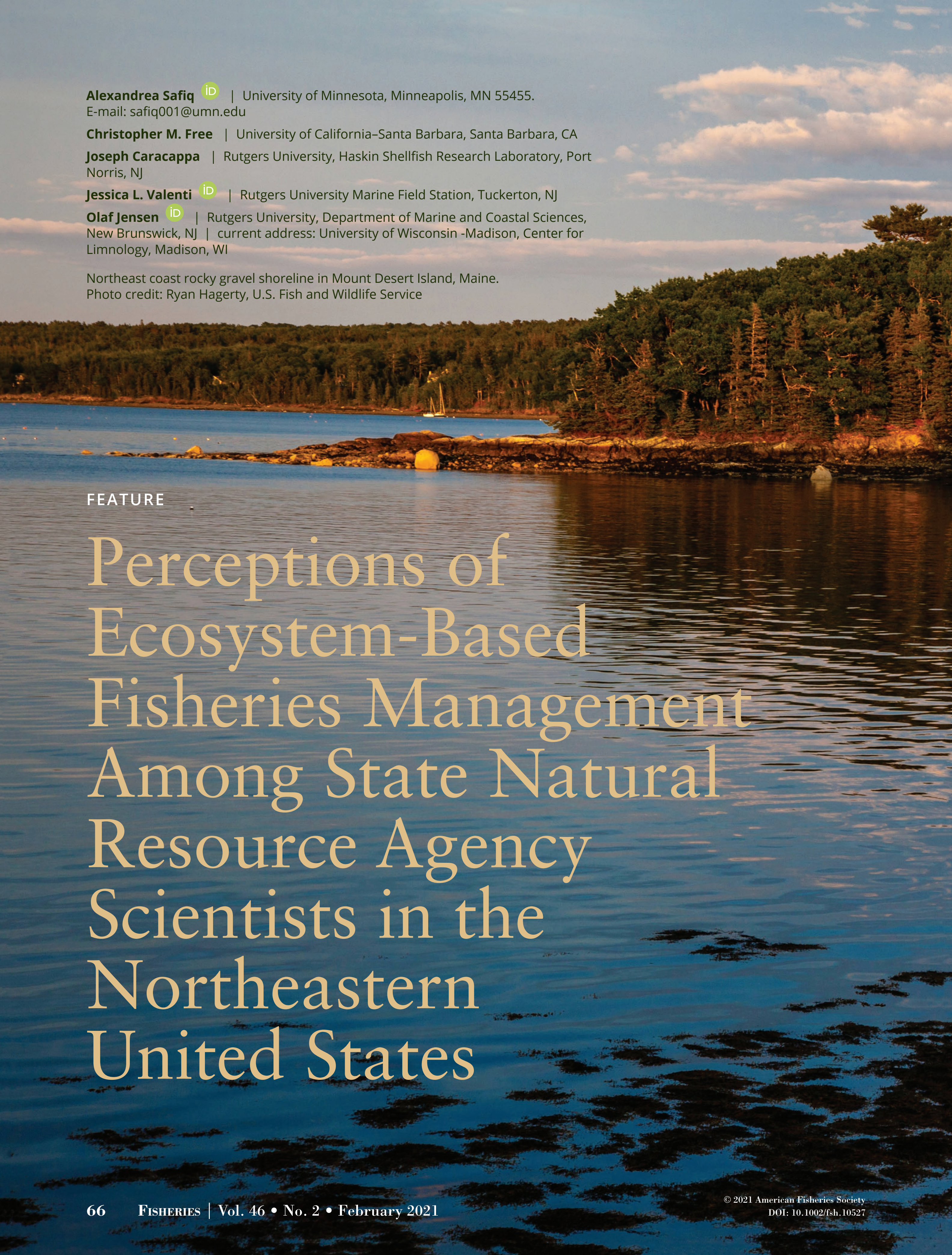

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Northeast coast rocky gravel shoreline in Mount Desert Island, Maine.
Photo credit: Ryan Hagerty, U.S. Fish and Wildlife Service

FEATURE

Perceptions of Ecosystem-Based Fisheries Management Among State Natural Resource Agency Scientists in the Northeastern United States

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Ecosystem-based fisheries management (EBFM) is an application of ecosystem-based management in which abiotic, biotic, and socio-economic interactions are considered when managing fisheries. The primary objectives of this study were: (1) to understand how state fishery scientists define EBFM; (2) to identify the perceived implementation of EBFM components within state agencies; and (3) to identify potential barriers in implementing EBFM at the state level. The uniformity across inclusion responses indicated that there was a shared definition of EBFM among state fishery scientists. The most frequently implemented component was *engaging stakeholders,* and the least frequently implemented component was *accounting for uncertainty* in ecosystems. Overall, the most frequently cited barriers were *stakeholder engagement* in the New England region and *regulatory barriers* in the mid-Atlantic region. These findings can help identify where potential human and fiscal resources should be allocated for successful implementation of EBFM at the state level.

INTRODUCTION

Ecosystem-based fisheries management (EBFM) is a holistic approach to fisheries management that recognizes the physical, biological, economic, and social complexities of managing living marine resources and considers the broader interactions between and among species that interact with target management species (Link 2010). Historically, policymakers and managers have relied on a single-species approach to natural resource management, but recent acknowledgments of the importance of complex interactions among species (such as trophic cascades, indirect competition, etc.) has led to a shift from the single-species approach towards an ecosystem-wide approach in the science supporting management (Pikitch et al. 2004; Hilborn 2011).

