# A Comparison of the Preferred Role of Science and Scientists in the Marine and Terrestrial Policy Process

by

Daniel H. Kloepfer

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APPROVED:

Denise Lach, representing Sociology

Brent Steel, representing Political Science

Roger Hammer, representing Sociology

Daniel H. Kloepfer, Author

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Denise Lach

The role of science in marine policy, and environmental policy in general, is a debated topic. Currently, there is an increasing desire for transparent and participatory democracy that involves more input from local residents and other non-experts. These demands often conflict with the increasing complexity of problems and the real or perceived mandate to use the "best available science" in policymaking. There have been few attempts to incorporate scientists' input into marine policymaking in the United States, while around the world we have seen scientific information used in marine policymaking at a higher rate. We have also witnessed a shift in the acceptance of science and scientist involvement in terrestrial policymaking. The literature suggests there are barriers that must be overcome in order to involve science and scientists in marine policymaking, including collaboration and engagement with policymakers who have different agendas than scientists. In order to better understand these differences in how science and scientists are being integrated into marine and terrestrial policymaking, I analyzed

and compared two surveys that asked managers, scientists, and other stakeholders their beliefs regarding the role of science and scientists in (1) terrestrial and (2) marine policy. I hypothesized that there was a significant difference between the preferred role of scientists in terrestrial and marine policy among all groups surveyed. After analysis, we found no significant differences between the two studies and their preferred role of scientists in terrestrial and marine policymaking.

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## Introduction

Implementation of science and scientists' input into natural resource policy is a complex subject that has gained momentum in the wake of calls for more public participation in environmental policy-making (Fischer 2000). Technical experts are asked to participate more actively in natural resource policy as policy related problems are becoming complicated and technically complex. This increase on the emphasis of scientific involvement in environmental policy-making has coincided with evolving management practices to incorporate both public opinion and scientific information (Boesch 1999, Barnes and McFadden 2008, McFadden and Barnes 2009).

The conflict arises from agreement on the extent to which science and scientists' input should be used in environmental policy-making. A variety of people believe scientists should be only objective reporters of scientific findings even though some believe that science itself cannot be truly objective in nature (Scott et al. 2008, Lackey 2006, Gray and Campbell 2008, Lach et al. 2003, Steel et al. 2006, Steel et al. 2004, and Yamamoto 2012). The question then remains, if we increasingly need experts to help us understand the world, how do we retain the legitimacy of democracy?

There have been multiple studies that examine the preferred role of scientists in natural resource policy, including Lach et al. (2003), Steel et al. (2004), Lackey (2007) Mills and Clark (2001), and Steel et al. (2009), among others. Most of these studies look at what stakeholders including scientists, managers, interest groups and the public, believe to be the proper role of scientists in natural resource policy. This study attempts to add to this discussion by evaluating these preferences within marine policy and comparing them with the preferences for science and scientist involvement within terrestrial policy.

There is evidence that many stakeholders in natural resource policy believe that science should play an integral role in environmental policy-making (Steel et al. 2006, and Gray and Campbell 2009, among others). To what extent scientists should be involved in environmental policy-making is often where the line becomes fuzzy between integration and policy advocacy. This is important because the traditional positivist view among scientists, that science is objective and unbiased, is losing momentum (Steel et al. 2004, Steel et al. 2006, Lach et al. 2003). When examining attitudes on advocacy in forest management, Steel et al. (2004) found that the engaged public and interest groups are more apt to believe in the positivist view that science can remain unbiased while scientists and managers are becoming skeptical of the process. This shift in thinking about how we view science and scientists presents a challenging dilemma and calls for further research.

One of the main ideas that most of these recent studies bring to attention is the role that positivism plays in determining the way people view science and the role of scientists in natural resource policy (Steel et al. 2004, Lach et al. 2003, Steel et al. 2009). Steel et al. (2004) find that the public and interest groups are more likely to believe in positivism, which leads to them accepting roles for scientists in natural resource policy. They say that because the public believes that scientists have the capability to report their findings in an objective way that it would benefit society for scientists to become more involved in environmental policy-making.

There are also several reports that find that scientists are reluctant to believe that they can find "truth" in their work and remain unbiased (Steel et al. 2004, Steel et al. 2009, Lach et al. 2003). These reports find that scientists are unlikely to believe that they themselves should have a prominent role in natural resource policy decision-making. It is possible that scientists feel this way because as Steel et al. (2004) state, "Clearly, their [scientists'] work will inevitably come under closer public and interest group scrutiny than that carried out in the traditional scientific contexts…" (Steel et al. 2004, p. 11).

This follows the same thought process that Lackey (2007) uses to warn other scientists. Lackey (2007) argues that scientists need to stay with what they know, not to let their personal opinions sway their scientific credibility and to be direct with managers when reporting the feasibility of the projects. Miller (1993) also cautions that too much involvement from scientists could take away focus from the more important issues at hand. Finally, Cortner (2000) states that scientific analysis is just one aspect of the policy process and that scientists should not try and make it the sole aspect of natural resource policy.

This study examines attitudes about the involvement of science and scientists in natural resource policy by comparing attitudes of ecological scientists, natural resource managers, representatives of public interest groups, and the general public in the context of both terrestrial and marine ecology. It is a comparison of two separate surveys that asked similar questions to stakeholders in the two different policy arenas. The purpose is to uncover any differences or similarities between the two groups, marine and terrestrial, and attempt to understand why these differences or similarities are occurring. We hypothesize that there will be a significant difference for the preferred role of scientists in environmental policy decision-making between the terrestrial and marine respondents.

