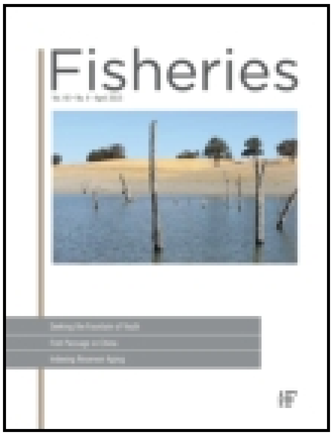

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Myths that Continue to Impede Progress in Ecosystem-Based Fisheries Management

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FEATURE

MYTHS THAT CONTINUE TO IMPEDE PROGRESS IN ECOSYSTEM-BASED FISHERIES MANAGEMENT

Ecosystem-based fisheries management has been perceived as something desirable but pragmatically unachievable due to several impediments identified earlier during its implementation phase. Over the years, many of these impediments have been resolved but not well communicated to stakeholders, managers, scientists, and policymakers. As a result, several past impediments to implementing ecosystem-based fisheries management have taken on a mythical status. Here we identify six common myths, address why they in fact no longer impede ecosystem-based fisheries management, and propose solutions for moving forward. We assert that these myths need not continue to exist and that improved approaches for fisheries are indeed feasible.

Mitos que siguen impidiendo el progreso del manejo de pesquerías basado en el ecosistema

El manejo de pesquerías basado en el ecosistema se ha percibido como algo deseable, pero de manera pragmática imposible de lograr debido a ciertos impedimentos que fueron identificados durante la fase de implementación del enfoque. Al pasar de los años, muchos de estos impedimentos se han resuelto pero esto no se le ha comunicado a los interesados en los recursos, manejadores, científicos y funcionarios. Como resultado, muchos obstáculos del pasado que impedían implementar el manejo de pesquerías bajo un enfoque de ecosistema, han adquirido un estatus mítico. Aquí se identifican seis mitos comunes, se ahonda en las razones por cuales actualmente ya no son un obstáculo para este tipo de manejo y se proponen soluciones para avanzar al futuro. Se asevera que no es necesario que estos mitos sigan existiendo y que, de hecho, si son factibles nuevos enfoques para manejo de pesquerías.

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INTRODUCTION

The canons of ecosystem-based fisheries management (EBFM) have been expounded upon for decades (Cicin-Sain and Knecht 1993; Grumbine 1994; Griffis and Kimball 1996) as a holistic approach to fisheries management that recognizes the physical, biological, economic, and social complexities of managing living marine resources. From the 1990s to present, discussions over marine EBFM have shifted from, "What is it and why we do it?" to "How can we do it and when can we operationalize it?" (Pitcher et al. 2009; Link 2010; Link and Browman 2014).

Yet, skepticism still remains about fishery managers', scientists', and policymakers' ability to operationalize EBFM. A multitude of articles discuss the daunting challenges of operationalizing EBFM (e.g., Browman and Stergiou 2004; Curtin and Prellezo 2010) and how they may differ between developed and developing countries (Pitcher et al. 2009; Tallis et al. 2010). In general, these works point to impediments such as defining, prioritizing, and monitoring long-term ecosystem-related goals and objectives (e.g., Cury et al. 2005; Ruckelshaus et al. 2008; Jennings and Rice 2011); issues with linguistic uncertainty and understanding the levels of ecosystem management (Arkema et al. 2006; Link and Browman 2014); developing appropriate data collection, analytical tools, and models (e.g., Hilborn 2011; Cowan et al. 2012; Walther and Möllmann 2014); and the need for drastically different governance structures to deal with the uncertainty and complexities of EBFM, as well as long-term planning (e.g., Leslie et al. 2008; Jennings and Rice 2011; Berkes 2012).

These and other issues have been around for over 20 years, and many of them, if not all, have already been resolved in the United States and other developed countries (Pikitch et al. 2004; Murawski 2007; Curtin and Prellezo 2010; Cowan et al. 2012). There are, of course, some issues that just will not die, such that these "myths" of EBFM impediments live on, still pervading the minds of the public, interest groups, managers, scientists, and policymakers who play a role in implementing EBFM. Until these myths are refuted, the operationalization of EBFM will continue to be hindered. Previously, Murawski (2007) addressed 10 myths that "counter-revolutionists" use to circumvent or disrupt the implementation of ecosystem-based management (EBM), and we found the approach an interesting tactic. Thus, we adopt a similar approach to refute the myths that impede the implementation of EBFM. Unlike Murawski (2007), however, we do not believe that these myths are primarily used to maintain status quo; rather, they are misconceptions about what is needed to operationalize EBFM (i.e., make functional). Here we note each of these common myths, address why they are indeed factually inaccurate today, and suggest ways to move forward.

MYTH #1—MARINE ECOSYSTEM-BASED MANAGEMENT SUFFERS FROM CRIPPLING LINGUISTIC UNCERTAINTY, SUCH THAT IT IS UNABLE TO BE OPERATIONAL

Over the last 20 years, a common observation about ecosystem management (EM) is that it means different things to different people (e.g., Lackey 1998; Yaffee 1999; Arkema et al. 2006). As a result of this linguistic uncertainty, many believe that the concept of EM has no universal definition or consistent way to apply it to different levels of management in terms of scope and jurisdiction.

