Received: 23 May 2020 | Revised: 16 December 2020 | Accepted: 31 December 2020

DOI: 10.1111/faf.12538

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FISH and FISHERIES WILEY

To EBFM or not to EBFM? that is not the question

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Abstract

The ecosystem-based fisheries management (EBFM) framework has a solid theoretical justification and has been embraced in principle by many regions; yet, systematic implementation remains a challenge. In regions with strong governance, single-species stock assessment and management has been successful in ending overfishing and maintaining stocks near levels that produce maximum catches. However, considering species in isolation and recognizing a limited set of management objectives leads to systemic inefficiencies, incentivizes waste and generates unintended consequences. To avoid undesirable outcomes, human values and needs must be positioned at the forefront of management, system-level objectives must be identified, and management actions must be systematically evaluated to ensure they are contributing to those larger objectives. Such processes, when implemented transparently, will lead to reduced conflict and improved stakeholder support for governance and should greatly facilitate long-term management. We argue here that, regardless of the management framework adopted, we inherently manage at the ecosystem level—albeit sometimes "blindly"—and that increased attention to ecosystem objectives and trade-offs will improve management outcomes.

KEYWORDS

Gulf of Mexico red snapper, human well-being, management objectives, single-species fishery management, socio-ecological system, trade-offs

> Friends, countrymen, lend [us] your ears.

Calls for ecosystem-based fisheries management (EBFM) have been numerous and increasing over the past two decades (Patrick & Link, 2015; Pikitch et al., 2004; Trenkel, 2018), often in the context of correcting deficiencies in single-species management (Hilborn, 2011). While there is much debate regarding the status of global fisheries depletion (Pauly & Zeller, 2016; Worm, 2016), neither the theoretical framework behind single-species fisheries management (SSFM), nor the science, can be blamed for the current state of affairs (Mace, 2004). Rather, when scientific guidance is heeded and fishing mortality on overfished stocks is reduced, stocks recover (Melnychuk

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et al., 2017; Murawski, 2010) and fisheries remain sustainable (Hilborn et al., 2020). Given that there remain serious issues with data availability and inadequate governance in SSFM, it is not surprising that there is widespread scepticism of EBFM due to present limitations in data, resources and governance (Patrick & Link, 2015).

Potential benefits of EBFM (and perceived deficiencies of SSFM) are most clearly evident in regions where SSFM has been successful. The United States has some of the strictest fishery legislation globally; the 1976 Magnuson-Stevens Fishery Conservation and Management Act (MSA) as amended by the 1996 Sustainable Fisheries Act (SFA) includes specific provisions for ending overfishing and maintaining stocks at maximum sustainable yield. Since then, the nation's fisheries have shown consistent progress in meeting these objectives (Patrick & Cope, 2014). For example, the Gulf of Mexico (hereafter "Gulf") has experienced many successes under SFA and a SSFM framework: during the past decade, overfishing has nearly ended, commercial revenues and recreational fishing activity have been maintained at or above historical averages, and ocean-related gross domestic product has steadily increased (Karnauskas et al., 2019). This suggests that the centuries-old principles of logistic population growth and surplus production underlying SSFM remain relevant and—when adhered to—produce positive outcomes.

Yet, the 21st century management landscape is becoming more complex. Increasing human populations rely on finite or shifting resources, increasing conflicts (Mendenhall et al., 2020; Spijkers et al., 2018). Chronic stressors make ecosystems increasingly susceptible to tipping points, characterized by drastic and difficult-to-reverse changes (Selkoe et al., 2015). These challenges, superimposed on complex human dynamics, with multiple competing objectives of social equity, yield and sustainability, result in increasingly "wicked" problems that defy simple solutions (Defries & Nagendra, 2017). Notably it is governance, and not science, that has been the major limiting factor in fishery management (Browman & Stergiou, 2004 and references within). Where SSFM has failed due to poor governance, so too will EBFM. Successful EBFM must therefore explicitly consider a broad range of human values, placed in the context of a socio-ecological system, in which humans are integral components interacting with the environment through regulations, politics and governance (Hilborn, 2004).