## Literature Review

### Role of Science in Marine Policy

Scientists' roles and their scientific input have not been integrated into the U.S. marine policy-making process with consistent success, although there are positive strides being made within the National Oceanic and Atmospheric Administration (NOAA). Specifically, in 2004 NOAA began to transform their management practices with an ecosystem approach in their 2004 Strategic Plan (McFadden and Barnes 2009). This approach adds an emphasis on stakeholder involvement and collaboration among all interested parties. Fischer (2000) accentuates this need for citizen participation because it gives meaning to democracy, it contributes normatively to the legitimation of policy-making, and it can contribute to professional inquiry.

Because marine ecosystems are such complex environments there have been multiple attempts by the National Research Council, the U.S. Commission of Ocean Policy and many academic researchers to advocate for the use of science and scientists input when creating marine policies (National Research Council 1994, National Research Council 1995, Boesch 1999, Hiscock et al. 2003, Peterman 2004, U.S. Commission on Ocean Policy 2004, Frid et al. 2006, Fletcher 2007, Levin et al. 2009, Stojanovic et al. 2009, Link et al. 2012). The highly technical nature of marine ecosystems and the recent push for more meaningful citizen involvement within natural resource policy-making, places this debate squarely within the realm of the democracy-technocracy quandary. The technocracy- democracy quandary is a focus on the dueling relationship between the role of technical scientific information and public participation in policymaking, which will be discussed in the literature review below.

Recent literature has been in favor of some sort of involvement for scientists in marine policy formation. Fletcher (2007) argues that the role of scientists in marine policy-making should be clear in intent; he suggests they must not specifically make policy decisions themselves but only used to inform policy-makers. Stojanovic et al. (2009) take this suggestion further and say that policy objectives must be led by science-based observations. Finally, Levin et al. (2009, p. 0023) make the most direct suggestion and propose that we begin to use “integrated ecosystem assessments”

(IEAs) as a framework for organizing science in order to inform decisions in marine EBM [Ecosystem-based Management] at multiple scales as across sectors." IEAs are important because they bring together policy makers, resource managers, scientists and stakeholders in order to identify specific ecosystem objectives and threats in the initial scoping process. IEAs attempt to integrate many different forms of physical, biological, and socioeconomic data in order to create policy (Levin et al. 2009). Another suggestion made by Peterman (2004) that could potentially change the role of science in marine policy-making is that managers should not put low weight on scientific research because of uncertainty compared to economic and social factors, where uncertainties also exist

One suggested way to better involve science and scientists in the policy-making process is to implement ecosystem-based management (EBM), which is a much more holistic approach than past management strategies. The general principles of EBM consist of: 1) the necessity to address multiple spatial and temporal scales between ecological and social systems while also considering stakeholder groups, 2) the need to take into consideration the linkages among marine ecosystems and the human communities dependent on these systems, 3) the need to connect environmental policy and management efforts between terrestrial and marine polices, and 4) the necessity to have meaningful engagement with stakeholders (Leslie and McLeod 2007). By considering these four principles in marine policy formation, the role of science and scientific input becomes essential but not the only form of information considered when creating successful marine policies. NOAA has been in the forefront regarding this movement towards implementing EBM on a large-scale basis and is slowly incorporating this management practice. McFadden and Barnes (2009, p. 157) state, “Within the marine management community, the gradual incorporation of ecosystem perspectives into natural resource polices has culminated in a formal embrace of ecosystem management by NOAA.”

Because of the recommendations to take into consideration the linkages between marine ecosystems and the communities dependent on them as well as the need to connect environmental policy-making and management efforts in order to bridge marine and terrestrial policies, transmitting knowledge from scientists to nonscientists is found in many research studies (Crosby et al. 2000, Leschine et al. 2003, Arkema et al. 2006, Boesch 2006, Frid et al. 2006, Barnes et al. 2008, Stojanovic et al 2009, House and Phillips 2012). The majority of these studies focus on and find that in order for marine policies to be successful, partnerships are created among scientists, managers, and stakeholders to produce and share relevant knowledge (Crosby et al. 2000, Arkema et al. 2006, Boesch 2006, Stojanovic et al. 2009) Many recommend highlighting the interconnectedness of the relationship between marine ecosystems and human actions in order to improve communication between these groups (Crosby et al. 2000, Boesch 2006, Arkema et al. 2006, Ruckelshaus et al. 2008, Stojanovic et al. 2009). They also point out that the role of science and scientists in marine policy-making may become meaningful and productive if there is a systematic approach to information sharing among managers.

As we will see later in the literature review, the dissemination of knowledge also can be considered a barrier to involvement of scientists in marine policy-making.

## Collaboration and Integration

In order to incorporate science into marine policy-making, the literature suggests there is a need for collaboration and integration among managers and scientists (NRC 1994, NRC 1995, Schneider et al. 2003, Kaplan and McCay 2004, USCOP 2004, Arkema et al. 2006, Boesch 2006, Fletcher 2007, Cheong 2008, Levin et al. 2009, Kraak et al. 2010). With a goal of uncovering ways to create efficient ways to integrate science and scientists into the policy-making process, the National Research Council (NRC) conducted three symposia organized around three marine areas including the Gulf of Mexico, the Gulf of Maine and the California coast. The overall consensus of these three symposia was that collaboration needed to take place among managers and scientists and that there is a desire for open communication among all levels of government to create a more cooperative governance system (NRC 1994 and NRC 1995). Schneider et al. (2003) contend that where there is a capacity in information sharing among all stakeholders there is a chance for successful policy formation and implementation. The U.S. Commission on Ocean Policy (2004) found, among other things, that open communication between agencies is important in order to promote collaboration and information sharing between scientists and managers. Collaboration also has the potential to bring transparency to marine policy. Cooperation and cooperative research between scientists and managers helps foster transparency (Kaplan and McCay 2004). The emergence of transparency around marine policy is important because it holds both managers and scientists accountable for their decision-making

There is a recurring theme in the literature that suggests for marine policies to be considered successful that multiple perspectives be considered and integrated and socioeconomic factors considered alongside the scientific components of the marine environments (Crosby et al. 2000, Leschine et al. 2003, Barnes and McFadden 2008, Cheong 2008, Link et al. 2012). There are multiple case studies where such integration and collaboration have been successful. Alaska, Canada, and the Binational Red Sea Marine Peace Park all have projects that integrate environmental and socio-economic goals in marine policy making (Crosby et al. 2000, Fletcher 2007). Cheong (2008) makes note that while integration and collaboration are essential in marine policy, a "one-size fits all" approach to policy-making is not the answer. Instead, he suggests there is a need for scientists and managers to create case-specific solutions in order to be successful.

