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POLICY PERSPECTIVE

Ecosystem-Based Fisheries Management for Social–Ecological Systems: Renewing the Focus in the United States with *Next Generation* Fishery Ecosystem Plans

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Abstract

Resource managers and policy makers have long recognized the importance of considering fisheries in the context of ecosystems; yet, movement towards widespread Ecosystem-based Fisheries Management (EBFM) has been slow. A conceptual reframing of fisheries management is occurring globally, which envisions fisheries as systems with interacting biophysical and human subsystems. This broader view, along with a process for decision making, can facilitate implementation of EBFM. A pathway to achieve these broadened objectives of EBFM in the United States is a Fishery Ecosystem Plan (FEP). The first generation of FEPs was conceived in the late 1990s as voluntary guidance documents that Regional Fishery Management Councils could adopt to develop and guide their ecosystem-based fisheries management decisions, but few of these FEPs took concrete steps to implement EBFM. Here, we emphasize the need for a new generation of FEPs that provide practical mechanisms for putting EBFM into practice in the United States. We argue that next-generation FEPs can balance environmental, economic, and social objectives—the triple bottom line—to improve long-term planning for fishery systems.

Introduction

Commercial and recreational fishing in marine waters contribute more than $140 billion USD to world economies, fueling coastal economies, supporting social and cultural well-being, and contributing to global food security (Cisneros-Montemayor & Sumaila 2010; FAO 2014). Yet commercial fishing alone removes some 80 million tons of biomass annually from the world's oceans (FAO 2014). The extent of fishing removals has far reaching effects on ecosystems and human communities.

International organizations and agreements have adopted ecosystem-based management frameworks in recognition of these connections (Bianchi & Skjoldal 2008). For example, the Food and Agriculture Organization (FAO) provides guidance on an ecosystem approach to fisheries (EAF, FAO 2003, 2009). In Europe, the Common Fisheries Policy (CFP) includes a discard ban, establishes stock recovery areas, and regionalizes decision structures (EU COM 2013), which are key components of EBFM. The EU's Marine Strategy Framework Directive (MSFD) (EU COM 2008) aims to achieve "clean, healthy, and productive" oceans ("Good Environmental Status") by 2020. Fisheries sustainability is defined under the MSFD as "Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population, age, and size distribution that is indicative of a healthy stock." Australia's ecosystem approaches include ecological risk assessment in all federal fisheries (Fletcher 2005; Hobday *et al.* 2011) and a stakeholder-driven process for cross-sector management strategy evaluation and implementation of harvest strategies (Fulton *et al.* 2014). These strategies and assessments have improved the biological, and economic performance of fisheries in the region (Smith *et al.* 2014).

In the United States, improved science and policy reduced overfishing and bycatch, restored depleted stocks (National Research Council 2014), and protected habitat in some regions (e.g., Georges Bank, off the Northeastern United States, Murawski *et al.* 2000). Yet, these improvements occurred under the auspices of conventional single species management. There is wide recognition that implementation of EBFM by resource managers could benefit U.S. fisheries. The eight U.S. Regional Fishery Management Councils—which guide management of federal fisheries—testified that more ecosystem-based decision making is needed (PFMC 2014). Here, we advise and encourage U.S. fisheries management bodies to use a formal adaptive planning process to advance EBFM. In the U.S. context, an instrument to accomplish this is a Fishery Ecosystem Plan (FEP).

We see three challenges to implementing EBFM in the United States related to how people interact with fishery resources. One, EBFM has often been viewed as a framework for protecting the biophysical marine environment over other social and economic goals. Two, the people and institutions responsible for managing fisheries (Councils, Interstate Marine Fisheries Commissions, and the agencies that support these institutions) are overextended. Three, managers have often approached EBFM as an added layer of science or modeling that informs conventional management (e.g., adding new parameters to stock assessments), without considering the goals, strategies, or allocation processes inherent to EBFM.

Fishery Ecosystem Plans (FEPs) were conceived as guidance documents for implementing ecological principles in U.S. fisheries management (Ecosystem Principles Advisory Panel 1999). U.S. law requires that regulations governing each fishery be set within Fishery Management Plans (FMPs). In contrast, FEPs are not mandated, and can be developed at the discretion of each Council to guide their efforts on EBFM. Four of eight Council regions have completed FEPs. The first generation of FEPs compiled information on interactions between fish stocks and the marine environment, but did not develop advice to incorporate the effects of those interactions into decisions. They also lacked detail on the social and economic dimensions of fisheries. Considering global progress on frameworks for EBFM and associated tool development, here we provide a revised vision of FEPs to overcome the three challenges above and advance EBFM in the United States. We assert that "*next generation* FEPs" should: (1) embrace fishery systems as linked, interacting biophysical and human systems; (2) support streamlined management to relieve, rather than aggravate administrative burdens; and (3) create a framework for deliberate, informed and transparent decision making that highlights rather than obscures the difficult allocation decisions of EBFM.