> What's in a name? That which we call ['ecosystem management'] by any other name would [sound] as sweet

"EBFM" has such a wide variety of interpretations (Trochta et al., 2018) that the concept has been compared to the "proverbial elephant encountered by three blind men" (Hilborn, 2011) whereby conclusions depend on each individual's perception. A commonly cited definition is "a systematic approach to fisheries management in a geographically specified area that contributes to the resilience and sustainability of the ecosystem; recognizes the physical, biological, economic, and social interactions among the affected fishery-related components of the ecosystem, including humans; and seeks to optimize benefits among a diverse set of societal goals" (NMFS, 2016). Ecosystem-based management (EBM) is an integrated management approach that recognizes the full array of interactions within an ecosystem, including humans, rather than considering single issues, species or ecosystem services in isolation (Dolan et al., 2016). Here we clarify EBFM and EBM to show that both frameworks complement current SSFM and are readily achievable (Figure 1).

1.1 | SSFM WITH ECOSYSTEM CONSIDERATIONS

SSFM has served as the prevailing framework for fisheries management. Stock assessment models estimate population status with respect to predetermined reference points, often maximum sustainable yield (MSY). While ecosystem impacts, both abiotic (e.g. temperature) (Hjort, 1914; Rice & Browman, 2014) and biotic (e.g. predation) (Longo et al., 2015), are widely acknowledged, explicit inclusion in management advice is rare (Skern-Mauritzen et al., 2016).

As we end overfishing, over-exploitation no longer eclipses environmental drivers (Fogarty, 2014) and as our assumptions regarding stationarity erode, more explicit ecosystem considerations become unavoidable. Previous catch levels may either be no longer sustainable or may no longer provide maximum yield, leading to over- or underfishing. For example, in the Gulf, harmful algal blooms can kill nearly 30% of the population of groupers (SEDAR, 2019); although fishing is not at fault, fewer fish results in reduced quotas. Explicitly accounting for the environment in SSFM—both positive and negative effects—and communicating these impacts, builds responsiveness and ultimately trust that management actions are not arbitrary, but rather a result of scientifically documented and widely corroborated environmental factors.

1.2 | EBFM

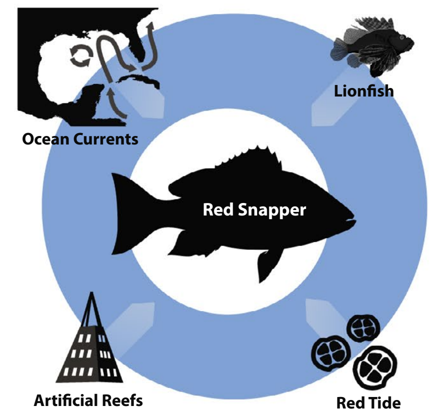
The focus of SSFM is on describing the basic stock and fishery dynamics, and incorporating critical ecological information, with the goal of setting catch limits closely aligned with the current state of the populations. Improvements to stock assessment models and derived management advice should, in theory, allow management to

FIGURE 1 Hypothetical framework examples of single-species fisheries management (SSFM) with ecological considerations, ecosystem-based fisheries management (EBFM) and ecosystem-based management (EBM). Examples are specific to the Gulf and revolve around single-species assessment of red snapper as the underlying foundation of each approach. White arrows indicate the directionality of the factors that are taken into account by fisheries managers in each schematic. Relevant management questions and actions, specific to the respective approaches, appear to the right. [Colour figure can be viewed at wileyonlinelibrary.com]

SSFM

Overarching Management Objectives

Prevent overfishing, maintain optimum yield



Management Questions

- Are red snapper overfished or undergoing overfishing?
- How does the Loop Current drive recruitment of red snapper?
- How do installations of artificial structures affect stock productivity of and fishing mortality rates on red snapper?
- Do lionfish increase juvenile mortality of red snapper?
- Does red snapper natural mortality increase significantly in years of severe red tide harmful algal blooms?

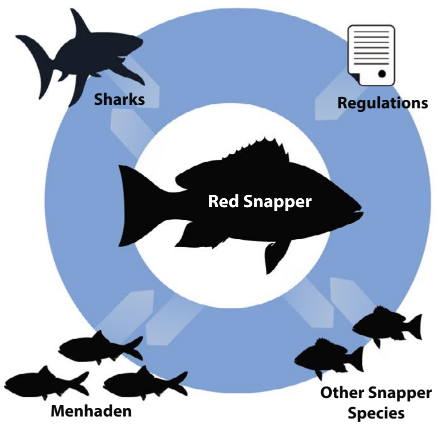
Management Actions

- Adjust catch limit of red snapper
- Adjust buffer on management reference points to account for risk
- Consider spatial or temporal closures

EBFM

Overarching Management Objectives

Maintain fishing opportunities, increase productivity of valuable species, increase efficiency, reduce waste and by-catch



Management Questions

- Are red snapper overfished or undergoing overfishing?
- What are the effects of changing fishing practices and regulations on red snapper?
- How do regulations affect discarding rates of red snapper and other species?
- How is maximum sustainable yield of red snapper affected by size of forage populations and increasing predator populations?