The integration of natural science and policy considerations has been identified as important across the existing literature (Crosby et al. 2000, Leschine et al. 2003, USCOP 2004, Boesch 2006, Barnes and McFadden 2008, Cheong 2008, Ruckelhaus et al. 2008, Levin et al. 2009, House and Phillips 2012). As noted earlier, Levin et al. (2009) propose the use of integrated ecosystems assessments within marine policies that rely heavily on scientific information and stakeholder involvement when scoping a specific marine ecosystem in order to identify policy objectives. This method of integrating scientific information and collaborating across all involved stakeholders has been used somewhat successfully in Tillamook Bay, Oregon through the Tillamook Bay National Estuary Project. Initial collaboration between technical experts, community leaders and stakeholders reduced a list of 150 potential management actions down to only three options which was encouraging although the final three policy options were highly controversial (Gregory and Wellman 2001).

## Barriers to Involvement

While new management models like eco-system based management require scientists integrated into decision-making, there are no clear models for involving them (Leschine et al. 2003, Fletcher 2007, Levin et al. 2009, House and Phillips 2012). Instead, the literature suggests there may be significant barriers to the involvement of scientists in marine policy. These barriers include: 1) the reluctance of some scientists to give their input for a variety of reasons, 2) communication difficulties between scientists and managers, 3) the dueling relationship between scientific uncertainty and management and stakeholder needs or expectations and, 4) political and institutional barriers. These barriers are discussed briefly below.

The discomfort and reluctance some scientists feel in providing concrete or definite predictions from their research regarding marine ecosystems is a barrier to the involvement of scientists in marine policy (Kraak et al. 2010, Frid et al. 2006). Scientists report feeling uneasy in participating in marine policy formation because the demand from managers and the public to have correct answers or solutions to complex marine problems seems unreasonable (Kraak et al. 2010). According to Frid et al. (2006) scientists feel uneasy reporting their findings to managers because of the deficiencies that remain in the scientific understanding of marine ecosystems.

While scientific uncertainties and scientists' discomfort in reporting their results are both significant barriers, closing the communication gap and vocabulary differences between scientists and managers appear to be another important barrier to highlight. Peterman (2004, p. 1339) states it rather simply and says, "It is difficult to convey assumptions, results, and implications effectively to people who are not actively involved in the analysis." Frid et al. (2006) make it clear that in order for the communication gap among managers and scientists to be reduced, scientists will need to directly engage managers to report their findings in clear and understandable fashion. Arkema et al. (2006) also make it evident that in order to create successful marine policies the communication and information sharing between scientists and managers must be standardized and streamlined in order to break down this gap in communication. Boesch (2006) evaluated two different cases in the Chesapeake Bay and Coastal Louisiana concerning the formation of marine policies and suggests giving scientists some sort of incentive to present their input to managers in an understandable fashion. Relating closely to inadequate communication, Link et al. (2012) find that unclear management objectives lead to less successful applications of EBM. The creation of clear management objectives by natural resource managers can help give guidance to technical experts and allow them to assist in clarifying what is reasonable to expect given certain management objectives.

Many researchers have also found that scientific uncertainty is a barrier to using science in marine policy-making (Hiscock et al. 2003, Peterman 2004, Frid et al. 2006, House and Phillips 2012, Link et al. 2012, Swaney et al. 2012). Peterman (2004) claims that scientific uncertainty can be blamed for many managers discounting science in policy and decision-making. The nature of scientific uncertainty makes it difficult for scientists to provide managers and stakeholders with the absolute answers they want to make decisions or policy (Kraak et al. 2010). Finally, Frid et al. (2006, p. 1571) state:

> Decision-makers and stakeholders need to recognize that cutting-edge science is inherently dynamic and, as such, there will be no single source for, nor necessarily a strong consensus on, the best advice.

The last identified barrier to scientific involvement in marine policy may have nothing to do with scientific information at all. There are inherent political and institutional barriers that can impair the attempts of scientists to integrate their findings and suggestions into actual marine policy (Leschine et al. 2003). For example, O'Connor et al. (2010) found in Ireland that cooperation among scientists and managers is beneficial, but the only way to create sustainable marine policies is to have a formal regulatory instrument in place. Ruckelshaus et al. (2008) claim that coordination among governing authorities is an important aspect of creating successful EBM practices. Finally, Arkema et al. (2006, p. 531) say, "Commitment from all levels of government to support and foster EBM is also needed."

In order to break down some of these barriers there have been suggestions in recent literature including creating and using new scientific models such as multimodel inference and formal selection criterion like the Akaike Information Criterion, which aids in determining which models merit further consideration (Link et al. 2012), planning for the future instead of trying to fix past problems, using qualitative modeling, and even including interpreters to convey scientific research to managers in a clear concise fashion (Link et al. 2012, Boesch 2006, Kraak et al. 2010, Stojanovic et al. 2009). Because of scientific uncertainty in marine environments, the difficulties of predicting future outcomes, and the demand for concrete solutions and conclusions, scientists remain somewhat skeptical about the attempt to integrate science into marine policy-making.