We envision next generation FEPs as iterative, adaptive management planning processes (Walters 1986). We recommend a process that builds on an existing Integrated Ecosystem Assessment framework led by the federal fisheries agency (Levin *et al.* 2014), adapted to focus on management actions (Essington *et al.* 2016). Briefly, the steps are: (1) inventory the state of the social–ecological system, (2) set strategic objectives for management of the system and prioritize issues that will be addressed, (3) develop projects and evaluate management strategies to achieve objectives, (4) implement management strategies, and (5) monitor progress and evaluate impacts. We envision a full FEP cycle may take about a decade, but targeted activities on prioritized issues would occur on a shorter time scale. Below, we describe how this process can help address the three challenges stated above and advance EBFM in the United States.

FEPs should focus on triple bottom line sustainability of fishery systems

The definition of an ecosystem in a fisheries context coevolved with increased public awareness of potential negative impacts of human activities on the environment. The declaration of a 200 nm Exclusive Economic Zone triggered rapid change in conservation and management of marine resources during the 1970s and 1980s. Growth in domestic fishing capacity co-occurred with government investment, limited regulatory constraint, and insufficient consideration of environmental impacts (National Research Council 2014). This led to increased overfishing, bycatch, and habitat destruction (Mansfield 2011). Some advocates of EBFM emphasized benefits to the biophysical components of fishery systems, while implicitly viewing fishing activities as "threats." This view implies that conservation goals and human uses are at odds, a perspective that pits different stakeholders against one another, undermines trust between resource users (fishers) and managers, and reduces the effectiveness of management and well-being of all players (Garcia *et al.* 2014).

Instead, fisheries should be considered social–ecological systems with linked human and biophysical components (Charles 1995; Berkes & Folke 1998; de Young *et al.* 2008; FAO 2009). Under this framework, EBFM is a process that considers the costs and benefits of alternative management decisions over a range of ecological, economic, and social objectives (de Young *et al.* 2008; FAO 2009). This vision for EBFM includes the features common to a conventional focus on the biophysical system, such as food web dynamics, climate forcing, bycatch, and habitats (Ecosystem Principles Advisory Panel 1999). But, it equally focuses on human well-being, equity, and economic considerations (see recent review by Long *et al.* 2015). While these ideas are not new, a management process that makes these considerations explicit and formally includes them has been elusive in the United States (Essington *et al.* 2016). FEPs that focus on fishery systems can demonstrate how fishery managers could improve outcomes across environmental, economic, and social (including cultural) dimensions (FAO 2009). This "triple bottom line" (Elkington 1997) offers an opportunity to build a broader, engaged community of stakeholders, scientists, and managers to improve U.S. fisheries management.

Next generation FEPs that embrace the triple bottom line could improve public perceptions about fisheries and their impacts. This challenge is also an opportunity to increase trust in the fishery management process. FEPs can improve public trust (sometimes referred to as social license) by addressing the ecological impacts of fishing in a credible and systematic fashion. And, they can improve public awareness of the economic and social benefits of well-managed fisheries, enhancing public support for fishing communities. In short, the public processes surrounding a next generation FEP can position fisheries as a vital, sustainable and valued component of coastal communities.

FEPs can support streamlined management

U.S. Fishery Management Councils are overburdened. They meet 20–30 days per year, with another 10–20 days of committee meetings, and most council members have other full time jobs. Each Council maintains multiple Fishery Management Plans (FMPs), which have extensive requirements to address mandates of the laws governing fisheries management in the United States (e.g., Magnuson Stevens Act [MSA], National Environmental Policy Act [NEPA], Marine Mammal Protection Act [MMPA], and Endangered Species Act [ESA]). While next generation FEPs require upfront resource investments, we suggest FEPs can be developed to assist in meeting existing requirements and create a process that could satisfy multiple mandates over the long term.