In recent years, emphasis has been placed on implementing ecosystem-based approaches to management within the context of marine systems, notably following the implementation of the U.S. Magnuson–Stevens Fishery Conservation and Management Act (MSA; NOAA 2007; Essington et al. 2016). The MSA mandates preservation of sustainable stocks by using the best available science, fair resource access among stakeholders, and an expectation to capitalize on the economic potential of stocks without degrading their ability to provide benefits in the future (i.e., optimum yield). In essence, the MSA calls upon science to inform sustainable management, efficient economic strategies, and stakeholder engagement, which are all components of EBFM (NMFS 2018). Although EBFM is not explicitly mentioned in the MSA, U.S. federal government agencies still point to the MSA as a legislative mandate for implementing EBFM (DOC et al. 2016). In addition to the governmental call for the implementation of EBFM, it has been noted by the scientific community to be one of the preferred frameworks for analyzing tradeoffs between and among social, economic, and ecological systems (Walters and Martell 2004).

The concept of ecosystem-based management as it applies to fisheries was solidified in Larkin's (1996) paper, with the main idea that EBFM provides a more holistic approach to natural resource management. Over the past several decades, scientists and government agencies have gone on to more specifically define the concept of holistic management. Link (2010) states that ecosystem based management implies the application of management options to a resource sector that accounts for all key factors and processes from the primary perspective of the entire ecosystem. Based on this definition of EBFM, the National Oceanic and Atmospheric Administration (NOAA), defines EBFM as existing along a management continuum that takes into account the complex suite of biological, physical, economic, and social factors associated with managing living marine resources (NOAA 2018). By including socio-economic factors into a management paradigm that considers the biological and physical dynamics of an ecosystem, EBFM transforms the ecological system into a social–ecological system. McLeod and Leslie (2009) defines these systems as people seascapes; as such, these systems have measurable components (such as but not limited to biomass removed from a fish stock, water temperature measurements, and fluctuating market values) that lend themselves to the definition and measurement of EBFM. The United Nations has also identified a suite of socio-ecological indicators to measure the outcomes of EBFM (UNEP and GPA 2014). These indicators reaffirm the definition of EBFM as a more holistic approach to management of marine, freshwater, and coastal resources by considering biological, physical, and socio-economic factors. However, while the general concept of EBFM is well-defined, the specific attributes that enable EBFM can differ.

Biedron and Knuth (2016) found that at the federal level most stakeholders agreed on definitions, practices, and possible outcomes for EBFM. Their study also found that the Mid-Atlantic Fishery Management Council and New England Fishery Management Council believed that state level fisheries management should gradually transition from single-species management to ecosystem-based management. Because their study focused exclusively on federally managed fisheries, it did not provide information whether similar perceptual patterns exist within state fishery management systems.

Despite acknowledgment among federal scientists and policymakers of the need to move toward EBFM, it remains unclear how state natural resource agencies should go about transitioning from single-species management to EBFM (Arkema et al. 2006). Patrick and Link (2015), identify six myths that inhibit the implementation of EBFM. (1) EBFM cannot be defined with linguistic certainty; (2) EBFM needs more governance structure and mandates than currently exist; (3) EBFM requires a great deal of data and model complexity; (4) EBFM management suggestions are too conservative and restrictive; (5) EBFM cannot adequately describe complexities of public natural resource allocation systems; and (6) EBFM requires additional resources to fully implement in an already complicated and difficult socioeconomic situation. It remains uncertain which, if any, of these could prohibit implementation of EBFM at the state level. State agencies are not unified under a single legislative mandate, are more heterogeneous in their approach to management, and often have broader management missions with a wider set of responsibilities compared to federal agencies (Table 1). To advance and improve implementation of EBFM, we need to understand how state fishery scientists perceive and implement EBFM across regions. State fisheries agency scientists were the targets of our survey efforts, as they are both knowledgeable about local fisheries management practices and were deemed likely to discuss perceptions on management and policy candidly. We defined state fishery scientists as those individuals working directly with the biology

Table 1. State mandates for ecosystem-based management

State	Direct Mandate for EBFM	Management Body	Applicable Legislation	Year	Summary
ME	No	Maine Department of Marine Resources	ME statute 6171 Conservation and Propagation of Marine Organisms	1977	• Requires ecosystem assessment to be considered in stock assessments
	No	Maine Department of Inland Fisheries and Wildlife	15-year strategic plan	2020	• Creates focus and defines practices for habitat protection, restoration, and enhancement
NH	No	New Hampshire Fish and Game	-	-	• Most fisheries management done in conjunction with federal management, but not state EBFM mandate
MA	No	Massachusetts Division of Marine Fisheries	MA Division of Marine Fisheries Strategic Plan	2010	• Includes area management and habitat protection
CT	No	Connecticut Department of Energy and Environmental Protection	CT Habitat Conservation and Enhancement	2014	• Creates a framework for habitat management with a focus on nearshore and inland fisheries, with goals of conservation and protecting sportfishing.
RI	No	Rhode Island Department of Environmental Management	RI Shellfish and Marine Life Management Areas	2012	• Allows for the designation of management areas, where restrictions and regulations of use can be made
NY	Yes	New York Ocean and Great Lakes Conservation Council	New York Department of Environmental Conservation	2018	• Requires the use of EBM in managing marine and freshwater resources
NJ	Yes	New Jersey Department of Environmental Protection	NJ Statute 13:1D-9 Powers of department	2013	• Conduct research and implement plans to promote EBFM
			N.J. Statute 13:19-34 Findings, declarations relative to coastal, ocean resources	2013	• Management of ocean resources should be guided by sustainability, ecosystem health, stakeholders, and terrestrial-marine interactions. • Recommendation that management should move towards EBFM
MD	No	Maryland Department of Natural Resources	-	-	
DE	No	Delaware Department of Natural Resources and Environmental Control	-	-	• Implements management mandates approved by federal management and can indirectly be required to implement EBFM
VA	No	Virginia Marine Resources Commission	-	-	
NC	No	North Carolina Department of Environmental Quality	North Carolina's Fisheries Reform Act: NC Coastal Habitat Protection Plan	1997	• Enables habitat protection and establishment of strategic habitat areas for resource allocation priority.