## Technocracy-Democracy Quandary

Consideration of the Technocracy-Democracy quandary is important when discussing the preferred role of scientists in marine policy but we must first identify and define what democracy and technocracy both mean. Scholars have identified three types of democracy: 1) participatory democracy where citizen participation is highly valued and gives meaning to democracy itself; 2) representative democracy where citizens' are simply delegated to voting in elections; and 3) a form of democracy where the time for citizen participation has passed (Fischer 2000). Technocracy on the other hand is a form of governance that relies on the capabilities of technical experts without any public deliberation. Pierce et al. (1992, p. 12) describe the quandary by stating:

> the postindustrial quandary is posed by the intersection of the two major streams just described: (1) individual level value change leading to changes in policy

> demands and enhanced claims for influence on policy outcomes, and (2) technological and scientific content being imparted to old issues and new policy conflict around technologies and their impact, both of which are direct consequences of postindustrial societies' heavy reliance on continuous scientific discovery and constant technological advancement.

In general, the debate focuses on the role of technical experts verses the role of the public in policy-making. Because of the highly technical nature of managing marine ecosystems *and* the call for more public participation within marine policymaking and environmental policy, the technocracy-democracy quandary lies at the heart of the issue of the preferred role of science and scientists in marine policymaking.

This dilemma rings especially true when working within the environmental policy arena because of the highly complex nature of the environment and the constant pressure for more public involvement (Pierce et al. 1992).

> While environmental policy issues have become increasingly complex over time as new knowledge about human effects upon the natural ecology becomes available, the environmental policy arena is nonetheless one in which there has been persistent pressure for expanding public involvement in the management of environmental affairs (Pierce et al. 1992, 1).

When addressing the issue of stakeholder engagement in marine spatial planning in particular, Pomeroy and Douvere (2008, p. 816) state, "Stakeholder involvement can increase stability in complex environment and expand capacity rather than diminish it under changing circumstances."

The attempt to incorporate science and scientists into marine policy-making, as seen throughout the literature review, has recently begun to gain momentum on an international scale as well as here in the United States (Ruckelshaus et al. 2008, McFadden and Barnes 2009, Stojanovic et al. 2009). Many researchers and organizations suggest that the best way to not only include technical expertise but also consider other forms of knowledge including public participation is to implement some form of ecosystem management, especially EBM (Boesch 1999, Boesch 2006, NRC 1994, NRC 1995, USCOP 2004, Cheong 2008, Levin et al. 2009,Link et al. 2012). Using EBM practices within marine policy has the potential to infuse technical expertise and democratic participation, increase collaboration among scientists and natural resource managers, and reduce the barriers to involvement of scientists in policy-making (Arkema et al. 2006, Boesch 2006, Leslie and McLeod 2007, Ruckelshaus et al. 2008).

Again, this study looks at the preferred role of science and scientists in marine policy as well as comparing the preferred roles of scientists in terrestrial policy to that in marine policy. By examining these preferences within marine policy and comparing the results to the preferred role in terrestrial policy we can begin to get an idea of how the four respondents, scientists, natural resource managers, interest group representatives and the public would accept or reject ecosystem management practices in the marine policy setting as EBM attempts to integrate science and scientists' input at a higher level than previous management practices.

## Methods

Surveys were administered in 2007 to national random samples of representatives of four different groups involved or interested in terrestrial issues and policy making: scientists, managers, representatives of non-governmental organizations, and members of the general public. Scientists working through the National Science Foundation's Long Term Ecological Research (LTER) program were sampled as a group of relatively homogenous scientists involved in potentially policy-relevant terrestrial research. These scientists work at universities, state and federal agencies, and private organizations. Managers of state and federal natural resource and environmental agencies (e.g., U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service, National Park Service, state departments of natural resources, parks, environmental quality, etc.) were also sampled. While many of these respondents have graduate science degrees, they identified themselves as resource managers responsible for implementing agency objectives. A sample survey of directors and leaders of natural resource and environmental organizations (e.g., environmental groups, industry associations, recreation groups, etc.) was also conducted. Again, some of these respondents have advanced science degrees, but for the purposes of this study self-identified as part of an organization that advocates for a particular policy position. Education levels are necessary to point out because those with graduate science degrees could potentially also be categorized as scientists but for this study it was necessary to distinguish between the four groups. Finally, a random sample survey of the general public was conducted. Unlike the other samples, this group tended not to have advanced science degrees.

The scientist sample was provided by the LTER program, the public sample was provided by a national sampling company, and the manager and interest group samples were compiled by systematic random sampling from association and group directories available in print and on the internet. Examples include *The National Environmental Directory* (http://www.environmentaldirectory.net/), which has over 13,000 environmental and conservation groups listed, and the *Conservation Directory 2004* (Island Press, 2004), which has nearly comprehensive lists of conservation and environmental organizations, government agencies, nongovernmental organizations, and colleges and more than 18,000 officials concerned with natural resource use, management and education.

The surveys were designed using Dillman's *Mail and Telephone Surveys: The Total Design Method* (1978). For all groups, up to three rounds of mail surveys were sent with a fourth telephone reminder if necessary. Sample sizes and response rates are displayed in Figure 1 (Steel et al. 2009).

