically acknowledge the interconnected nature of regional resources to each other, to users, and to the rest of the world more broadly (Conca and Dabelko, 2010). Notions of sustainability are increasingly tied to stated socioeconomic goals, and developing in a sustainable manner has become an expressed priority of U.S. officials and many others in the international community.

Generally speaking, "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"

(WCED, 2010, p. 207). This stated goal contains two key concepts, one of "needs," and "the idea of limitations imposed by the state of technology and social organization on the environments ability to meet present and future needs" (WCED, 2010, p. 207). Out of this proclaimed desire for more thoughtful development, the concept of a sustainable economy, which relies on sustainable resource usage practices, has also risen greatly to prominence.

As defined by Press and Mazmanian, "the concept of a sustainable economy has several meanings but is essentially analogous to a healthy biological system in which little is wasted and human activity does not significantly undermine species diversity and resource availability" (2000, p. 259). Though growing scarcity of natural resources and public awareness can both help to promote cooperation, formal public policies are sometimes necessary to aid and direct consumptive practices if the collective effect of individual practices becomes dangerously detrimental when left unaccompanied by official oversight.

In order to achieve the expressed goals of sustainability, governments create and implement regulations for existing natural resources that dictate management methods and guidelines for resource extraction and utilization through the use of various public institutions. While it is typically the job of government to regulate industries that extract and utilize natural resources, science has been increasingly called upon to inform regulatory policy development at all levels of government (Johnson et al, 1999).

In order to regulate natural resources, governments have to decide what practices are to be regulated, and in what manner. In the US, command and control methods were initially utilized for this purpose almost exclusively (Davies and Mazurek, 1997). Though various US agencies influence management of natural resource practices in this respect, the Environmental Protection Agency (EPA) provides a particularly illustrative example. The EPA was created to oversee U.S. environmental regulatory processes, while resource managers from states and local governments were primarily responsible for implementation. According to Davies and Mazurek (1997, p. 5), EPA officials would:

> declare acceptable pollution standards, specify the appropriate control technology for every regulated pollution source, issue each source a permit specifying the acceptable limit of its pollution emissions, and enforce the standards through inspections and, if necessary, legal action, including fines.

While the EPA met with success in some instances, command and control methods became increasingly unpopular in the eyes of Congress and the private sector, and increasingly unable to address non-point source pollution. It was generally agreed that the system utilized far too much micromanagement, limiting flexibility of both the EPA and regulated industries. In response to these concerns, the EPA began making use of economic incentives as opposed to direct regulation. These new practices included taxing units of pollution (as opposed to setting limits), as well as providing tradable discharge permits that gave some industries more flexibility in complying with federal pollution reduction goals (Freeman, 2000).

The EPA also began to officially endorse risk assessment and risk management practices as a method for policy decision making. As defined by Covello and Menkes (1985, p. xxiii), Risk assessment can be understood as "the process of obtaining quantitative measures of risk levels, where risk refers to the possibility of uncertain, adverse consequences." Thus, the EPA began focusing on the identification of risks, often related to health hazards, and the likelihood or probability that these particular risks would occur.

In order to identify risks and their likelihood of occurrence, regulators increasingly turned to professionals in scientific fields to aid in analyses. The process that materialized from these methods came to be known as quantitative risk assessment, which is now used to varying degrees by all federal environmental and health regulatory agencies. This reliance on science and scientific findings has leant an air of legitimacy to many regulatory processes, where agencies can report tangible results from collected data and provide quantifiable products to justify particular choices or decisions. This reliance on scientific method however, as well as the acceptance that it garners from regulated entities and the public, reflects deeply set social expectations concerning the value of science and the validity of various results and findings.

Positivism

Levels of trust or faith in science are not universal, but rather come in degrees. Most people generally have a respect for the objective nature of scientific processes, which have generated important historical and technological innovations while benefitting a broad range of groups in society. However, extreme positivism, another type of faith in science, reflects deeper conviction in an alternative world view, one in which science and science alone is capable of making definitive statements or conclusions about the world and nature of reality.

Positivism more generally, for the purposes of this study, is meant to describe the widely held belief that science and the scientific method provide the most accurate tools for understanding and predicting bio-physical phenomenon (Steel et al. 2004). While there is no consensus in the realm of positivist thought, positivists tend to view the functions of the universe through laws of cause and effect, and similarly believe that science can be used to understand, separate and define these laws. Science is valued for its repeatability, its perceived objectivity, and its general success in terms of advancing cultural and technological development. Leanings towards positivism typically describe faith in science to solve problems, uncover truths, and make sense of reality; those with a strong positivist orientation place high value on the ability of science to discern a truth independent of human thought, while remaining fundamentally accessible to any and all individuals (Scruton, 1982).

The degree to which individuals hold positivist perceptions can directly influence their preference for the role of scientists and science in everyday life, including public policy formation and natural resource management decisions. As such, perceptions of science from both experts and groups of the public have the potential to deepen conflict within policy making arenas. A faith in science to solve problems is not a recent development, but scientists have traditionally been expected to maintain a certain level of distance from particular public policy processes. The extensive and pervasive nature of modern problems however, particularly with regard to natural resources and the environment, has caused a major shift in some circles of thought that challenges the traditional roles of science, and consequently seeks a more involved role for scientists in certain decision making arenas because of their unique professional expertise (Levien, 1979).

Role of Scientists

Traditionally, the role of scientists with regard to natural resources has been as objective evaluators, and advocacy by scientists on behalf of particular actions or policies has generally been perceived as unprofessional. Scientists have typically elected (and been strongly encouraged) to inform policy makers, resource managers and general members of the public using three general approaches:

- Active informing (directly informing policy makers and other interested parties as experts using data and information directly related to particular issues)
- Passive informing (generation of publications and information for policy makers and other relevant audiences)
- Indirect informing (training students and collaborating with next generations of scientists).

This traditional role of scientists contrasts with emerging expectations that science and scientists become more directly involved in particular public policy and management practices. The contrast between emerging and traditional roles of scientists in policy is well demonstrated by two diverging (but not mutually exclusive) perceptions of advocacy. On the one hand, advocacy can be seen as beneficial normative declarations by informed experts; on the other, it can be perceived as the stretching of data or truth to strengthen a larger or weakly related agenda. To complicate matters further, a number of arguments suggest that scientists are already routinely involved in covert advocacy or "stealth policy advocacy" (Lackey, 2007). Also referred to as 'normative science,' stealth policy advocacy refers to science that is "developed, presented, or interpreted based on a tacit, usually unstated, preference for a policy or class of policy choices" (Lackey, 2007, p.6). Admittedly, such an interpretation, while useful to consider, is vulnerable to post modern critiques, which would counter that *all* science is socially constructed, driven by values, and thus normative (Rosenau, 1992).

Though scientists are not generally discouraged from serving in management agencies (e.g. Jane Lubchenco, Undersecretary of Commerce for Oceans and Atmosphere), their role as researchers has typically been to inform other participants in policy arenas. So while certain scientists may conduct pressing research with important implications for particular policy issues, it has largely been up to congressional officials, agency managers, and interest groups to interact with applicable literature and science and then translate the results into policy proposals.

Recent research demonstrates that the public and managers would be relatively open to an increased role for scientific advocacy in natural resource decision making, but scientists themselves are generally reluctant to openly endorse an increasingly technocratic system (Fischer, 2000). These perceptions are gaining in relevance because of growing trends towards environmentalism, where concern for the environment, as opposed to simply maximizing the efficiency of natural resource usage, is contributing to an extensive paradigm shift that began emerging significantly during the previous century (Brown and Harris, 1992). These shifting perceptions of the environment have served as a catalyst for many individuals to request a greater role for scientists in natural resource policy making arenas, where policies could benefit directly from their professional expertise.