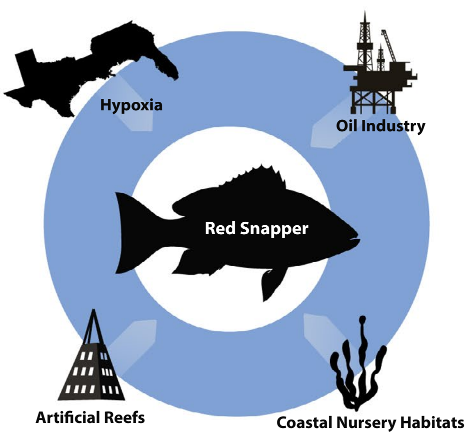
Management Actions

- Adjust catch limit of red snapper
- Modify catch limits or other regulations to address trophic and fleet interactions
- Identify harvest shifts associated with regulatory-induced discarding rates of red snapper
- Develop reference points that explicitly consider key species interactions; when those species span management jurisdictions, develop reference points jointly

EBM

Overarching Management Objectives

Maintain fishing productivity in light of ecosystem change



Management Questions

- Are red snapper overfished or undergoing overfishing?
- What are the long-term effects of the 2010 Deepwater Horizon oil spill on fisheries productivity?
- How does the loss of coastal nursery habitats affect fisheries productivity?
- How is population productivity of red snapper affected by Mississippi River eutrophication and hypoxia?
- How do installations of artificial structures affect stock productivity of and fishing mortality rates on red snapper?

Management Actions

- Adjust catch limit of red snapper
- Work with state and federal restoration agencies to ensure that restoration projects contribute to essential fish habitat and increased fisheries productivity
- Work with hypoxia task force to target nutrient input levels that are not detrimental to fisheries
- Work with state and federal agencies to ensure that artificial structure installations contribute to meeting fisheries management objectives

better achieve the objectives of avoiding overfishing and maintaining stock yields near MSY. SSFM does not, however, allow for a diverse suite of management objectives to be explored, nor does it allow complex trade-offs to be transparently considered within the science and management frameworks. EBFM allows for additional management objectives to be defined and evaluated beyond a single species or fishery management plan (FMP). Trade-offs that are inherent in any particular management action can then be evaluated in reference to these higher-level management goals.

Regardless of whether EBFM is explicitly implemented, the physical, biological, economic and social interactions inherent in fishery ecosystems are ever present and, thus, trade-offs and their consequences exist whether they are explicitly recognized or not. For example, the 1990s Gulf Shrimp FMP required a reduction in juvenile red snapper (*Lutjanus campechanus*, Lutjanidae) by-catch, deemed necessary to meet rebuilding goals for red snapper (Gallaway et al., 2017). Several FMPs reflect the importance of habitat; a 2020 amendment to the Gulf Coral FMP regulated the anchoring of fishing vessels in areas of concern. Implicit in these actions are value judgements regarding trade-offs between ecosystem components (e.g. what the social and economic goals should be, and who should benefit). In EBFM, such trade-offs become explicit, reducing risk of unintended consequences that undermine governance and hinder management success.

1.3 | EBM

As it addresses factors beyond fisheries, EBM inherently addresses trade-offs among diverse interests, activities and objectives. This requires a broader set of policy approaches and governance. While a single authority typically implements EBFM (such as a Fisheries Management Council), EBM requires a broader approach spanning multiple jurisdictions (Cormier et al., 2017; Dolan et al., 2016). For example, the United States Environmental Protection Agency's Gulf Hypoxia Action Plan includes multiple goals related to the environmental and socioeconomic effects of hypoxia (Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, 2008). Achieving these goals, and addressing trade-offs between agricultural and fisheries production, requires collaborations between state and federal partners as well as stakeholders within the watershed. Similar state and federal partnerships exist to create fishing opportunities from decommissioned oil and gas infrastructure. Since shared objectives are grounded in diverse human needs and values, considering the needs of human communities and articulating the overarching objectives of fishery management is a valuable opportunity to determine where "win-win" situations exist within the realm of EBM (Figure 1). And as is the case with EBFM, implementation of EBM does not necessarily require overhaul of the status quo, but rather increased attention to achieving ecosystem objectives.