and interactions of fish species, although all individuals contacted may not self-identify as fishery scientists. The objectives of our study were to: (1) learn how state fishery scientists define EBFM; (2) identify the perceived implementation of EBFM components within state agencies; and (3) identify any barriers to implementation of EBFM at the state level. We focused on the 11 states represented in the Mid-Atlantic and New England Fishery Management Councils.

METHODS

Respondent Demographics

We interviewed 40 state fishery scientists working for state natural resources agencies in the coastal states of the mid-Atlantic and New England fisheries management regions (Figure 1) to obtain their perceptions and viewpoints regarding their agency's implementation of EBFM. We identified state fishery scientists to interview through a combination of agency websites and referrals from colleagues and interviewed scientists (i.e., "snowball sampling;" Ellard-Gray et al. 2015). The response rate of our study was 35.4% (40 of 112 scientists contacted). Respondents were first contacted through e-mail. If they replied to the e-mail, they were then contacted by phone. If respondents did not respond to the initial e-mail, a follow-up e-mail was sent. Respondents worked in a variety of systems (e.g., marine and freshwater), with a variety of species (e.g. finfish and shellfish), and had medians of 15 and 19 years of experience at their agencies and in fisheries management, respectively (Figure 1).

Interview Design

We conducted standardized interviews with respondents over the phone using a survey designed to collect four categories of information: (1) respondent covariates (e.g., ecosystem of focus, years of experience, and familiarity with EBFM); (2) respondents' definitions of EBFM; (3) respondents' perceptions regarding implementation and effectiveness of EBFM; and (4) perceived barriers to the implementation of EBFM (Supplemental Appendix A). We used Biedron and Knuth (2016), as a guide to investigate perceptions at the state level, although our survey was not identical in design or scope.

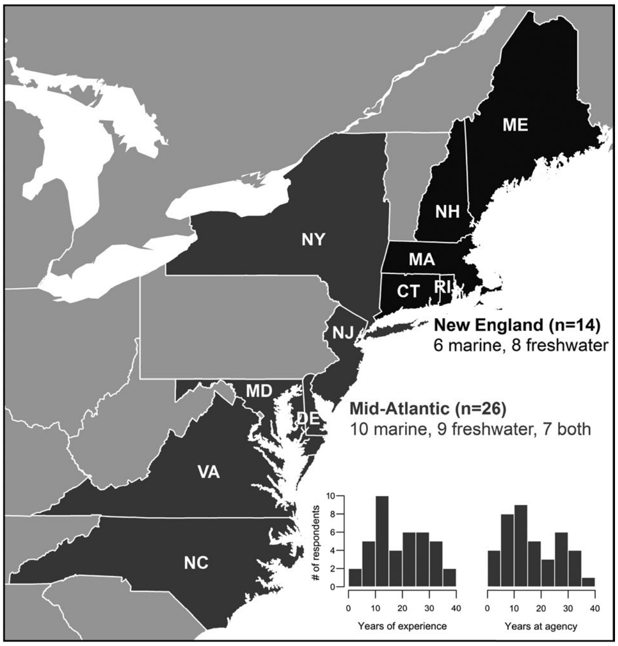

Figure 1. Map of the study region and respondent demographics.

After asking respondents for covariate information, we asked for their open-ended definition of EBFM, prior to prompting them with our definition. Next, we asked respondents to what degree each of eight components of EBFM listed (Table 2) were included in their definition of EBFM and whether their agencies were implementing each of these. Our 8 EBFM components represented a consolidation of 13 components identified by Biedron and Knuth (2016). Responses to component inclusion and implementation were measured on a Likert scale of 1–5 and "do not know," where 1 represents "strongly disagree," 3 represents "neutral," and 5 represents "strongly agree." Implementation was conveyed to the respondent as direct action taken by their agency toward a component and inclusion was conveyed to the respondent as whether or not a component was part of their definition of EBFM.

Table 2. Ecosystem-based fisheries management components (adapted from Biedron and Knuth 2016).

	Component	Definition
1	Habitat protection	Protecting/enhancing habitat
2	Geographically specific	Incorporating geographically specific management needs
3	Adaptation to change	Adapting to changing biological and social conditions
4	Stakeholder engagement	Engaging stakeholders
5	Considering complex interactions	Considering the interactions between the physical, biological, and human factors that affect the health of fisheries
6	Considering socioeconomics	Considering the social, economic, and cultural impacts on industries and communities that depend on fisheries
7	Accounting for uncertainty	Accounting for uncertainty in ecosystems
8	Including flexibility	Including flexibility in management strategies

Data Analysis

As respondents' definitions of EBFM were open-ended responses, a semi-quantitative analysis was used to identify similar response patterns. We identified 13 response categories using our 8 EBFM components, as well as concepts that were present in responses but did not fit any of the 8 components (*Large-scale* and *Conservation*). Furthermore, the component *considering complex interactions* was divided into four different response categories (*multispecies management, species interactions, environmental interactions,* and *human factors*) since many responses only partially fell within this component. Next, respondents' definitions were read and scored based on response categories. Two reviewers were used to ensure agreement of scoring. Response rates were calculated for each category as the percentage of respondents whose definitions included each category. Definition responses were then divided into combinations of management regions (New England and mid-Atlantic) and primary systems (marine, freshwater, or both).