Humans and the Environment

As stated previously, most early public policies with regard to natural resources were designed to provide optimum economic opportunity and encourage industrial growth (Davis, 1997). However, the norms that resulted from these early developmental policies are now often at odds with changing demographics, growing environmental awareness, and the strain caused by rising affluent population levels (Inglehart, 1997). By many metrics, these policies are now ill suited to address the complex challenges and issues which accompany increasingly constricted natural resource allocation and distribution practices.

The modern environmental movement, which encapsulates these various concerns (i.e., pollution, environmental degradation, habitat destruction, decreasing biodiversity, endangered species, etc.), is a part of evolving value transformations that began during the decades following World War II (e.g., Dalton and Kuechler, 1990; Rosenau, 1992). The new stage of socioeconomic development and prosperity, primarily within western industrialized democracies, ushered in what has since been labeled “post-industrialism” (Rosenau, 1992). Post-industrial societies generally share a set of common traits:

> Economic dominance of the service sector over those of manufacturing and agriculture; complex nationwide communication networks; a high degree of economic activity based upon an educated workforce employing scientific knowledge and technology in their work; a high level of public mobilization in society (including the rise of new social causes such as the civil rights movement, the anti-war movement, the anti-nuclear movement, the environmental movement); increasing population growth and employment in urban areas (and subsequent decline in rural areas); and historically unprecedented societal affluence (Steel, 2009, p. 2).

In many instances, this new post-industrialism caused “altered individual value structures among citizens (particularly younger persons) such that ‘higher order’ needs (self-actualization) have supplanted more fundamental subsistence needs (basic needs, material acquisition) as motivation for much societal behavior” (Steel, 2009, p.2). As a consequence, these new value structures began to deeply affect people’s perception of the environment, as well as their own interaction with and perceived placement within it.

What generally emerges from these changes and their history, are two dominant and competing natural resource management paradigms. Among other labels, these paradigms have been identified as the “Dominant Resource Management Paradigm (DRMP),” and the “New Resource Management Paradigm (NRMP)” (Brown and Harris, 1992**)**. The DRMP is commonly associated with anthropocentrism, and tends to view nature and natural resources in terms of their usefulness to humans in a consumptive or service oriented sense. The NRMP, the newer of the two paradigms, is commonly associated with biocentrism, a perception of natural resource management where the welfare of all elements in any particular ecosystem or environment, outside of their strictly economic value, is to be taken into consideration when making natural resource management decisions (Taylor, 1986).

Though outspoken concern for environmental preservation in the US can be found as far back as the 1800s with the writings and activities of John Muir, Henry David Thoreau and many others, this movement picked up considerable momentum during the latter half of the twentieth century. According to authors Vig and Kraft (1997, p. 27):

> Over the past three decades, public concern and support for environmental protection have risen significantly, spurring the development of an expansive array of new policies that substantially increased the government's responsibilities for the environment and natural resources, both domestically and internationally.

The U.S. government has designed and implemented national land management policies for over a century, but official developments framed in terms of environmental preservation did not fully emerge with substance until the 1960s, when congress passed the Wilderness Act and approved the Land and Water Conservation Fund Act. Water pollution mandates had been around since the 1940s, but these were largely unenforced or neglected until passage of the Clean Water Act in 1963. Environmental policy escalated throughout the 1960s and 70s, which saw strengthening of the Clean Air and Water Acts, passage of the National Environmental Policy Act, and establishment of the Environmental Protection Agency. While these were seen as positive developments by many concerned constituents, enforcement and direction of U.S. environmental regulation proved to be problematic.

> The policies have not been entirely successful, particularly when measured by tangible improvements in environmental quality. Given the country's persistent and severe budgetary constraints, further progress requires that the nation search for more efficient and effective ways to achieve these goals (Vig and Kraft, p. 27).

In part because of the difficulties and costs that environmental regulations can impose, there has been increasingly visible struggle between proponents of the DRMP and the NRMP. Though some common ground can be found at times between anthropocentric views of the environment and biocentric ones, the two place different priorities in certain contexts that are often impossible to reconcile. As a result, the conflicts between advancement of human socio-economic development and preservation of stable ecosystem function often produce extreme polarities.

While several differences separate the two paradigms, many of the concerns expressed by members within the environmental community mirror those that prioritize responsible consumption of natural resources (e.g. energy efficiency, air and water quality, preserving the function of ecosystems). As some environmental problems persist, grow, and spill over into multiple arenas, modern developments are forcing the increased regulation of many individual practices. Outlining 'why' or 'if' these measures are necessary is an important issue to address, but growing efforts have been directed at 'how' such decisions should be made, and 'who' should be making them (Van Bouwel, 2009).

As traditional natural resource management practices are increasingly brought into question, advocates attempt to reconcile the desire for more science driven policy with deference to the conflicting wills of increasingly active interests and constituents. Ultimately, this growing confrontation is about the proper role of experts and non-experts in deciding natural resource policies, as well as in reconciling the differences between technocracy and democracy.

The Technocracy/Democracy Quandary

At heart, the technocracy/democracy quandary highlights tension between democratic governance and professional expertise with regard to increasingly complicated and interconnected public management decisions, where difficulty is expressed in determining the optimum role or level of citizen participation as non-experts (e.g., Goggin, 1986; Pierce et al. 1992; Fischer, 2000). Ultimately, this perspective questions the knowledge or competence of the attentive public, and their ability to add to relevant discourse in a way that meaningfully contributes to political decision making. Conversely, the rightful role of experts is also questioned, particularly with regard to scientists, who traditionally have been discouraged from engaging in direct advocacy of particular management decisions.

Recent academic queries have addressed this increasingly visible quandary between technocracy and democracy, and a large body of foundational literature addresses several theoretical dimensions of the debate. While such disputes can and do arise in many policy arenas, these conflicts are more likely to arise when management decisions involve science, technology and the environment (Fischer, 2000).

The higher likelihood of conflict under these circumstances is fairly straightforward. Environmental problems are typically intertwined with natural resource decisions, and often involve substantial economic interests and a wide variety of actors who compete for access to limited resources. Science is often relied upon to help settle differences, but the results of scientific inquiries can be ambiguous, without clear directives for specific policy application, making them more or less open to interpretation by opposing interests. Technology can exacerbate these situations, by posing unproven solutions or by providing opportunities and incentives for new interests to enter problematic issue arenas.

All three of these variables—the environment, science, and technology—are inherently subject to uncertainties, which cannot be fully known, leaving doubt as to the optimal arrangement or solution to particular disputes. With regard to such conflicts, public officials and resource managers have had to balance the principles of democracy and technocracy when implementing decisions in these sensitive policy arenas.

This quandary is typically presented in terms of a dilemma, wherein it is difficult in a democratic society to deny citizens a role in policy decision-making processes, even though it is believed by decision makers that most citizens don't have the necessary background or expertise to make meaningful contributions to traditional management strategies and discourse. This perception of the conflict presents technocracy and democracy as mutually exclusive and presumes that increasing citizen involvement in natural resource decision making is a lofty ideal, but impractical or dangerous due to non-experts' lack of prerequisite skills and knowledge.