> [We] say there is no darkness but ignorance

Managing fisheries under the SSFM framework, without considerations of interactions, disregards trade-offs that "…do not go away when ignored. They do, however, lead to suboptimal decisions and outcomes" (Fogarty, 2014). Maintaining all populations within a mixed-species fishery brings difficult challenges (Murawski, 2010), particularly in a diverse system such as the Gulf. As stocks recover, managers must consider limits to the total ecosystem productivity (Link & Watson, 2019) and accept that simultaneously maintaining all stocks at their MSY levels is not possible, though often "pretty-good yield" can be obtained (Rindorf et al., 2017). Furthermore, MSY itself is not fixed, but is a product of the biological productivity of the stock, and societal decisions about allocations, selectivity and management of other species (Goethel et al., 2018).

Inevitable trade-offs and conflicting objectives among user groups require a policy statement that is independent of individual FMPs. Fishery ecosystem plans (FEPs) provide a template to "improve decision-making through the incorporation of the principles of EBFM" (Levin et al., 2018). A FEP highlights the values of diverse user groups, and is a framework for equitable decision-making. Such decision-making is limited in a single FMP framework, with objectives relevant only to a particular fishery, preventing consideration of trade-offs among different fisheries (Levin et al., 2018). The FEP is thus the avenue for consideration of these trade-offs, given that SSFM will continue to be the predominant approach for tactical management decisions.

> Our doubts are traitors, and make us lose the [fish] we
> oft might win, by fearing to attempt

Our fisheries systems face numerous challenges to more systematic and explicit incorporation of EBFM (Hilborn, 2011). As Marshall et al. (2018) note: "Acknowledging tradeoffs does not make decision-making easier," and in fact, it may make decision-making more complex. However, pains taken to understand diverse human needs and values, and evaluate management actions to meet such needs will pay off over the long-term. More holistic management and transparent considerations of stakeholder expectations will garner support, increasing engagement, creating further buy-in and better compliance. Such engagement is of the utmost importance to fishery management; while our stock assessment models provide advice on how many fish to catch, the unavoidable fact is that we are managing humans, not fish. A lack of recognition of the importance of this "people management" in SSFM is perhaps the main reason for its perceived failure (Hilborn, 2004).

> We know what we are, but know not what we may be

In the SSFM framework, we can quite easily answer the question: where are we? Are we overfished and overfishing? But it is only the EBFM framework that allows us to ponder: what might we be? What are the causes of declines in valuable species, and which of these causes are under fisheries management and/or human control? What potential would our fisheries have if we improved habitat? Improved water quality? Reduced by-catch? What are the effects of system shocks, such as oil spills, hurricanes, and global pandemics? Is fishery management meeting the needs of humans? Are management actions leading to equitable outcomes? These questions are increasingly necessary to maintain well-being and resiliency of coastal communities in the current environmental and management landscape.

When Shakespeare's Hamlet poses the question: "to be or not to be?" he ponders whether it is better to live with all the present shortcomings of life, or die, with an unknown afterlife. We hope that our perspective provides some comfort to those involved in fisheries management that questions surrounding EBFM do not carry such existential weight. Implementing EBFM does not require us to "take arms against a sea of troubles" associated with stock assessments, ending SSFM in favour of an alternative but unknown fate. The question: "to EBFM or not to EBFM?" is irrelevant; our current choices about species allocations, user-group allocations and anthropogenic influences already reflect implicit decisions about ecosystem trade-offs. The correct question is: Will we explicitly incorporate the diversity of human values, communicate ecosystem-level objectives, and acknowledge trade-offs that exist, and choose to assess these against management objectives to ensure optimal and equitable management outcomes? We hope that the answer to this question is a resounding "yes"—as human well-being, social equality, cultural heritage and the perseverance of coastal communities depend on it.

ACKNOWLEDGEMENTS

We thank Nick Farmer and Luiz Barbieri for helpful comments on earlier drafts. We acknowledge NOAA's Integrated Ecosystem Assessment Program for funding and providing the authors' opportunities for discussions that ultimately motivated this manuscript. The lead author thanks the fishing community members who participated in workshops in Pine Island, Madeira Beach, Panama City, and Destin, Florida, the discussions from which were influential in the present essay. The authors have no conflicts of interest to declare. The scientific results and conclusions, as well as any views or opinions expressed herein, are those of the authors and do not necessarily reflect those of NOAA or the Department of Commerce.

DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analysed.

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How to cite this article: Karnauskas M, Walter JF III, Kelble CR, et al. To EBFM or not to EBFM? that is not the question. *Fish Fish*. 2021;22:646–651. https://doi.org/10.1111/faf.12538