Implementation and Inclusion scores for each component were compared using Wilcoxon rank sum tests with a Bonferroni correction (n = 8). Non-parametric tests were necessary due to the non-normal distribution of scores and since our data set consisted of one nominal variable (our eight components) and one ranked variable (respondents scored responses). The analysis of stated barriers to implementation followed the methods used for analyzing respondent's definitions of EBFM. After a review of responses, 12 broad categories of barriers were created. Each response was then read to identify major concepts, and each response was assigned to one or more of the barrier categories. This was repeated for each EBFM component. The response rate for each component-barrier combination was calculated based on the total number of respondents who were asked that question. If respondents indicated a particular component was not being implemented, they were not asked whether there were barriers to implementation. In order to determine how perceived barriers differed between regions, response rates were calculated for New England and the mid-Atlantic interviews independently, and the difference between the two groups was calculated for each component–barrier combination. This was used to identify which barriers were most commonly cited in each region. An analogous analysis was done to investigate barrier responses between systems (i.e. marine versus freshwater).

RESULTS

Definitions of EBFM

Due to the complete open-endedness of the question, respondents' definitions varied a great deal both in terms of detail and focus. However, most definitions generally fell within the scope of *considering complex interactions*, which led to a division into sub-categories. Most definitions included the concepts of multispecies management (77.5%) and species interactions (55%). The least mentioned categories were the components *accounting for uncertainty (2.5%)* and *including flexibility (2.5%)*. These two categories were not mentioned by any New England respondents, and only by mid-Atlantic respondents that worked in both marine and freshwater systems. Few respondents mentioned either *adaptation to change* or *stakeholder engagement*, and no respondents working in exclusively freshwater systems mentioned either of these categories. Though not reaching a majority, many respondents mentioned some form of *habitat protection* or large-scale processes in their definitions.

Implementation and Inclusion of EBFM Components

Generally, all eight EBFM components scored highly for both inclusion (mean 4.5 ± 0.2) and implementation (mean 3.6 ± 0.4; Figure 2). However, six of eight EBFM components scored higher for inclusion than implementation (Wilcoxon rank sum tests, all $p < 0.001$). The exceptions were *stakeholder engagement* ($v = 60$, $p = 0.18$) and *considering socio-economics* ($v = 112$, $p = 0.13$), where there was no statistical difference between implementation and inclusion scores. In all cases, components were scored higher for inclusion than for implementation. *Stakeholder engagement* and *habitat protection* scored highly in both categories, where the latter received the highest inclusion score overall. *Stakeholder engagement* scored highest for implementation, while *accounting for uncertainty*, scored lowest.

Implementation scores for the components *geographically specific* and *complex interactions* differed significantly between regions (Figure 3), with respondents from New England scoring these higher than those in the mid-Atlantic. Implementation scores for individual components did not differ significantly between freshwater and marine ecosystems (Figure 3). However, when asked whether EBFM was being implemented overall, respondents working in freshwater systems more strongly agreed than those working in marine systems.

Barriers to Implementing EBFM

We identified 12 commonly cited barriers to implementing EBFM in open-ended discussions with respondents