In a very basic sense, democracy, with respect to the quandary, means increasing citizen participation in political processes. In support of this seemingly fundamental characteristic, Fischer (2000, p. 1) states that "citizen participation, defined as deliberation on issues affecting one's own life, is the normative core of democracy." Establishing a uniform definition of democracy after agreeing on this initial point, however, is often problematic as every individual has their own perception of this loaded and value laden term. However, while difficulties exist, theories of democracy tend to share a few additional key principles where "democracies are egalitarian and inclusive, such that all citizens have equal rights to contribute to, and benefit from, the political system" (Solomon, 2009, p.42).

Theories of technocracy generally reinforce the viewpoint that technical experts are in an especially unique position to inform policy processes by providing insight towards the methods that should be used to pursue the collective goals of society (Weber, 1949; Popper, 1971). Levels, degrees, and forms of technocracy vary between arenas and political systems; however, a technocrat is commonly understood to be "a social scientist—modeled on the engineer—that provides technical insight and optimal problem solving strategies to the public and society and is impartial vis-à-vis the ultimate goals the public and society should pursue" (Van Bouwel, 2009, p.3). Technocratic perspectives mirror other theories concerning hierarchical structures of authority, sharing particularly strong communalities with epistocracy, a term coined by David Estlund (2003, p. 53):

> If some political outcomes count as better than others, then surely some citizens are better (if only less bad) than others with regard to their wisdom and good faith in promoting better outcomes. If so, this looks like

> an important reason to leave the decisions up to them. For purposes of this essay, call them the knowers, or the wise; the form of government in which they rule might be called epistocracy, and the rulers called epistocrats.

Another body of literature is more critical of the experts themselves, along with their relationship to interests that are subsequently affected by professional recommendations. These authors suggest that it is not necessarily policy decisions themselves that are the rightful jurisdiction of the public. Instead, a more realistic role of the public is said to lie in setting the priority for scientific research questions as well as in what manner such research findings should be applied and disseminated, since such matters “reflect social priorities and values that are indeterminable by specialist expertise” (Solomon, p.57). This line of thought challenges the presumption that scientists and technocrats are capable of being impartial or politically neutral when carrying out sensitive public policies or responding to the collective goals of society, a crucial justification for their authority as ideal decision makers.

This is particularly relevant in regard to government usage of risk assessment and management for a wide body of public policy decision making, a tool that is becoming increasingly standard among resource management agencies. While it is difficult to formulate an alternative method that might effectively increase democratic involvement in public policy and administration, Andrews specifies a component of risk management that demonstrates the need for significant improvement:

> A key unresolved issue for comparative risk assessment was whether it really was a technical procedure to be carried out by experts, or a broader process of assigning value judgments, which should involve public input

> rather than merely the subjective consensus of technical or administrative elites…Skeptics also criticized narrowly technical comparative risk assessments for forcing false choices by comparing environmental risks too narrowly with one another, a procedure which implicitly biased the comparison by leaving out broader and perhaps more effective policy strategies for reducing risks. (200, p. 221)

As with the case of climate politics, the risk is high that management and regulatory decisions can be made with reference to selective scientific findings that benefit financial and political elites over the general good. To combat this potentiality, increasing public discourse as to the merits of particular scientific claims, where “purported scientific claims, as well as claims to expertise, need to be critically examined, rather than passively accepted” becomes a priority (Lahsen, 2005, p. 161).

Though the quandary has traditionally been addressed as a set of contrasting or conflicting principles, scholars more recently have sought to redefine the issue by attempting to determine the “realistic possibilities of meaningful citizen participation” (Fischer, xi). Such literature attempts to discern when public participation is more useful, what types of participation are most effective, and what role non-experts should play in interacting with experts. Therefore instead of merely asking whether or not citizens should even be involved in the first place, it strives to discern the most effective and practical role for citizens, experts and non-experts in typical management settings.

This approach has already been used in various policy arenas where citizen participation has been sought, and structures for developing this interaction have been placed into decision making processes. The 1970s Federal Advisory Committee Act (FACA), for example, imposed legislation to standardize openness for federal regulation, and increase notification to and participation of a wider range of constituents. However, this body of literature is in need of more quantifiable assessment, where the real-life perceptions of scientists, the public, and other professionals more generally can be collected and contrasted with more theoretically oriented works. With this in mind, two general approaches to environmental management are presented, followed by a more detailed section of recent relevant research.

Scientists and Models of Collaboration

There are two broad environmental management methods that have been subjected to significant analysis fairly recently, which have strong implications for the research presented in this report. One of the methods, Ecosystem Management (EM), focuses attention on terrestrial environments while Integrated Coastal Zone Management (ICZM) is occupied with more marine oriented applications. The EM approach has enjoyed growing acceptance and utilization among different agencies and levels of government in the United States, where managers and officials have increasingly sought the recommendations or observations of scientists to reinforce environmental and natural resource policy decisions. Dale Robertson, former head of the US Forest Service, describes EM as “a multiple use philosophy built around ecological principles, sustainability, and a strong land stewardship ethic, with a better recognition of the spiritual values and natural beauty of forests” (Robertson, 1991, p. 19). Through the exercise of this method, science and scientists themselves are placed in a position to critically influence policy design and implementation (Steel and Weber, 2001).

While EM has become increasingly popular, concerns have surfaced to challenge the technocratic aspect of the method, encouraging the devolution of authority mechanisms and an increased role for local interests and non-experts in decision making processes (Osborne and Gaebler, 1993). Though increased involvement of scientific experts, devolution of authority, and efforts to increase stakeholder involvement may seem like contradictory goals from previous management perspectives, tenants of EM have come to find stable definition from interaction between these interests. Leanings toward the use of EM methods of natural resources has heightened the roles of communities and experts, as EM has increasingly become both “a pragmatic attempt to solve increasingly intricate and complex problems of natural resource management and an opportunity to improve government performance by catalyzing many resources as possible in support of public goals” (Steel and Weber, 2001, p. 123).

A similar method, ICZM, is an integrative approach to coastal resource management that emphasizes:

> the integrated planning and management of coastal resources and environments in a manner that is based on the physical, economic and political interconnections, both within and among dynamic coastal systems, which when aggregated together, define a coastal zone (Sorenson, 1997, p. 9).

The approach values the participation of the public and stakeholders in management decision making, but some scholars of the approach have lamented what they see as the increasingly peripheral role science has taken in related integrative policies. Though scientists have accumulated vast sets of data regarding the coastal environment and fundamental understanding of coastal systems has increased considerably over the previous century:

> integrating this knowledge to understand the total behavior of the coast and applying this knowledge to achieve tangible outcomes (e.g. plans that allow the coast to adapt to long-term coastal evolution) are still major challenges for successfully managing coastal systems (McFadden, 2007, p. 441).

This line of critique seems to reflect care for the environment, a basic valuation of democratic participation, and respect for the knowledge of all stakeholders involved. However it also demonstrates strong support for a higher valuation of science in natural resource policy, as well as a heightened desire for an increased role by scientists in natural resource policy decision making processes.

Discussion of Previous Work

Various works, including these models of environmental management, have examined the theoretical and historical relationships between the democracy/technocracy quandary, natural resource management, positivism, environmentally oriented paradigm shifts, and the rightful role of scientists, experts and non-experts. Other studies (Lach et al. 2003; Steel et al. 2004; Steel et al. 2008) have operationalized these concepts through the use of interviews and surveys. These studies have targeted subsections of the population by separating and questioning scientists, resource managers, interest group representatives and the attentive public. Respondents have typically been asked a similar set of questions, which test their tendencies toward positivism, their attitudes toward the environment and natural resource management, as well as their preferred role of scientists and the public with regard to public policy decision making.