Table 1: Sample Size and Response Rate for Terrestrial Surveys

| *Sample:* | *Surveys Sent:* | *Surveys Returned:* | *Response Rate:* |
|---|---|---|---|
| Scientists | 424 | 355 | 84% |
| Managers | 500 | 272 | 54% |
| Interest Group Representatives | 500 | 287 | 57% |
| Public | 3,147 | 1,605 | 51% |

In 2011, the terrestrial science study was replicated in the marine and ocean science area. The scientists sampled work at universities, state and federal agencies, and private organizations that deal with ocean and marine policy issues (including only ocean coastal states). The sample was developed using relevant websites in each coastal state including Hawaii and Alaska (but excluding Great Lakes states) and from systematic random sampling from association and group directories available in print and on the Internet as was used for the 2007 study. Sources included *The National Environmental Directory* (http://www.environmentaldirectory.net/) and the *Conservation Directory 2004* (Island Press 2004), which has nearly comprehensive lists of conservation and environmental organizations, government agencies, nongovernmental organizations, and colleges and more than 18,000 officials concerned with natural resource use, management and education.

Managers of state and federal natural resource and environmental agencies working on coastal or marine issues were also identified and sampled (e.g., NOAA, Oregon Parks and Recreation Department, Alaska Division of Ocean and Coastal Management, U.S. Bureau of Ocean Energy Management, etc.). While many of these respondents have graduate science degrees, they identified themselves as resource managers responsible for implementing agency objectives. A sample of directors and leaders of natural resource and environmental organizations that deal with coastal and ocean issues were contacted for the survey (e.g., environmental groups, industry associations, recreation groups, etc.). Again, some of these respondents have advanced science degrees, but for the purposes of this study self-identified as part of an organization that advocates for a particular policy position. Finally, a random sample of the general public in ocean coastal states was conducted. As with the terrestrial public sample, a national sampling company was used to generate a random sample for all of the states. Sample sizes and response rates for the marine survey are displayed in Table 2 (personal communication with Brent Steel).

Table 2: Sample Size and Response Rate for Marine Survey

| *Sample:* | *Surveys Sent:* | *Surveys Returned:* | *Response Rate:* |
|---|---|---|---|
| Scientists | 300 | 211 | 70% |
| Managers | 300 | 165 | 55% |
| Interest Group Representatives | 400 | 194 | 48% |
| Public | 2,200 | 1,054 | 48% |

In attempting to uncover any differences or similarities between the two different policy arenas regarding preferred roles for scientists in natural resource policy-making, respondents were asked to describe their acceptance and preference for five different roles that scientists could take in policy making. The five roles are: 1) Scientists should only report scientific results and leave others to make natural resource management decisions; 2) Scientists should report scientific results and then interpret the results for others involved in natural resource management decisions; 3) Scientists should work closely with managers and others to integrate scientific results in management decisions; 4) Scientists should actively advocate for specific natural resource management policies they prefer; and 5) Scientists should be responsible for making decisions about natural resource management.

In order to uncover any differences between the two different policy arenas in regards to the preferred role of scientists in natural resource policy data were examined in four different ways using the statistical analysis program STATA. First, the descriptive statistics for each of the five preferred roles of scientists of the four different groups of respondents was recorded. Frequencies of agreement with each role, mean response for each role within a stakeholder group, and standard deviations for each were developed separately for each of the two studies. Next a difference in means testing was used to examine the differences of preferences of similar participants within a policy arena (e.g., terrestrial and marine policy). An analysis of variance tests (ANOVA) was run to further uncover any differences between all respondent groups within each survey.

Finally, following the same lines as Steel et al. (2004) and Steel et al. (2009), a multivariate analysis using logistical regression models was conducted for both surveys with each of the five preferred roles of scientists used as the dichotomous variables to determine if positivist and New Environmental Paradigm (NEP) value orientations had any significant effect on participants' attitudes about the preferred roles of scientists in the environmental policy process. The NEP is a widely used scale to measure respondents' bio-centric and pro-environmental values.

## Findings and Discussion

When examining the preferred role of scientists in terrestrial policy in Table 3 we find that there is fairly general agreement across all participants that they prefer a more involved role for scientists than simply reporting findings to natural resource managers. Many agree that scientists should not only report their scientific results but should also interpret the results for others involved in making natural resource decision-making. The highest agreement for the preferred role of scientists in terrestrial policy for all participants was that scientists should work closely with managers and others to integrate scientific results in management decisions. What is most compelling about these results is that there are a very high number of respondents who believe scientists should take a more involved role in environmental policy-making. Interestingly, 27% of scientists actually believe that they should be responsible for making decisions about natural resource management. There are also a high number of interest group respondents who believe scientists should be the ones making natural resource decisions.

Table 3. Attitudes towards scientific advocacy, Terrestrial Sample

| Statements | Scientists: % agree[a], mean | Managers: % agree, mean | Interest Groups: % agree, mean | Public: % agree, mean |
|---|---|---|---|---|
| Scientists should only report scientific results and leave others to make natural resource management decisions; F-test=22.64*** | 21%, 2.21 | 50%, 3.02 | 22%, 2.27 | 27%, 2.46 |
| Scientists should report scientific results and then interpret the results for others involved in natural resource management decisions; F-test=16.48*** | 90%, 4.32, | 79%, 4.02 | 87%, 4.19 | 77%, 3.91 |
| Scientists should work closely with managers and others to integrate scientific results in management decisions; F-test=10.33*** | 93%, 4.49 | 93%, 4.57 | 93%, 4.53 | 86%, 4.32 |
| Scientists should actively advocate for specific natural resource management policies they prefer; F-test=25.54*** | 42%, 2.95 | 32%, 2.75 | 50%, 3.23 | 54%, 3.37 |
| Scientists should be responsible for making decisions about natural resource management; F-test=13.99*** | 27%, 2.55 | 18%, 2.23 | 38%, 2.89 | 28%, 2.64 |
| *n* | 354 | 262 | 282 | 1,602 |

Scale used: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree.
[a] Percent agree and strongly agree
***Significance level $P < 0.001$

In exploring differences and similarities for the preferred role of scientists in policy making between the terrestrial and marine participants, we found more similarities than differences. After performing difference in means testing, there were no significant differences between the participants in similar categories in the terrestrial and marine arenas. As in the terrestrial survey, the highest level of agreement for the four different categories of participants for the preferred role of scientists was that they should work closely with managers to integrate their findings in management decisions (Table 4). Interestingly, we also found that like the terrestrial scientists, marine scientists somewhat agree that scientists should play a larger role in policy-making with 28% of them agreeing that scientists should make natural resource management decisions. This is an interesting finding because we hypothesized that there would be a significant difference between the two distinct policy arenas.