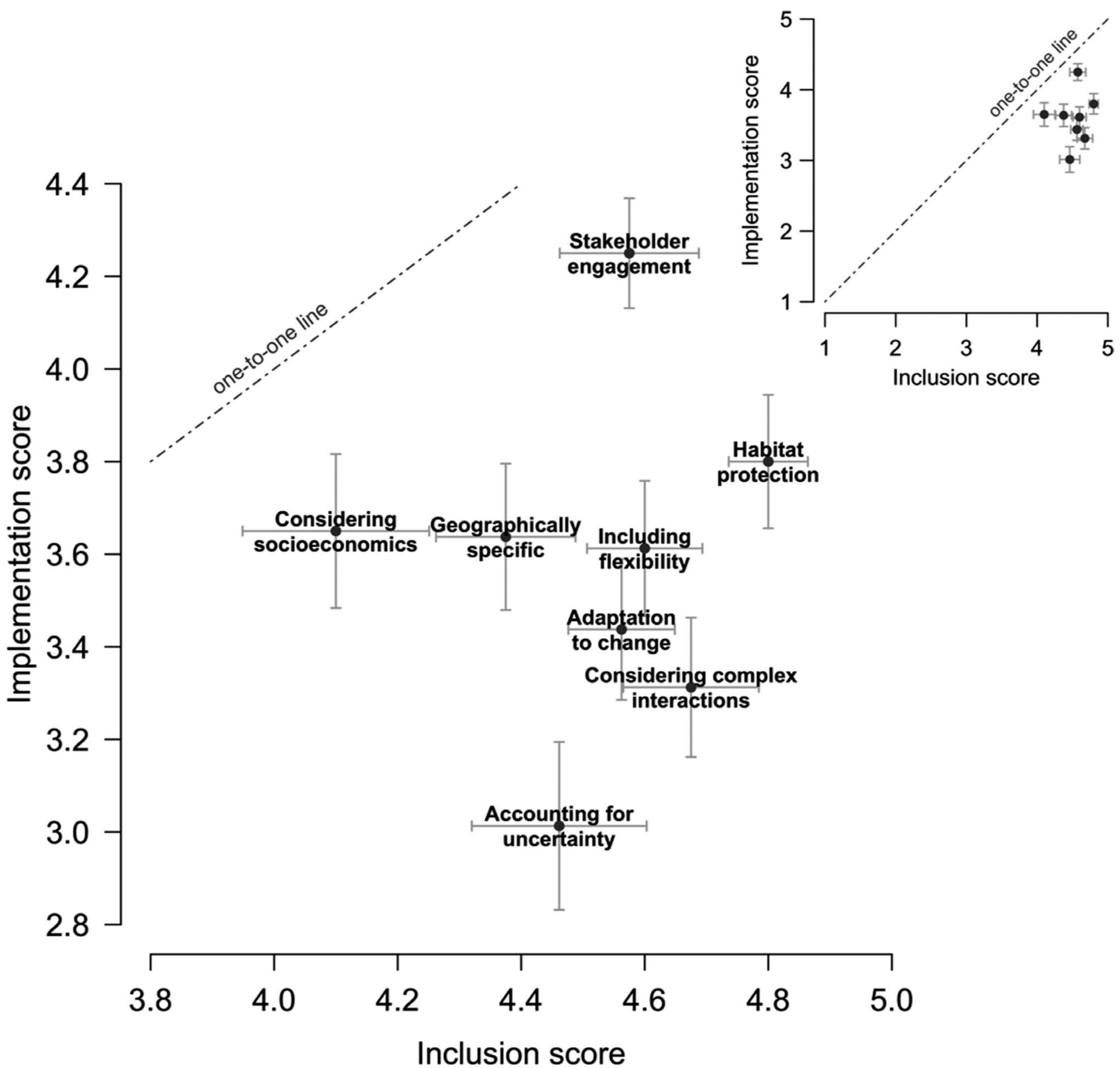

Figure 2. Mean inclusion and implementation scores for the eight ecosystem-based fisheries management components. The one-to-one line represents equal inclusion and implementation. Error bars represent ±1 standard error of the mean.

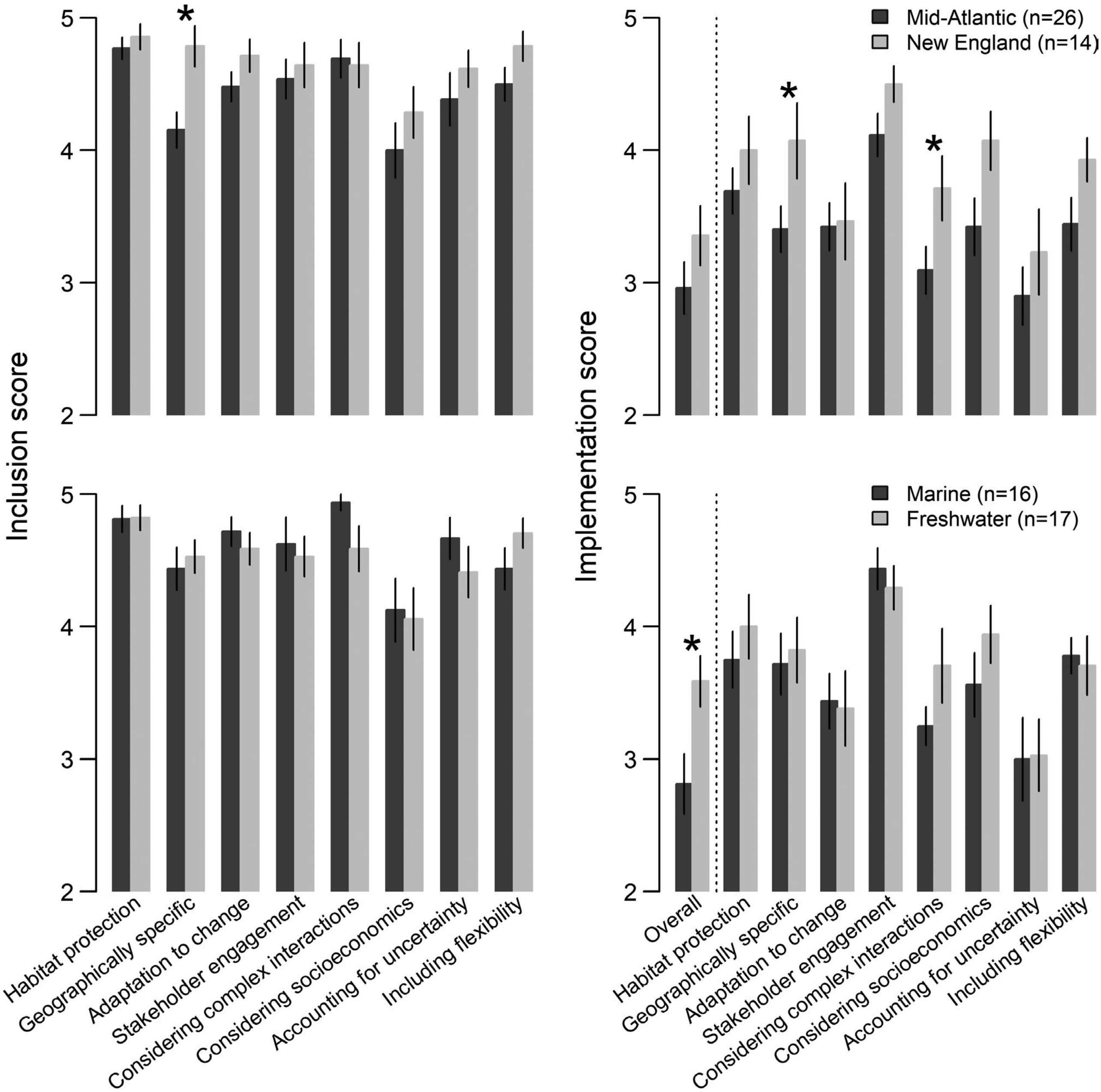

Figure 3. Mean inclusion and implementation scores for the eight ecosystem-based fisheries management components between Mid-Atlantic, New England, marine, and freshwater respondents. Respondents working in both systems were not included. Error bars represent ±1 standard error of the mean. Asterisks represent statistically significant means.