Results from these studies generally tend to demonstrate a number of similar outcomes. First of all, their results suggest that interest groups and the attentive public who have been involved with natural resource policy and management, show higher positivist tendencies and growing support for a more prominent role of science and scientists in policy making processes. In contrast, scientists in the same studies express more doubt in their ability to uncover definitive truths and facts (i.e., are less posivistic than interest groups and attentive public), and are more skeptical of an increased advocacy role for scientists with regard to natural resource decision-making. However, these scientists do show support for greater involvement of scientists in policy management generally, but in more “integrative” roles as opposed to direct advocacy (Steel et al. 2004).

Other previous studies (Shindler, List, Steel, 1996; Lach et al. 2003) seem to verify these conclusions, primarily by affirming that the attentive public and scientists are generally in favor of a more integrative role for scientists in natural resource management. These studies further suggest that some scientists and others in the non-scientist population would likely support a more activist role for research scientists in resource management. All of these studies tend to suggest that scientists will soon need to leave the comfort of their labs, as well as their traditional interactions with scientific colleagues, in order to engage agency personnel, resource managers, interest groups and the public more directly.

A recent nation-wide study replicated methods from these earlier studies, and similarly concluded that substantial differences exist between scientists, natural resource managers, interest groups and the public concerning the role of science and scientists in the environmental policy process (Steel, Warner, and Lach, 2008). The study found that differences exist between the groups about their overall agreement with positivism and positivist principles, suggesting once again that interest groups and citizens held a high preference for scientists to work more closely with resource managers to integrate their results into management decisions. Conversely, the study found that ecological scientists and resource managers were more reluctant to support an increasingly active role for scientists in environmental policy processes (Steel et al. 2008).

APPROACH

The NPRB and its research funds are the result of a legal dispute between the United States government and the state of Alaska concerning oil deposits in submerged lands along Alaska's Arctic coast. In 1979, the U.S. filed a complaint with the Supreme Court over ownership of the submerged lands. While the matter was being deliberated in court, the state and federal governments conducted joint oil and gas leasing of the submerged lands, the proceeds from which were placed in two interest-accruing escrow accounts.

By 1997, the escrow accounts had grown to approximately $1.525 billion. That same year the Supreme Court ruled that the U.S. government was entitled to nearly the full amount of the sales from the 1979 leasing. Through the Department of Interior and Related

Agencies Appropriation Act (HR 2107), the disputed monies were placed into the Environmental Improvement and Restoration Fund (EIRF). Passage of the bill thus led to the creation of the EIRF as well as the NPRB. The NPRB now provides $4-6 million in scientific research annually, based upon its portion of earnings from the interest on the EIRF (U.S. Congress, 1997).

During the summer of 2010, a survey was administered to marine scientists and other professionals in the Pacific Northwest. The primary purpose of the survey was to aid an external review of the NPRB, but several additional questions were included in the survey that asked respondents about their preferred role of scientists and the public in natural resource policy making, as well as their tendencies toward positivism and their attitudes toward the environment. Besides scientists, this most recent survey was administered to individuals working in marine oriented private industry, NGO's, tribal associations and a number of other professions. Though the various professions added versatility and could have led to interesting cross professional analysis, responses from non-scientists were not typically large enough to draw significant statistical conclusions in most instances.

The study provided a unique opportunity for directly comparing the attitudes and beliefs of terrestrial and marine scientists, because previous studies conducted by OSU researchers focused solely on terrestrial ecology scientists. In this regard, two separate studies by Steel et al, collected data from terrestrial scientists that are directly comparable to those collected in this NPRB study. The first of these terrestrial studies was completed between 1999 and 2000. Researchers initially conducted 50 face-to-face interviews with members in the scientific community in order to develop survey questions which would identify relevant issues, concerns and expectations for science and scientists in managing natural resources. The resulting survey questions were sent to scientists, natural resource managers, members of public interest groups, and the attentive public in the Pacific Northwest.

Only scientists involved with research and management of Pacific Northwest forests were included in the initial sample, and most of these were from the H. J. Andrews (HJA) Experimental Forest LTER site, located in the McKenzie River Watershed east of Eugene in the Oregon Cascades (Lach et al. 2003). The Long Term Ecological Research (LTER) program is a National Science Foundation (NSF) supported multi-site research endeavor (Hobbie, 2003), and LTER scientists were well suited for the initial and secondary studies because of their involvement with the public as well as their efforts to develop, and at times implement, natural resource policies. The second study that is used for this comparison also targeted terrestrial ecology scientists, resource managers, interest group representatives and members of the public. Data were collected between 2006 and 2007, and responses from scientists were once again collected from those who had participated in the national LTER program research.

This study directly compares results from the NPRB survey with those of terrestrial LTER scientists from the 2000 and 2007 studies. All three surveys sought to measure the "attitudes of scientists, resource managers, representatives of interest groups, and members of the involved public regarding preferred roles for research and field ecologists in natural resource management" (Lach et al. 2003, p. 170). More specifically, a major goal was to examine whether or not scientists believed in a more involved role for themselves in terms of engaging in, advocating for, and actually directing various policy alternatives in natural resource management. The term “scientists” was used rather broadly in the two LTER samples, but was meant to include those who actively conducted research, worked as advisors to managers who interpreted science in management contexts, and who were appropriately qualified in terms of education. The NPRB study utilized similar considerations, but scientists also fall into several additional categories which included the separation of university, agency, NGO and private industry research scientists.

Because of differences between medium-specific environmental issues, as well as the potential differences in epistemic communities, it was proposed that significant differences could exist between marine and terrestrial scientists, both in terms of their preferred role for scientists in natural resource decision making, and their positions with regard to the technocracy/democracy quandary. Generally, the results of this study were meant to help verify or reject the existence of a cross-disciplinary consensus between marine and terrestrial scientists about tendencies toward positivism, NEP perspectives, beliefs concerning the democracy/technocracy quandary, as well as general perceptions about the role of scientists in the natural resource decision making process. Results from the 2000 and 2007 surveys have been subjected to considerable analysis; however data collected from the NPRB study had not yet been thoroughly examined in a similar fashion, offering a unique opportunity to compare the 2000 LTER (PNW LTER), 2007 LTER (National LTER) and 2010 NPRB (NPRB) data sets.

METHODS

The NPRB data set was created during the summer of 2010, when Oregon State University (OSU) researchers oversaw development and implementation of a survey to aid an external review of the North Pacific Research Board. The purpose of this study was to review programs and processes of the NPRB, as well as to gather information about attitudes towards and experiences with the NPRB funding process. The study analyzed the accessibility and relevance of research funded by the NPRB, and this knowledge was intended to help NRPB personnel assess issues such as the responsiveness of its directives, research prioritization processes, the proposal review and approval process, and the impacts of results. In addition, demographic information (e.g., education, agency, state, etc.) was collected to see if there were differences among different audiences or types of respondents. This information was used to understand more fully how people who conduct and use NPRB funded research view the work of the NPRB.

The survey itself had two distinct parts. The first part of the survey was developed to satisfy informational needs of the NPRB Review Committee. These survey questions were designed in conjunction with the External Review Committee and NPRB staff, and each section dealt with particular aspects of the NPRB funding and research process. Questions from the second part of the survey replicated previous studies conducted by OSU researchers as described earlier. The questions asked respondents about their preferred role of scientists, policy makers, interest groups, and the public in the natural resource policy process, but some questions also targeted values, attitudes and beliefs as they relate to natural resource management.