Table 4. Attitudes towards scientific advocacy, Marine Sample

| Statements | Scientists: % agree[a], mean | Managers: % agree, mean | Interest Groups: % agree, mean | Public: % agree, mean |
|---|---|---|---|---|
| Scientists should only report scientific results and leave others to make natural resource management decisions; F-test=11.72*** | 23%, 2.26 | 47%, 2.96 | 22%, 2.25 | 26%, 2.43 |
| Scientists should report scientific results and then interpret the results for others involved in natural resource management decisions; F-test=11.61*** | 90%, 4.33 | 80%, 4.02 | 86%, 4.18 | 75%, 3.88 |
| Scientists should work closely with managers and others to integrate scientific results in management decisions; F-test=8.00*** | 92%, 4.48 | 95%, 4.59 | 92%, 4.51 | 84%, 4.29 |
| Scientists should actively advocate for specific natural resource management policies they prefer; F-test=11.45*** | 44%, 2.97 | 35%, 2.85 | 48%, 3.20 | 54%, 3.36 |
| Scientists should be responsible for making decisions about natural resource management; F-test=6.11*** | 28%, 2.53 | 21%, 2.27 | 35%, 2.80 | 29%, 2.63 |
| *n* | 208 | 165 | 194 | 1,053 |

Scale used: 1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree.
[a] Percent agree and strongly agree
***Significance level $P < 0.001$

In order to further examine the differences in attitudes regarding the preferred role of scientists in marine and terrestrial policy we preformed an analysis of variance test (ANOVA) for each of the different respondent groups. In performing these ANOVA tests it is possible to see which groups of respondents held significantly different preferences for scientists' role in terrestrial and marine policy from one another.

When analyzing the results of the ANOVA tests, the public was the most different from the other three respondent groups in both the terrestrial and marine surveys (Tables 4 and 5). Much of the results were as expected and were in line with what was reported in Tables 1 and 2, with the public and interest groups supportive of an involved role for scientists in policy-making with managers, and scientists more likely than the public and interests to express support for a restricted role for scientists. In general, the public surveyed in both policy arenas was more supportive of an active and involved role for scientists in the policy-making process when compared to the other three participant groups with one exception. In the terrestrial survey the public was significantly less likely than the interest group respondents to agree with the statement that scientists should make environmental policy decisions. This difference did not show up in the marine study.

There were also some other results where significant differences showed up in the terrestrial study but not the marine study. Managers in the terrestrial study were less likely than scientists to agree that scientists should make natural resource policy decisions; interest groups in the terrestrial study were significantly more likely than other respondents to agree that scientists should advocate and make natural resource policy decisions; and the public was more likely than scientists to believe that scientists should only report their findings to natural resource managers. These differences could be for a variety of reasons but it could vey well be because the public are not experts in ecological science nor in the intricacies of natural resource policy-making.

Table 5. Terrestrial ANOVA results

| Dependent Variable | Managers v. Scientists | Managers v. Interest Groups | Public v. Managers | Interest Groups v. Scientists | Public v. Scientists | Public v. Interest Groups |
|---|---|---|---|---|---|---|
| Report, F-test=22.64*** | 0.806*** | 0.746*** | -0.554*** | 0.060 | 0.252** | 0.192 |
| Interpret, *F-test=16.48**** | -0.294** | -0.169 | -0.108 | -0.126 | -0.403*** | -0.277*** |
| Integrate, *F-test=10.33**** | 0.084 | 0.046 | -0.253*** | 0.038 | -0.169** | -0.207*** |
| Advocate, *F-test=25.54**** | -0.198 | -0.485*** | 0.625*** | 0.287** | 0.427*** | 0.140 |
| Make, *F-test=13.99**** | -0.321** | -0.657*** | 0.408*** | 0.336*** | 0.088 | -0.248** |

*Significant levels*: *.10, **.05, ***.01

Table 6. Marine ANOVA results

| Dependent Variable | Managers v. Scientists | Managers v. Interest Groups | Public v. Managers | Interest Groups v. Scientists | Public v. Scientists | Public v. Interest Groups |
|---|---|---|---|---|---|---|
| Report, F-test=11.72*** | 0.698*** | 0.710*** | -0.527*** | -0.012 | 0.171 | 0.183 |
| Interpret, *F-test=11.61**** | -0.304* | -0.151 | -0.140 | -0.153 | -0.444*** | -0.291*** |
| Integrate, *F-test=8.00**** | 0.112 | 0.078 | -0.300*** | 0.034 | -0.188* | -0.223** |
| Advocate, *F-test=11.45**** | -0.123 | -0.347* | 0.511*** | 0.225 | 0.388*** | 0.164 |
| Make, *F-test=6.11**** | -0.267 | -0.534*** | 0.361*** | 0.267 | 0.094 | -0.173 |

*Significant levels*: *.10, **.05, ***.01

Finally, multivariate analysis was used to examine differences among the four groups concerning attitudes toward scientific roles while controlling for various explanatory variables. Recent studies (Steel et al. 2004 and Steel et al. 2009) have found that attitudes about the preferred roles of scientists are influenced by a variety of different factors. The factors that have been outlined in these previous studies include socio-demographic characteristics, and political and environmental value orientations. The socio-demographic variables included as predictors of orientations toward the role of scientists in the natural resource policy process are gender, age, and the level of formal education. These variables have all been shown in recent literature to affect attitudes toward science (Steel et al. 2006). We also included in the multivariate analysis a self-assessment measure of general political orientation, which was on a scale of one (very liberal/left) to nine (conservative/right,); questions from the New Environmental Paradigm (NEP) scale (Dunlap et al. 2000) to assess political and environmental value orientations; and a positivism scale that measures the orientations of the respondents' attitudes about science.