concerning effectiveness and challenges of implementation (Table 3). *Stakeholders* and *regulatory* barriers were cited most frequently across a variety of EBFM components (36% and 31% mean response rate across components, respectively; Figure 4). As one respondent stated, "Fisheries are political. Fisheries [management] is not about managing fish, it is about managing people." *Data* and *funding* were also cited frequently (20% and 19% mean response rate, respectively), though not as consistently across components. Conversely, *politics* (8%), *staff* (7%), and *resources* (3%) represented less significant barriers to the implementation of the EBFM components (Figure 4). Interestingly, *single-species management* was not a common barrier to any component, potentially indicating that EBFM as a concept isn't inhibiting implementation. Data was a frequently cited barrier to *accounting for uncertainty* and funding was a frequently cited barrier to *habitat protection* (Figure 4). One respondent mentioned that "data quality, amount of data, funding to get data, and expertise" were barriers and another echoed those concerns by saying, "[it is] hard to plan for any unexpected events that might happen and in that regard, it is almost impossible to get funding for something like that."

Barrier responses had a clear degree of geographical specificity (Figure 4). *Stakeholders* were more commonly cited as being a barrier in New England, particularly for components *habitat protection*, *geographically specific*, and *including flexibility* components. *Data* was a more dominant barrier in the mid-Atlantic, especially for *considering complex interactions,* *geographically specific,* and *adaptation to change* components. Though not as consistent across all components, *biology* was more commonly stated as a barrier to the *geographically specific* component in the mid-Atlantic. No barrier categories occurred entirely within a single region, indicating that similar types of challenges were faced in both regions despite the nature of those interactions differing. Furthermore, respondents from both regions identified some barriers in relation to all EBFM components, indicating that no aspect of implementing EBFM posed a unique challenge within either region.

As with regional differences, perceived barriers to implementing EBFM also varied with the aquatic system in which respondents worked. Across all components, those working in freshwater systems reported *stakeholder*, *regulatory*, *data*, and *participation* barriers more frequently. Conversely, *funding* and *politics* were barriers more commonly experienced in marine systems across many components. Despite stakeholders being cited as a more prevalent barrier for those working in freshwater systems, *stakeholders* was cited much more frequently as a barrier for *considering complex interactions* in marine systems. *Biology* was seen as a barrier for some of the more abstract components, specifically in *adaptation to change* in freshwater systems and *accounting for uncertainty* in marine systems. While there was slightly higher consistency in response differences between freshwater and marine systems, no barrier category was solely cited for either system.

DISCUSSION

Defining EBFM

Previous studies have suggested that one of several challenges in implementing EBFM has been a lack of consensus on its definition (Patrick and Link 2015). However, our respondents generally agreed that all components were a part of EBFM (mean responses greater than 4), which indicates that state fishery scientists in the northeastern USA seem to have similar perceptions of the definition of EBFM. Although it should be noted that our components may not encompass a complete definition of EBFM, and does not mean there weren't other aspects of EBFM that respondents thought were important. In fact, analysis of the open-ended definitions showed that other aspects of EBFM were included in some respondents' definitions, but not explicitly defined within our components (e.g., a sense of large-scale and conservation goals). Another important difference between our components and respondent perceptions was an explicit focus on multi-species management, which was included in our component *considering complex interactions*, but not as a separate component. Despite the overall agreement in EBFM definitions among respondents, a recent study by Trochta et al. (2018) found that, globally, there does not appear to be consensus on the definition of EBFM among different fisheries.

Our results do not necessarily contradict Trochta et al. (2018). Instead, our results offer greater insight into how perceptions of EBFM may change over different geographical scales. Since disagreement in the definition of EBFM was not apparent over the smaller regional scale of our study, our findings suggest that geographical scale may influence the degree of agreement on the definition of EBFM. Biedron and Knuth (2016) also found a common definition of EBFM among Mid-Atlantic Fishery Management Council and New England Fishery Management Council members and stakeholders. Their study also focused on the inclusion of trophic interactions between species, stakeholder engagement, and the inclusion of habitat as a focal point for maintaining sustainable ecosystems.

Table 3. Keywords of ecosystem-based fisheries management (EBFM) component barriers.

	Barrier	Definition
1	Stakeholders	Stakeholder buy-in
2	Regulatory	Conflicts arising from vagueness, conflicting objectives, and/or scope of previously existing rules and laws
3	Data	Data limitations
4	Funding	Funding limitations
5	Knowledge	Staff experience/knowledge
6	Participation	Engagement of stakeholders and/or staff
7	Biology	Challenging species biology and/or community ecology (e.g., food webs are often poorly characterized)
8	Politics	Conflicts arising from lack of consensus, engagement, and/or mismatched objectives
9	Staff	Staff size and/or time
10	Resources	Availability of tools and/or technology
11	Single-species management	Inertia to overcome single-species management policy
12	Infrastructure	Difficulty navigating and/or operating within pre- existing programs and/or departments

Implementing EBFM

For all components of EBFM in our study, agreement regarding implementation of each component was less than its corresponding inclusion score. This may be due to respondents being self-critical in their assessment of whether their agency was doing enough to implement EBFM. However, it is difficult to directly relate responses to these two questions. Even though one component is stated to be very important, it does not necessarily mean that it has a proportional priority, especially if there is some relative importance attributed to each component that was not addressed by this survey. This discrepancy can be understood in a practical sense, whereby despite a perceived importance, it may not be possible to properly implement certain EBFM components. In this case, a better understanding of the barriers to implementation will be crucial for resource allocation, especially if those barriers are specific to one's geography and system of focus.