The survey was administered online between July 22 and August 16, 2010 using a proprietary software program called SurveyMonkey. Potential respondents were contacted via email with a live link to the survey. The sample was compiled from two sources:

- Alaska and Washington government agencies (state and federal), environmental groups, fishing cooperatives, NGOs and other private enterprises with relevant ties to the interests of the NPRB were identified using individual websites and online directories;
- An NPRB list of individuals who had applied for funding from the NPRB over the past three years.

The survey was sent to 1,298 individuals and 334 responses were received (26% response rate). Fifty percent of respondents who filled out the survey received funding from the NPRB, 20% of respondents applied but didn't receive funding, and 30% of respondents fell in the "other" category with a fairly even distribution among agency, NGO, and other potential users. In addition to their primary association with the NPRB, respondents were asked to answer a number of demographic questions at the beginning of the survey. Nearly 80% of respondents acknowledged attainment of an advanced degree (MS/MA or PhD) and two thirds of respondents reported 11 to 30 years involvement with scientific research. In terms of gender, 65% of respondents identified as male. Most respondents

(83%) described themselves as scientists working in agencies, universities, nongovernmental organizations, private industry, and tribal governments (Table 1). Respondents were asked to choose a discipline that best characterized their interests; the most frequently chosen disciplinary interests were Fish (32%), Integrated Studies (17%), and Marine Mammals (13%), with 38% choosing "other."

Table 1: Professional affiliation

University Research Scientist	30% (93)
Agency Research Scientists	37% (114)
Non-Government Organization Research Scientist	7% (21)
Private Industry Scientist	3% (8)
Tribal Research Scientist (or affiliate)	3% (8)
Non-governmental Organization Policy Advocate	2% (5)
Resource Manager	12% (37)
Other	8% (26)

For most questions, respondents were instructed to choose between several options on a scale typically ranging from positive to negative. For questions answered with a negative response, respondents were directed to provide more information in the form of an open-ended typed response.

Potential survey respondents who replied to the email with a link to the survey were first brought to an informed consent page, after which they were allowed to move on to the survey itself if they agreed with the terms of the research. The rest of the survey was designed so that several transitional questions were used to direct respondents to appropriate sections of the survey following their informed consent and completion of the initial demographic section. For example, respondents who had applied for and received funding were asked to complete the entire survey; those who had reviewed proposals but never applied for funding were directed to the "proposal review" section of the survey and didn't see any of the questions about grant management. All respondents— except those who disagreed with the terms on the first page—were asked to complete the second part of the survey, regardless of their affiliation with the NPRB. Responses from the survey were transferred directly to a statistical software package (SPSS) for more detailed and substantive analysis. Open-ended questions likewise were analyzed and coded.

Response Bias

Following implementation of the survey and a preliminary review, efforts were made to identify potential response bias. Because responses were anonymous – responses were not connected to specific names - it was impossible to determine response bias (i.e. whether respondents were different than non-respondents). However some sense of potential response bias was gathered by comparing the demographics of the 26% who responded to the survey with those who didn't respond. One hundred names were randomly selected from the full sample list of 1,298, and then analyzed using available websites to determine their gender, education level and professional affiliation. Overall for the three variables (Tables 2-4), it appears that non-respondents were very similar to respondents.

Table 2: Response bias gender

	NPRB Survey Results	Response Bias Sample
Male	65%	67%
Female	35%	33%
	N = 308	N = 97

Table 3: Response bias education level

	NPRB Survey Results	Response Bias Sample
BS/BA	8%	5%
Some Graduate/MA/MS	31%	33%
PhD	52%	56%
Other	8%	6%
	N = 334	N = 86

Table 4: Response bias professional affiliation

	NPRB Survey Results	Response Bias Sample
University Scientist	30%	33%
Agency Scientist	37%	36%
NGO Scientist	7%	6%
Private Sector Scientist	3%	2%
Tribal Scientist	3%	2%
NGO Policy Advocate	2%	1%
Resource Manager	12%	14%
Other	8%	6%
	N = 312	N = 93

Though it is impossible to determine why the survey response rate was not higher, email replies from several potential respondents are illustrative. During the survey implementation phase, many individuals stated that they could not complete the survey because of research priorities. Thus, if the survey had been implemented in the off-peak research season for the North Pacific Ocean, a higher response rate may have resulted.

FINDINGS AND DISCUSSION

Findings

A primary goal of this study was to determine the attitudes of scientists towards science, their ideal role for scientists and citizens in natural resource policy making processes, as well as their orientations towards the environment. Additionally, this study sought to determine whether or not the preferences of marine and terrestrial scientists differ significantly with regard to these variables. Because of previous studies that had explored these questions with terrestrial ecologists in 2000 and 2007, questions were already developed to measure these preferences and used in the 2010 NPRB survey. As a result, three samples of scientists from three different studies (two terrestrial and one marine) have been analyzed to satisfy the goals of this inquiry.

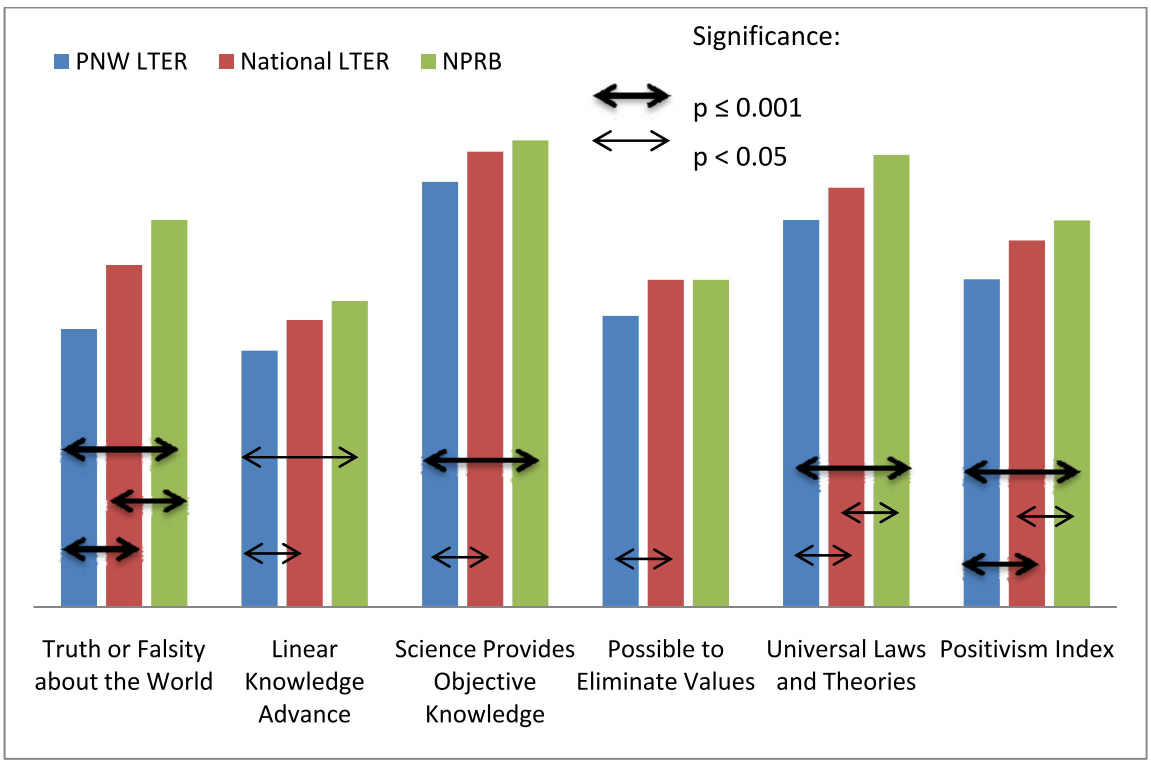
To measure positivist orientations, respondents were asked a series of questions with assumptions directly connected to perceptions of science and positivist principles. Potential answers were ranked on a scale from one to five, with one signifying strong disagreement with the statement and five signifying strong agreement with it. Respondents were asked to indicate their level of agreement or disagreement with ten of these statements concerning the scientific process. Using factor analysis, five of the ten questions were found to load moderately well for the three samples of scientists (PNW LTER, National LTER, and NPRB), though noticeably less so for scientists in the PNW LTER sample (Table 5). Agreement or disagreement with the statements is meant to signify an individual's positivist orientations, and a comparison of sample means is presented in Table 5. Scores from these questions were added together to provide an index of positivist orientations for each respondent. An index score of five represents strong disagreement with positivist principles, while a score of 25 demonstrates strong agreement with them.