Like previous studies (Steel et al. 2006, Steel et al. 2009) the dependent variables concerning the roles of scientists have each been dichotomized with 1 = "agree" and "strongly agree" responses and 0 = all other responses. Logistic regression models were estimated in order to explore the impact of the multiple explanatory variables of attitudes of the preferred roles of scientists in the environmental policy process. For the series of dummy variables assessing the four groups studied, scientists are the omitted category in order to be consistent with previous studies (Steel et al. 2004, Steel et al. 2009).

Table 7. Logistical regression estimates for roles of scientists in the terrestrial policy process

| Variables | Report: β (S.E.) | Interpret: β (S.E.) | Integrate: β (S.E) | Advocate: β (S.E.) | Make: β (S.E.) |
|---|---|---|---|---|---|
| Age | 0.005 | 0.010* | 0.006 | 0.006 | 0.000 |
| | (0.00) | (0.00) | (0.01) | (0.00) | (0.00) |
| Gender | -0.370*** | 0.026 | 0.038 | 0.114 | 0.214* |
| | (0.11) | (0.11) | (0.14) | (0.09) | (0.10) |
| Education | -0.168*** | 0.147** | 0.163** | 0.143*** | 0.057 |
| | (0.05) | (0.05) | (0.06) | (0.04) | (0.05) |
| NEP | -0.066*** | 0.059*** | 0.108*** | 0.042*** | 0.061*** |
| | (0.01) | (0.01) | (0.01) | (0.01) | (0.01) |
| Ideology | 0.189*** | 0.030 | 0.028 | -0.112*** | -0.025 |
| | (0.03) | (0.04) | (0.05) | (0.03) | (0.03) |
| Positivism | -0.024 | 0.055*** | 0.056** | 0.062*** | 0.130*** |
| | (0.01) | (0.02) | (0.02) | (0.01) | (0.01) |
| Managers | 0.803*** | -0.451 | 0.602 | 0.070 | -0.028 |
| | (0.20) | (0.26) | (0.34) | (0.19) | (0.21) |
| Interest | -0.307 | -0.226 | 0.439 | 0.578*** | 0.650*** |
| Groups | (0.22) | (0.27) | (0.34) | (0.18) | (0.19) |
| Public | -0.526** | -0.595** | 0.008 | 1.102*** | 0.325 |
| | (0.19) | (0.23) | (0.27) | (0.16) | (0.17) |
| | | | | | |
| N | 2390 | 2390 | 2390 | 2390 | 2390 |
| % correctly classified | 73.47 | 80.29 | 88.45 | 60.29 | 71.51 |
| $\chi^2$ | 260.57*** | 111.63*** | 134.35*** | 180.72*** | 202.37*** |

*Note*: The dependent variable for scientific advocacy was dichotomized for use in logistic regression (1=strongly agree and agree, 0=else)
*Significance level $P < 0.05$
**Significance level $P < 0.01$
***Significance level $P < 0.001$

Table 8. Logistical regression estimates for roles of scientists in the marine policy process

| Variables | Report: β (S.E.) | Interpret: β (S.E.) | Integrate: β (S.E) | Advocate: β (S.E.) | Make: β (S.E.) |
|---|---|---|---|---|---|
| Age | 0.007 | 0.011 | 0.005 | 0.007 | -0.001 |
| | (0.01) | (0.01) | (0.01) | (0.00) | (0.01) |
| Gender | -0.415** | 0.064 | 0.098 | 0.050 | 0.225 |
| | (0.13) | (0.14) | (0.17) | (0.11) | (0.12) |
| Education | -0.140* | 0.135* | 0.199** | 0.117* | 0.066 |
| | (0.06) | (0.06) | (0.07) | (0.05) | (0.06) |
| NEP | -0.074*** | 0.060*** | 0.123*** | 0.044*** | 0.051*** |
| | (0.01) | (0.01) | (0.02) | (0.01) | (0.01) |
| Ideology | 0.201*** | 0.035 | 0.046 | -0.137** | -0.019 |
| | (0.04) | (0.04) | (0.05) | (0.04) | (0.04) |
| Positivism | -0.021 | 0.040* | 0.047* | 0.046** | 0.129*** |
| | (0.02) | (0.02) | (0.02) | (0.02) | (0.02) |
| Managers | 0.646* | -0.570 | 0.865 | -0.004 | -0.091 |
| | (0.26) | (0.34) | (0.46) | (0.24) | (0.27) |
| Interest Groups | -0.362 | -0.381 | 0.384 | 0.335 | 0.454 |
| | (0.27) | (0.34) | (0.41) | (0.22) | (0.24) |
| Public | -0.615** | -0.799** | -0.028 | 0.987*** | 0.249 |
| | (0.24) | (0.28) | (0.33) | (0.20) | (0.22) |
| | | | | | |
| N | 1550 | 1550 | 1550 | 1550 | 1550 |
| % correctly classified | 74.52 | 79.35 | 87.42 | 60.58 | 71.29 |
| $\chi^2$ | 176.55*** | 74.28*** | 116.09*** | 108.05*** | 113.58*** |