NEPA requires Councils (in partnership with the fisheries division of the National Oceanic and Atmospheric Administration, or NOAA Fisheries) to issue Environmental Impact Statements (EIS) for management actions that evaluate cumulative impacts of management decisions on ecological, social, and economic objectives—the triple bottom line objectives for sustainability. NEPA provides a formal process that considers alternative actions and their impacts. If Councils were to set strategic objectives via FEPs through a participatory process similar to what is required by NEPA, then opportunities may arise to borrow from FEPs to meet NEPA requirements or use existing EISs to develop FEPs. Similarly, ESA compliance requires formal consultations when fisheries might interact with and negatively impact federally protected species. A FEP could assess risks of those interactions with protected species (a requirement of the ESA), and thus provide information to support ESA responsibilities. FEPs will not replace existing regulatory requirements, but they could aspire to consolidate the information required by MSA, NEPA and ESA into a single proactive Plan that evaluates ecological, economic, and social domains.

The FEP process could also support streamlining by prioritizing the many systemic issues that managers face, and establishing goals. Councils will not have the resources to pursue all objectives of their FEP simultaneously, but they can still move forward. Many frameworks and criteria exist for prioritization that could be adapted for Councils (e.g., Joseph *et al.* 2009). Risk assessment is one way to prioritize and has been used extensively in Australian fisheries (Fletcher 2005). Risk assessment reveals hidden uncertainties in a fishery system by mapping the biophysical and human systems and identifying components that are vulnerable to influences like climate change, fishing, habitat destruction, or economic and political shifts (Fletcher 2005). Similarly, a risk assessment could identify vulnerabilities in human communities from managing sectors separately rather than as linked units, such as evaluating the risks of catch share programs on income diversification of fishers (Kasperski & Holland 2013). System components (e.g., species, fisheries, markets, or human communities) identified as at risk can be prioritized for management actions. While risk and uncertainty will always exist, a triage approach to risk assessment can rule out low risks, and target areas where management action is urgent and can improve outcomes (Fletcher 2005; Levin *et al.* 2014).

FEPs should support deliberate, informed choices

Next generation FEPs should establish an open and transparent process that assesses risks and weighs the costs and benefits of management decisions on all parts of the fishery system. Councils are expert at planning processes, but rarely engage in planning at a scale above a single fishery, or create objectives for the entire fishery system. In cases where EBFM objectives have been developed, they primarily focus on the biophysical subsystem. This implicit weighting of ecological considerations and conservation goals more strongly than economic and social objectives is unlikely to lead to effective management since it does not include humans as key agents of change, thereby disenfranchising their voices and interests (FAO 2009).

Next generation FEPs should assess tradeoffs. Decision makers must weigh multiple objectives and allocate resources accordingly. FEPs could reveal the full spectrum of costs and benefits, monetary and nonmonetary, of fishery management actions to all parties (including, but not limited to, single species catch limits). Tools for examining tradeoffs within and among economic and ecological objectives are ubiquitous, and methods to incorporate social and cultural dimensions are emerging (Smith *et al.* 2007; de Young *et al.* 2008; Fletcher & Bianchi 2014). For example, Plagányi *et al.* (2013) evaluated management strategies against social, economic, and ecological objectives in a small-scale Australian fishery. Their analysis revealed a tradeoff between an economic objective (total profit) and a social objective (total employment) that represented the fishing community's sense of equity and ownership. Voss *et al.* (2014) also assessed tradeoffs across the triple bottom line for multispecies fisheries in the Baltic Sea.

Acknowledging tradeoffs does not make decision making easier. Social indicators like total profit or total employment are spread unequally among different participants in a community, thus distributional equity and multiple social indicators should be considered (e.g., Gini indices, Kasperski & Holland 2013). Resolving tradeoffs is difficult, but ignoring their existence does not make them disappear. Without a formal process to evaluate tradeoffs, we may unintentionally select suboptimal combinations.

Moving forward

Next generation FEPs can advance EBFM in the United States. Progress is possible now. Below, we suggest next steps for the three goals we laid out for FEPs: embracing triple bottom line sustainability, supporting streamlined management, and creating a framework to support deliberate, informed, and transparent decision making.

Achieving sustainability across the triple bottom line may require expanded monitoring and approaches that explicitly include human dimensions in fisheries management considerations. While new science is probably not the dominant limitation to EBFM (e.g., Bundy *et al.* 2008; Patrick & Link 2015), monitoring the performance of fishery systems is critical to an adaptive process. Existing biophysical monitoring varies by region, and data on human systems are almost always insufficient. We need better understanding of the links between biophysical systems and well-being in coastal communities to evaluate tradeoffs between ecological and social objectives (Perry *et al.* 2010). Recent advances include work by multidisciplinary teams of scientists conceptualizing human well-being in the context of EBFM (e.g., Breslow *et al.* 2016; Hicks *et al.* 2016), including a conceptual model that brings humans and social systems into integrated ecosystem assessment (Levin *et al.* 2016), and research that implements social performance metrics and defines fishing communities (Hall-Arber *et al.* 2009).