Table 5: Attitudes towards positivism

Positivism		**PNW LTER:** *Mean (S.D.)*	**National LTER:** *Mean (S.D.)*	**NPRB:** *Mean (S.D.)*
A.	Use of the scientific method is the only certain way to determine what is true or false about the world. *F-test* = 22.47***	2.47 (1.24)	3.04 (1.36)	3.44 (1.32)
B.	The advance of knowledge is a linear process driven by key experiments. *F-test* = 5.91**	2.28 (1.08)	2.55 (1.23)	2.72 (1.16)
C.	Science provides objective knowledge about the world. *F-test* = 7.21***	3.78 (0.91)	4.05 (0.93)	4.15 (0.92)
D.	It is possible to eliminate values and value judgments from the interpretation of scientific data. *F-test* = 4.28	2.59 (1.1)	2.91 (1.22)	2.91 (1.2)
E.	Science provides universal laws or theories that can be verified. *F-test* = 10.53***	3.44 (1.06)	3.73 (1.24)	4.02 (1.02)
	Positivism index mean S.D. Cronbach's alpha *F-test* = 20.92***	14.57 3.23 0.54	16.3 3.96 0.67	17.19 3.66 0.66
		n = 148	n = 347	n = 187
Scale used: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree. Significance level: *** p ≤ 0.001 Significance level: ** p < 0.01				

The mean of NPRB respondent answers demonstrate a higher rate of agreement than terrestrial ecologists on all five of the positivist statements, while the PNW terrestrial ecologists reported the lowest rate of agreement with all five statements. There are significant differences among the respondents' mean scores for all of the statements, although it varies for each statement. Figure 1 displays the significance at two levels ($p \leq 0.001$ and $p < 0.05$) between the three respondent groups for each statement. In general, the two groups of terrestrial scientists hold less positivistic views toward science than do the marine scientists involved with the NPRB.

Figure 1: Comparison of Attitudes towards Positivism



Another major goal of this study was to identify scientists' attitudes toward advocacy and their ideal role for scientists in natural resource decision making. Respondents were asked to provide their level of agreement or disagreement with statements describing five potential roles for scientists in natural resource management. The questions were likewise developed from the interviews and exploratory survey administered in the initial PNW LTER survey (2000), and comparison of means for the three samples' responses are presented in Table 6.

Table 6: Attitudes towards scientific advocacy in natural resource management

Scientific advocacy		**PNW LTER:** *Mean (S.D.)*	**National LTER:** *Mean (S.D.)*	**NPRB:** *Mean (S.D.)*
A.	Scientists should only report scientific results and leave others to make resource management decisions. *F-test* = 16.24***	2.86 (1.37)	2.21 (1.24)	2.65 (1.34)
B.	Scientists should report scientific results and then interpret the results for others involved in resource management decisions. *F-test* = 1.66	4.19 (0.86)	4.32 (0.78)	4.34 (0.89)
C.	Scientists should work closely with managers and others to integrate scientific results in management decisions. *F-test* = 33.43***	4.09 (0.94)	4.49 (0.71)	4.73 (0.57)
D.	Scientists should actively advocate for specific natural resource management decision they prefer. *F-test* = 20.77***	2.20 (1.17)	2.95 (1.26)	2.90 (1.26)
E.	Scientists should make natural resource management decisions. *F-test* = 37.08***	1.66 (0.9)	2.55 (1.25)	2.64 (1.25)
		n = 153	n = 352	n = 197

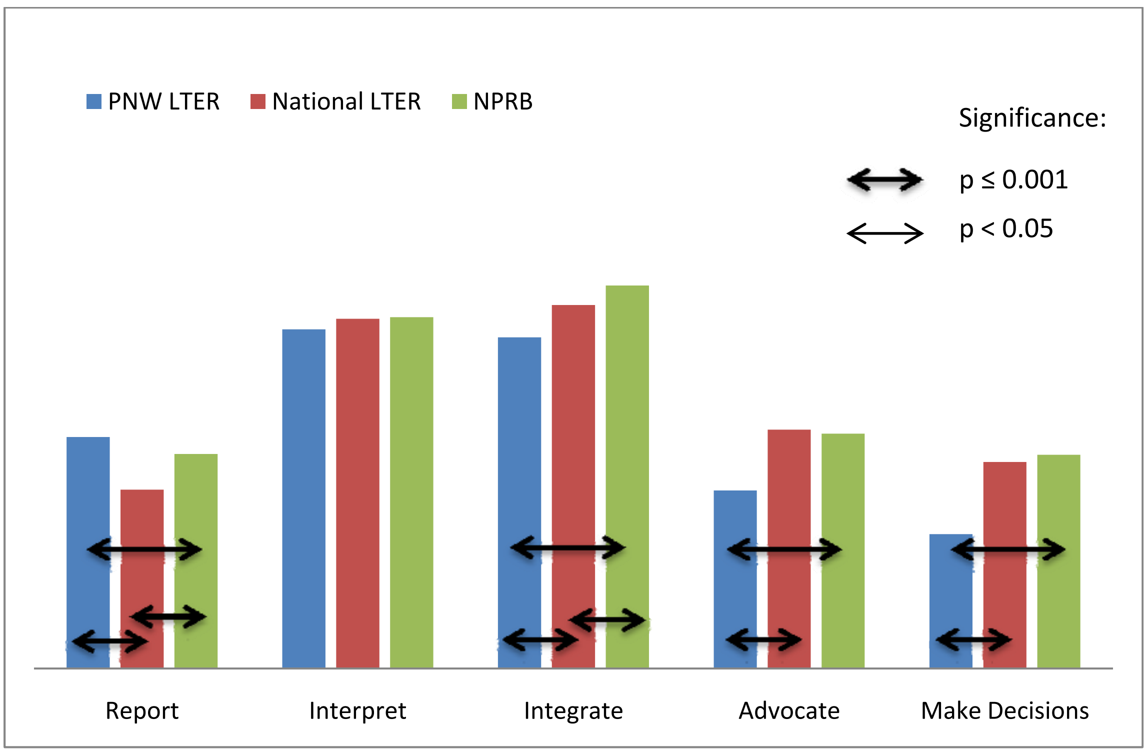
Scale used: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree.
Significance level: *** $p \leq 0.001$

The statements themselves reflect a complex interaction between perceptions of science with regard to natural resource decision making and the ideal relationship with natural resource managers. The first question (A) represents a more traditional perception of the role of scientists, where scientists should only report their findings and leave deciphering of results and decision making to resource managers and others. The next two options (B and C) represent the emerging role of scientists, where scientists not only report their findings, but also interpret their results for others and/or work closely with those involved in resource management to integrate their results into management decisions and practices. Another option was for scientists to serve as advocates for their own preferences regarding natural resource management, and a final role was for scientists to actually make natural resource decisions themselves.