*Note*: The dependent variable for scientific advocacy was dichotomized for use in logistic regression (1=strongly agree and agree, 0=else)
*Significance level $P < 0.05$
**Significance level $P < 0.01$
***Significance level $P < 0.001$

When examining the five models presented in Tables 7 and 8, the two studies have very similar significance results, which was unexpected. In both the logistic regression models the positivism index has a significant relationship in four out of five models for both the terrestrial and the marine studies. It is noteworthy to point out that those respondents who have a more positivist orientation toward science are less supportive than those with less positivist orientations of a limited role for scientists in the environmental policy decision-making process. In both of the studies these regression results indicate that respondents with more positivist orientation tendencies are significantly more likely than others to support scientists' involvement in the environmental policy decision-making process. These respondents support scientists interpreting their research for managers, integrating research results into policy, advocating for specific policies that they prefer, and finally actually making environmental policy decisions.

Among the socio-demographic variables, age does not have a significant effect on most preferences for the different roles in either study. The respondents' gender is significant on "report only" and "make decisions" in the terrestrial study while significant only on "report only" in the marine study. Women in both studies are less supportive then men of scientists only reporting their research findings and, in the terrestrial study are more supportive then men of scientists making environmental policy decisions.

Education seems to affect the respondents' preferences for the different roles in both marine and terrestrial studies. Respondents with high levels of education were more likely than those with low levels of education to support an involved role for scientists (interpret, integrate and advocacy) in environmental policy-making. Also, respondents in both studies with high levels of education were unlikely to prefer scientists only reporting their findings to natural resource managers.

The NEP indicator has a significant effect for all five roles in both the marine and the terrestrial studies. In both studies, those respondents with high NEP scores are significantly less supportive than those with low NEP scores of scientists only reporting their findings. These same respondents with high NEP scores are very supportive of scientists having a larger role in environmental policy-making and likely to agree that scientists should interpret their data for managers, integrate their research, advocate for preferred policies, and even make certain environmental policy decisions compared to those respondents with low NEP scores.

As to political ideology, similar results were found in both the terrestrial and marine studies. Those respondents with left/liberal tendencies tended to be significantly more supportive than those with right/conservative views of scientists advocating for their preferred policies and significantly less supportive of scientists only reporting their results. These results are similar to those found in previous studies regarding effects of value orientations on role preferences (Steel et al. 2004; Steel et al. 2009).

The final set of variables included in each model is the dummy variables for the four participant groups in each study. In Tables 1 and 2 (pages 17 and 19 respectively) we see that for both of the different policy arenas, interest groups and the public are more supportive than scientists and natural resource managers of a more involved role for scientists in the environmental policy-making process. When controlling for various socio-demographic factors and value orientations, similar but not identical results are found for the terrestrial and marine respondents. Interest groups are significantly more likely than scientists to prefer that scientists make natural resource decisions in the terrestrial study but not in the marine study. The public is significantly more likely than scientists to prefer that scientists should advocate for their preferred policies in each of the two studies. The public is also significantly less likely than scientists to agree that scientists should only interpret their findings for natural resource managers. But what is interesting and confirmed by the findings reported in Table 1 and 2 is that managers are far more likely than scientists to agree that scientists should have a minimal role in the environmental policy process and are most likely to report that scientists should only report their findings. This finding is in line with what previous studies have reported and like Steel et al. (2009) noted this could very well be because managers want to maintain some sort of control in policy decision-making process. Finally, once other factors have been controlled for, there is no significant difference among the four groups when it involves the role of scientists integrating their research into environmental policies.

## Summary and Conclusion

Overall, similar results were found in the terrestrial and marine policy arenas regarding the preferred role of science and scientists in policymaking. While there have been recent calls for the integration of EBM practices in marine policy, this is quite new compared to the several decades of EBM and conservation based practices in terrestrial policy and research. Prior to conducting this research, I hypothesized that I would in fact see a significant difference between the preferred role for scientists in the terrestrial and marine policy arenas due to the difference in policy and management engagement with EBM. With the recent calls for the use of more ecosystem management practices, the implementation of ecosystem management abroad, and the attempt to actually put ecosystem management into practice by a large U.S. government agency, we could be witnessing a shift in the way stakeholders are perceiving and preferring the role of scientists in marine policy-making. Crosby et al. (2000) found similar evidence with their Red Sea case study with a possible paradigm shift occurring in the way scientists and scientific information are being viewed by stakeholders. As witnessed in the literature review, there are many potential barriers for involvement of scientists in marine policy-making with EBM, but through this research, it seems as though these four stakeholder groups would welcome an expanded role for scientists in the marine policy-making process.

The calls to implement some versions of ecosystem-based management into marine policy-making have been widespread (Arkema et al. 2006, Barnes and McFadden 2008, Ruckelhaus et al. 2008, and Levin et al. 2009). Beginning to implement ecosystem management practices in marine policy-making could not only help alleviate the technocracy-democracy quandary within marine policy but it could also receive high levels of support from all stakeholders because of its goals of considering stakeholder and scientific information in creating marine policies. Although we have not found any significant differences for the preferred role of scientists between the two different policy arenas we have uncovered that the potential stakeholders in the marine policy arena support more involvement of scientists in policymaking. All four groups agree that scientists should work closely with natural resource managers in order to integrate their research into marine policies, which is a more technocratic role than the traditional role of scientists in environmental policy. If EBM continues to be implemented on a much broader policy scale as suggested by NOAA, it appears as if the public is likely to welcome increased involvement by scientists and scientific information. Further research could examine these roles in the context of specific environmental policies (e.g., habitat conservation) to examine how preferences may change when it comes to explicit policies instead of general terrestrial and marine policy.

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