Some conventional management approaches have considered social objectives such as the maintenance of small-scale fishing and fishing communities. These tools could be applied more broadly. For example, in 1995, the Alaskan halibut and sablefish ITQ fishery enacted constraints on quota share trading and ownership limitations to meet social objectives (Kroetz *et al.* 2015). Equity concerns prompted managers to develop programs to increase fisheries access, for example, in the Community Development Quota and Community Quota Entity Programs in Alaska (Ginter 1995; Carothers 2011). Evaluating alternative management strategies with respect to social goals, as in Plagányi *et al.* (2013), is another way to explicitly include social considerations. These activities support sustainable and equitable fishery systems for future generations.

Using FEPs to streamline, rather than complicate, U.S. fisheries management requires matching the needs of regional decision makers with available natural and social science knowledge, and applying a range of existing tools to match available data and technical expertise. Smith *et al.* (2007) developed a conceptual model that categorizes approaches to ecosystem assessment and management along three axes that describe varying complexity in methods, scope, and tools. This conceptual model demonstrates that qualitative and quantitative tools, comprehensive datasets, and expert opinion can all support an ecosystem planning process. The scope of next generation FEPs may vary by region because tools and data differ across regions. But, action is possible now in every U.S. region with current tools and data.

An adaptive planning process for FEPs would facilitate setting objectives and prioritizing among them. We have suggested a process (above, and Essington *et al.* 2016), but do not prescribe what those objectives should be. Establishing open, transparent processes will allow for cocreation of objectives and prioritization based on risk assessments or other methods. We have highlighted numerous existing tools and approaches that have been used to achieve desired outcomes (e.g., protect habitat, account for species-environment interactions, reduce bycatch, better incorporate social dimensions, and elucidate tradeoffs). Yet, applying these tools without an overarching planning process could be seen as ad hoc. Next generation FEPs can formalize a planning process to make greater use of existing tools to implement EBFM.

Overcoming all three challenges to EBFM may require that NOAA Fisheries and the regional Councils refine their relationship as partners in managing federal fisheries. The most formal pathway of science into management is through stock assessments. NOAA Fisheries scientists conduct most assessments, which are reviewed by a science review board of the Council, the Scientific and Statistical Committee (SSC). The make-up of SSCs vary, but natural scientists and statisticians are more common than economists and other social scientists. New collaborations and capacity may be needed if the objectives of next generation FEPs embrace triple bottom line sustainability. For example, partnerships between ecosystem and stock assessment scientists at NOAA Fisheries can support including ecosystem considerations in the stock assessment review process. Two possibilities include presenting ecosystem status indicators alongside stock assessment results during deliberations on catch limits, or including ecosystem indicators in stock assessment models. Developing relationships between regional Integrated Ecosystem Assessment programs (Levin *et al.* 2014) and stock assessment teams within NOAA create opportunities for collaboration (e.g., an indicator of harmful algal blooms was recently developed to add time-varying natural mortality to the Gag Grouper assessment in the Gulf of Mexico). NOAA's (2016) EBFM policy statement and road-map also create a pathway for collaboration with Councils.

A more difficult challenge is formalizing the use and review of social science to achieve management goals. NOAA Fisheries may need to expand its capacity for social science and the development of social and economic metrics to support broader goals in next generation FEPs. New social metrics would be reviewed by SSCs, which may require broadening their membership to include sufficient representation and involvement of anthropologists, geographers, sociologists, economists, and other social scientists. These steps would support Councils to become comfortable evaluating and including all three dimensions of sustainability science into management decisions (Hicks *et al.* 2016).

Formalizing a coordinated management planning process for fishery systems will take time and political will, but it can be done within the current governance structure. A decade passed between the first recommendations for FEPs (Ecosystem Principles Advisory Panel 1999) and completion of the first FEP (NPFMC 2007), and these first generation FEPs have generally not influenced management decisions. Next generation FEPs may require as long to implement because coordinating individuals, plans, information, and institutions is a time and resource-consuming challenge. However, near-term actions are possible with existing data, tools, and approaches within the current system of laws and governance (Patrick & Link 2015), and we propose a triage approach to this end. Despite upfront costs, formalizing the process surrounding next generation FEPs is a worthwhile goal that could guide and improve equity, environmental justice, and sustainability in fishery systems. These benefits can broaden the constituency for moving EBFM forward in the United States and around the world.

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