In contrast to the statements related to positivism, there appears to be a less straightforward trend in terms of the three mean scores (Figure 2). Generally, all three groups of scientists favor the involved roles for scientists – interpreting (B) and integrating (C) – rather than the traditional role (A) or the activist roles (D) and (E). The national terrestrial and marine scientists were significantly more likely than the PNW terrestrial scientists, however, to prefer the integrating role (C) for scientists while there is no significant difference among the groups' high preference levels for the interpreting role (B). An interesting interaction is found for the first potential role – only report scientific findings (A) – where PNW terrestrial scientists were significantly more likely than scientists from the national LTER and NPRB samples to agree with this role.

Again, the national terrestrial ecologist means tended to fall between the means of the PNW terrestrial and NPRB scientists, although this time they trended closer to agreement with the NPRB scientists. The PNW terrestrial scientists were *least* likely to agree with the roles describing more scientist involvement when compared to the national terrestrial and NPRB marine scientists although the preference levels are high for all three groups. For the final activist role – scientists making management decisions (E) – the national terrestrial and marine ecologists were both significantly more likely than the PNW ecologists to prefer this role, although this was the least preferred role for all scientists.

Figure 2: Comparison of Attitudes towards Scientific Advocacy



Respondents were also asked to characterize the value of citizen participation in government policy decision making. Respondents were presented with a scale from one to seven, where a choice of one corresponded with the belief that "citizen participation is of no value and adds needlessly to the cost of government," while a choice of seven conversely corresponded with the belief that "citizen participation is of great value even if it adds to the cost of government (Table 7)."

Table 7: Attitudes towards citizen participation

Citizen participation	**PNW LTER:** *Mean (S.D.)*	**National LTER:** *Mean (S.D.)*	**NPRB:** *Mean (S.D.)*
Recently there has been considerable debate over efforts to increase citizen participation in government policy making. Where would you locate yourself on the following scale regarding these efforts? *F-test* = 5.29**	5.55 (1.13)	5.58 (1.13)	5.24 (1.36)
	n = 154	n = 349	n = 196
Scale used: 1 = no value, 4 = neutral, 7 = great value Significance level: ** p < 0.01			

Though all three groups appear to value citizen participation in government policy making regardless of increased costs, marine scientists repeat a statistically significant skepticism of citizen participation compared to scientists from either of the terrestrial samples. The question represents one of the only instances where mean scores from the two terrestrial scientist samples demonstrate very little variance, but together vary significantly with the responses from marine scientists.

While analysis of the three groups of scientists was made possible for describing attitudes towards science, the proper role of scientists in natural resource policy, and the value of citizen participation, only two of the samples (National LTER and NPRB) could be used to satisfy the other goals of this inquiry. Because of question wording, results from the

PNW LTER survey, the earliest of the three, could not be used to directly compare orientations toward the environment or opinions about the levels of understanding of ecological science by various groups.

Respondents were asked a series of questions relating to beliefs about humans and the environment. Statements for these questions were designed to identify the presence of either biocentric or anthropocentric tendencies among respondents, concepts addressed at length in the previous literature review. These statements were taken from Van Liere and Dunlap's (1981, 1980) "New Environmental Paradigm" (NEP) indicator. Respondents from all three samples were asked questions from the NEP indicator, but some questions asked of National LTER and NPRB survey respondents were not asked of PNW LTER respondents. Therefore the mean NEP scores presented in Table 8 only include responses from National LTER and NPRB scientists.

Table 8: Beliefs concerning humans and the environment

NEP		National LTER: *Mean (S.D.)*	NPRB: *Mean (S.D.)*
A.	The balance of nature is very delicate and easily upset by human activities. *F-test* = 10.05**	3.54 (1.3)	3.89 (1.07)
B.	Humans have the right to modify the natural environment to suit their needs. *F-test* = 0.063	2.59 (1.17)	2.56 (1.16)
C.	We are approaching the limit of people the earth can support. *F-test* = 2.2	4.01 (1.14)	4.16 (1.04)
D.	The so-called “ecological crisis” facing humankind has been greatly exaggerated. *F-test* = 1.17	1.72 (0.95)	1.81 (1.04)
E.	Plants and animals have as much right as humans to exist. *F-test* = 1.09	4.13 (1.15)	4.02 (1.07)
F.	Humans were meant to rule over the rest of nature. *F-test* = 2.14	1.36 (0.83)	1.47 (0.89)
	NEP score S.D. Cronbach’s alpha *F-test* = 0.24	24.02 3.9 0.64	24.19 3.79 0.65
		n = 346	n = 191
Scale used: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree. Significance level: ** p < 0.01			

As with the questions concerning positivism and orientations towards science, an index of question scores was created for each respondent, where a score of 6 represents strong disagreement with biocentric principles, as reflected in NEP indicator questions, and a score of 30 represents strong agreement with these principles. The NEP questions were similarly subjected to factor analysis, and loaded similarly to the positivism variables in terms of an index for both the National LTER and NPRB samples.

In contrast to previous questions, National LTER and NPRB scientists showed little disagreement in terms of their beliefs concerning humans and the environment. With only one exception (A), the two samples exhibit no significant variance, and both groups score equally high in terms of their overall NEP scores, demonstrating strong agreement with NEP principles regarding humans and the environment. This generally seems to suggest that little separates marine and terrestrial scientists in terms of ecological values, where both groups show biocentric tendencies, except perhaps in that marine scientists are more wary of the fragility of the ecological systems they work with in relation to human activities (A).

Respondents were similarly asked to give their opinions about the levels of understanding of ecological science for various groups, including elected officials, resource managers, members of environmental and industry groups, as well as the general public. As with the comparison of NEP statements, though respondents from the PNW LTER sample were asked a similar set of questions, a difference in question wording prevents direct comparison, therefore only National LTER and NPRB scientists are presented in Table 9. Scientists from the samples were asked to rate their perceived level of understanding for each of the five groups on a scale from one to five, where one corresponded to no understanding by the group in question, and five corresponded to a great deal of understanding.

Table 9: Opinions regarding levels of understanding of ecology science

Scientific Understanding		**LTER:** *Mean (S.D.)*	**NPRB:** *Mean (S.D.)*
A.	General level of understanding of marine ecology science by Elected Officials. *F-test* = 23.95***	1.82 (0.49)	2.05 (0.58)
B.	General level of understanding of marine ecology science by Resource Managers. *F-test* = 3.2	3.34 (0.68)	3.45 (0.7)
C.	General level of understanding of marine ecology science by Members of Environmental Groups. *F-test* = 18.89***	2.93 (0.78)	3.22 (0.75)
D.	General level of understanding of marine ecology science by Members of Industry Groups. *F-test* = 75.07***	2.09 (0.74)	2.67 (0.81)
E.	General level of understanding of marine ecology science by the General Public. *F-test* = 14.31***	1.97 (0.5)	2.14 (0.51)
		n = 351	n = 201
Scale used: 1 = none, 2 = limited, 3 = moderate, 4 = high, and 5 = a great deal Significance level: *** $p < 0.001$			

In general, respondents have low opinions regarding the levels of understanding of ecology by non-scientists. With one exception, marine scientists are significantly more likely than terrestrial scientists to hold a higher opinion of ecological knowledge of various groups (Table 9). The highest rating from both terrestrial and marine scientists is for resource managers (B), and there is no significant difference in the opinions held by these two groups. Both marine and terrestrial scientists give particularly low ratings to elected officials and the general public when it comes to understanding ecological science.