While state fishery scientists agreed that *accounting for uncertainty* was an important component of EBFM, they noted that implementing this component is particularly challenging. Several respondents mentioned that acquiring data for the measures needed to implement *accounting for uncertainty* was a barrier. Although *stakeholder engagement* was reported to be the most highly implemented component of EBFM, *stakeholders* were also one of the most frequently reported barriers to implementation of EBFM components. Several respondents mentioned that failure to reach compromise between competing objectives inhibited or prolonged implementation of management objectives. This suggests that future work should investigate the relationship between stakeholders and regulatory agencies to identify specific operational, political, and economic dynamics that could be improved upon. One potential solution to this problem would be to have a moderator at sessions who is specifically trained at moving discussion

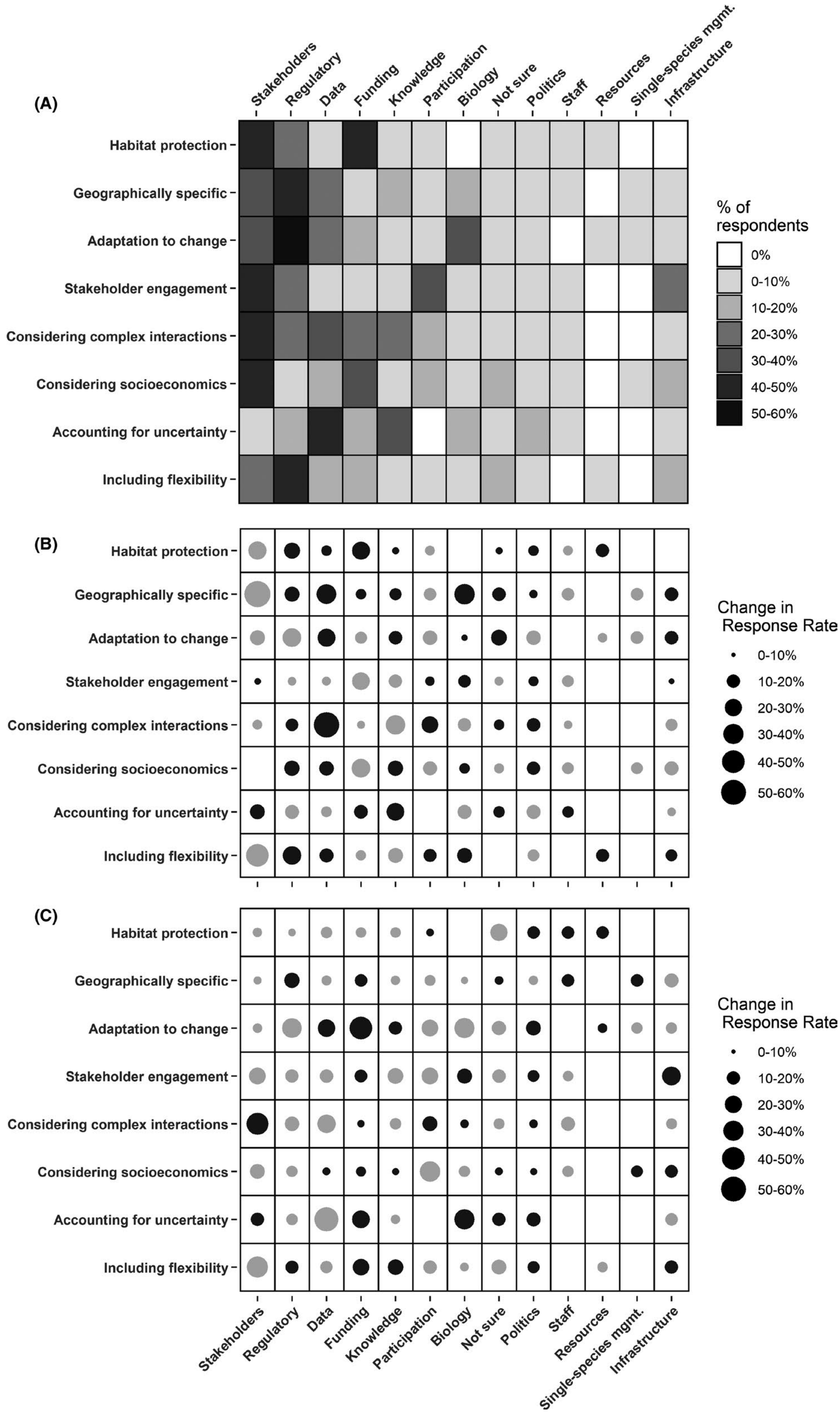

Figure 4. **(A)** Percent of respondents that identified each barrier category (columns) for each ecosystem-based fisheries management component (row) are indicated by color shade. **(B)** Regional barriers are shown as differences in response rates between both of the focal regions. Grey circles indicate a response bias towards New England respondents, and black circles denote a bias towards those in the mid-Atlantic. **(C)** Systematic barriers are shown as differences in response rates between respondents working in stated ecosystems. Grey circles show a bias towards those working in freshwater systems, while black circles show biases for those in marine systems. In panels B and C, the size of the circle relates to the degree in bias and empty cells denote categories where no barrier was indicated by respondents.

along an "argument" based framework as opposed to a consensus based framework. Stakeholders who believe in a public participation process to create consensus enter the process with inflated expectations, only to be disenchanted by contrary behavior of those with opposing views (Peterson et al. 2002). The resolution to this problem lies in the ability to hold sustained debate on opposing ideas in an ecological framework without expectation of consensus by majority. Consensus by majority often only reinforces the current socio-political imbalance of power, which further inhibits implementation of sustainable practice (Peterson et al. 2004).

It is unsurprising that *stakeholder engagement* and *habitat protection* scored highly in inclusion and implementation since these components are often incorporated into the mission statements of state agencies. For example, North Carolina's Division of Marine Fisheries vision statement says, "North Carolina Division of Marine Fisheries ensures healthy, sustainable marine and estuarine fisheries and habitats through management decisions based on sound data and objective analysis" (NCDMF 2018). New York State Department of Environmental Conservation Division of Marine Resources is another example of an agency explicitly mentioning stakeholder engagement and habitat protection as management objectives. Their mission statement is as follows: "To manage and maintain the state's living marine, estuarine and anadromous resources, and to protect and enhance the habitat upon which these resources depend… to achieve optimum benefit by providing for the broadest range of uses including commercial and recreational harvest, human consumption, natural forage and observation and appreciation" (NYDEC 2018). Although *accounting for uncertainty* was scored highly for inclusion, it is also one of the most difficult to implement (Figure 3). A study by Wiedenmann and Jensen (2018) showed how this phenomenon might develop within agencies. They found that although stock assessment models account for uncertainty, they still resulted in biased projections of stock status, resulting in inaccurate catch limits and ultimately, overfishing of target species. Implementing many of our EBFM components will likely encounter similar challenges, and require the development of new methods as well as facilitation of communication and collaboration across state agencies and federal managers. Survey participants working with freshwater systems perceived that EBFM as a whole was being implemented to a greater degree than participants working in marine systems. However, this difference was not present when they were asked about individual EBFM components. The perception that EBFM was implemented to a greater degree in freshwater systems may reflect the comparatively longer history of stock enhancement and habitat management in freshwater systems (Welcomme et al. 2010). For example, fish stocking began in the United States in the mid-1800s and was central to the strategy of the U.S. Fish Commission, which was established in 1871 (Pister 2001). Though controversial (Cowx 1994), stocking has remained an important component of U.S. freshwater fisheries management, where it is implemented largely by state agencies (Halverson 2008) and is used to subsidize recreational fisheries and rehabilitate endangered or threatened fish populations. By contrast, marine stock enhancement has been rare and more controversial (Grimes 1998; Hilborn 1998): Red Drum *Sciaenops ocellatus* is the only fully marine species with a stock enhancement program in the USA (implemented by state agencies in Texas, Florida, and South Carolina). Similarly, habitat restoration is a central component of freshwater fisheries management (Cooke et al. 2014) and has been more easily implemented in freshwater systems than in marine systems due to easier accessibility, reduced spatial size, and lower dispersal rates among, and connectivity of, freshwater systems (Arlinghaus et al. 2016; Geist and Hawkins 2016). Despite increased difficulty, most state agencies incorporate some form of marine habitat management as a part of their operations; although this may not always be done with EBFM explicitly in mind.

Limitations of the Study

An accepted standard for survey response rates has yet to be clearly defined (Rogelberg and Stanton 2007). The 35.4% response rate for our study was comparable to other published fisheries surveys. For example, Biedron and Knuth (2016) reported a response rate of 19.2%, and Brinson and Wallmo (2017) reported a response rate of 35%. However, response representativeness is arguably more important for evaluating collected survey data quality as it directly addresses the potential for nonresponse bias (Cook et al. 2000; Rogelberg and Stanton 2007). State fishery scientists interviewed in our study were fairly evenly distributed between both survey regions (i.e. mid-Atlantic and New England) and both systems of interest (i.e., freshwater and marine), and represented early career to seasoned professionals. However, given the relatively small number of respondents from each state and concerns over maintaining respondents' anonymity, we did not compare EBFM perceptions among individual states. Unfortunately, this precluded analyzing the influence of state specific frameworks and management requirements on perceptions of EBFM among state fishery scientists.

Although we specifically targeted perceptions of EBFM implementation and barriers among state fishery agency scientists in the northeastern United States, we did not quantitatively asses how well scientists' perceptions corresponded to the actual status of EBFM implementation by their state agencies, which would have been useful for examining potential disconnects between perception and reality (Dunning et al. 2003). State fishery scientists interact with managers, council members, and stakeholders, and therefore offer a unique perspective on implementation of, and barriers to, EBFM within their respective agencies. However, state fishery scientists only represent one professional group within the agency and likely hold different perspectives concerning EBFM than agency social scientists, economists, and managers (Clay and McGoodwin 1995; Trochta et al. 2018). Perceptions of EBFM can differ across larger geographic scales (Pitcher et al. 2009) and so may differ regionally within the United States. In order to attain a comprehensive assessment of the perceptions of EBFM at the state level, future studies in the United States should not only consider additional regional perspectives (e.g. Pacific, South Atlantic), but also include perceptions of state social scientists, economists, and managers, council members, and stakeholders (Jacobson and McDuff 1998; Kaplan and McCay 2004).

CONCLUSION

Overall, this study provides evidence that the perceived definition and implementation of EBFM of state fisheries scientists is similar across New England and Mid-Atlantic states. However, participants indicated that components of EBFM are not being implemented to the same degree as their perceived importance. This study also highlights specific barriers that state fisheries scientists face in implementing components of EBFM and provides a useful framework for similar studies in other geographic regions.

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SUPPORTING INFORMATION

Additional supplemental material may be found online in the Supporting Information section at the end of the article.

Supplementary Material