Discussion

Though traditional positivists have experienced discomfort in mixing "value-free" scientific endeavor with value-driven public policy decision making, the results from this study demonstrate that while most scientists maintain consistent positivist belief structures, they are also in favor of more involvement for themselves and science in the value-laden realm of public policy decision making (Tables 5-6). This contradicts traditional positivist perspectives, but the emerging willingness of scientists to participate actively in decision making processes appears to resonate with suggestions by Fischer (2000), and other scholars of technocracy and democracy, who suggest that involvement by scientists with collaborative public policy approaches is an increasingly desirable and necessary outcome. Some post-modern and post-industrial perspectives (Rosenau, 1992) suggest that past pretensions of positivist scientific neutrality may have only existed in the minds of scientists and their colleagues, and the apparent contradiction of high positivism paired with acceptance of increased involvement by the scientific community could signal tacit resignation to more post-modern perspectives of science, though with a strong reservation to respect traditional conceptions of scientific method.

The suggestions by Fischer and other proponents for more collaborative forms of public policy decision making appears to reflect growing consensus among both terrestrial and marine ecology scientists. Though significant differences exist between the two groups, marine and terrestrial ecologists from these studies demonstrate agreement with modern conceptions of a post technocracy/democracy quandary environment (Tables 6-7), where simple allocation of important decisions to *only* scientists and experts, or *only* citizens and local stakeholders, are outdated alternatives.

While scientists may not hold a high opinion of non-expert comprehension of ecology science (Table 9), they still generally support democratization and the devolution of authority mechanisms in natural resource management (Table 7). These results support perceptions advanced by scholars of various management models for collaboration (Sorenson, 1997; Steel and Weber, 2001; McFadden, 2007) who report caution among ecological scientists for the potential devaluation of scientific results, but recognize the potential value for involvement by a wider array of non-scientific stakeholders and constituencies.

The consensus between marine and terrestrial ecology scientists in terms of environmental values and biocentrism (Table 8) seems to validate claims (Brown and Harris, 1992; Rosenau,1992; Steel, 2009) that altered value structures since World War II have led to the emergence of a new resource management paradigm in the wake of post-industrialism. The consistency and high degree of biocentric beliefs reported by experts from the three studies also validate the need to continue addressing environmental issues with strong regard to human impact, and to utilize science and scientific findings to do this.

CONCLUSION

The results from this study demonstrate that there is consistent support by both terrestrial and marine ecology scientists for a more active role for scientists in natural resource management than a traditional positivistic approach to science suggests. While there is still only minimal support for increased advocacy and decision making on the part of scientists, the favored role of most scientists from the three groups discussed in this report is a close working relationship with resource managers to integrate results from their research. Though marine scientists may be more wary of the resilience of natural systems when subjected to human activities, no significant difference was exhibited between marine and terrestrial scientists in terms of their beliefs about humans and the environment. Marine and terrestrial scientists appear to hold strong orientations towards more biocentric value structures with regard to the environment, as opposed to more anthropocentric ones. Similarly, both groups seem to value citizen participation in government processes, regardless of the increased costs such involvement imposes.

However, some significant differences do exist between marine and terrestrial scientist respondents. As shown in Table 5, marine scientists appear to hold significantly higher positivist orientations than their terrestrial counterparts. Although neither marine nor terrestrial scientists prefer an advocacy role for scientists, marine scientists are significantly more supportive than terrestrial scientists of an increasingly active role for scientists in natural resource policy, one where scientists themselves report, interpret and then work closely with resource managers to integrate scientific results into management decisions. While these findings may seem contradictory at first glance, they resonate well with critiques posed by proponents of change within the ICZM model applications, and reflect sentiments described by R. Levien (1979) more than 30 years ago, wherein scientists themselves recognize their unique position to contribute positively to policy processes because of personal knowledge, skill sets and perspectives.

While marine scientists show more support for an active role for scientists in natural resource decision making, they also tend to value citizen participation in government policy making significantly less than their terrestrial colleagues. Oddly enough, this does not seem to reflect an overtly negative opinion of the competence of the public and other non-scientists in terms of understanding ecological science, and could symbolize recognition by marine scientists of a growing competition for positioning within public policy arenas, where a larger array of stakeholders are increasing their involvement and limiting the potency of marine scientists' traditional influence. As is shown in Table 9, marine scientists tend to hold a significantly higher opinion of elected officials, members of interest groups and the general public regarding levels of understanding of ecological science than do terrestrial scientists reported in this study. These differences seem to correspond with the perspectives from the EM and ICZM management models, which encourage integrative policies and the participation of all stakeholders in natural resource management, but also reflect critiques of ICZM, which suggest that while marine scientists value the integration of diverse interests in environmental management, the opinion that science and scientists are being overly marginalized in relevant policy processes is becoming increasingly overt (McFadden, 2007).

Based on the findings in this study and others, it appears that interest groups and the public would be strongly in favor of an active and more integrative role for marine and terrestrial ecologists in natural resource management. Likewise, many scientists and resource managers themselves seem to support this type of active role as opposed to the simple reporting of scientific results dictated by the norms of positivistic science. The critiques of current approaches to ICZM, which suggest that some marine scientists feel the role of science is being increasingly marginalized in collaborative resource management circles, also suggest that new ways to involve science and scientists in increasingly democratized decision making is required. Resource agencies, coastal community interest groups and the NPRB itself all seem uniquely situated to help marine scientists achieve this goal. Through collaborative partnerships, these entities can work together to create forums which increase dialogue and problem solving among the public, resource managers, interest groups, and scientists.

However, if scientists accept a more active role in natural resource management decision making arenas, they should perhaps be ready to surrender some of the independence of their research directives and funding priorities to reflect the goals and concerns of the attentive public. Though this may be difficult for some scientists to swallow, the findings of this and other studies suggest that all the players in natural resource management may be ready to make some changes in the way that science and scientists are used in decision making. The idea that there are multiple roles that scientists can *choose* to play in natural resource management is likely to resonate with both professionals and students; and increasing opportunities for scientists – professionals and students – to understand and experience working with non-scientists to solve problems may increase not just the skill of scientists to participate but also their willingness. Organizations like the NPRB can provide opportunities and training for its participating scientists and managers to ensure that the science they fund is usable, not just useful.

The next step for subsequent studies and research should be in exploring forums for collaboration. Effort should be expended to decipher what forums are best for optimal participation by a wide range of constituencies in management arenas, and what forms of information sharing, dissemination, and collaboration are most useful. Research could target application of general theories for management at state and regional levels, but pressing research could also be conducted to evaluate strategies for more local level management (i.e. comparative case studies of individual watersheds, forests, or aquatic zones). Further research on the issue, particularly with regard to the technocracy/democracy quandary, should also extend cross-sample analysis to the general public, resource managers and members of interest groups with regard to technical expertise and citizen participation in natural resource management. As with this study, interesting findings could result from a comparison of coastal and inland communities.

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