As with Murawski (2007), this issue is at the top of our list of myths, given that definitions of EM, EBM, EBFM, and ecosystem approaches to fisheries management (EAFM) have been thoroughly vetted in the scientific literature over the last 20 years (e.g., Larkin 1996; Arkema et al. 2006; Link and Browman 2014). Although scientists will always discuss nuances to these definitions, the scientific community largely agrees that marine EM contains three hierarchal levels, with EM being the umbrella term used by stakeholders to generally describe the various levels of implementation (Table 1). Ecosystem management, or even EBM, is used colloquially as effective shorthand to note more holistic resource management—management that considers more facets of the ecosystem than just a species of interest. Building upon that foundation there are sector-specific systems efforts (i.e., EBFM), followed by ecosystem-cognizant species specific approaches (i.e., EAFM; see Table 1).

Although the scientific literature has been clear about the definition of EM and its levels of implementation, it appears that the translation to stakeholders, managers, and policymakers has been somewhat erratic. For example, Arkema et al. (2006) compared common EBM principles noted within the scientific literature, to agency management plans that were implementing EBM. Their results showed that some principles of EBM are being practiced, but the gap between the scientific literature and management plans suggests that the concept of EBM needs to be more effectively translated. We simply assert that applying the appropriate EM levels of the hierarchy may help to alleviate this confusion.

MYTH #2—FISHERIES MANAGEMENT LACKS THE GOVERNANCE STRUCTURE AND MANDATES TO IMPLEMENT EBFM

Some claim that to fully implement EBFM, there needs to be drastic changes to fishery governance structures to overcome the regulatory constraints of current mandates designed for single-species management (e.g., Leslie et al. 2008; Pitcher and Lam 2010; Berkes 2012). Governance impediments have been described as the lack of mandates to implement EBFM; a more complex and costly approach to management that our current management regime can accommodate; or changing the focus of what is actively managed (Rice 2011).

Yet, Murawski (2007) noted that many, if not all, marine resource management institutions have already adopted some form of EM. There also exist a plethora of mandates worldwide that emphasize the use of EBFM, such as the Convention for the Conservation of Antarctic Marine Living Resources (Constable 2011), Marine Planning Framework for South Australia (Day et al. 2008), and the Common Fisheries Policy for European countries (Jennings and Rice 2011).

Within the United States, McFadden and Barnes (2009) reviewed how the National Oceanic and Atmospheric Administration (NOAA) has been committed to implementing EM over the last two decades. They identified more than 90 separate federal legislative mandates, which give NOAA its stewardship authorities either implicitly or explicitly to implement EM. In their study, among the various line offices of NOAA, NOAA Fisheries reported the largest number of projects that focused on EAFM and EBFM (McFadden and Barnes 2009). Tromble (2008) highlighted that four (now five) of the eight regional fishery management councils have developed fishery ecosystem plans that work within the existing management framework, even though such plans have never been mandated.

Table 1. Levels of ecosystem management (EM) as applied in a fisheries context: EAFM (ecosystem approaches to fisheries management), EBFM (ecosystem-based fisheries management), and EBM (ecosystem-based management).

Level of EM	Definition	Focus of Management	Management framework*	References
EAFM	Inclusion of ecosystem factors into a (typically single species) stock focus to enhance our understanding of fishery dynamics and to better inform stock-focused management decisions	Fisheries stocks	Fishery Management Plan	Pitcher et al. 2009; Link and Browman 2014
EBFM	Recognizes the combined physical, biological, economic, and social tradeoffs for managing the fisheries sector as an integrated system, specifically addresses competing objectives and cumulative impacts to optimize the yields of all fisheries in an ecosystem	Fisheries systems	Fishery Ecosystem Plan	Link 2010; Link and Browman 2014
EBM	A multi-sectored approach to management that accounts for the interdependent components of ecosystems, and the fundamental importance of ecosystem structure and functioning in providing humans with a broad range of ecosystem services	All sectors, including fisheries	Regional Ocean Plan	MacLeod and Leslie 2009; Curtin and Prellezo 2010; Link and Browman 2014

*Examples from the United States

Another related concern has been the lack of operational decision criteria for undertaking EBFM. Operationally, fishery managers and scientists already implement EM via modifications to existing biological reference points and harvest control rules that incorporate ecosystem considerations in an EAFM context. For example, extended stock assessments, multispecies assessments, and related models can produce routine biological reference points that incorporate ecosystem considerations, such as predation mortality on forage or thermal effects on growth. Additionally, there are aggregative or system-level analogues to these common biological reference points (see Bundy et al. [2012] and references therein). There are also other efforts to explore indicators of ecosystem overfishing defined by Murawski (2000) and Link (2005) and as proposed by others (Coll et al. 2008; Libralato et al. 2008). There have also been both empirical (Samhouri et al. 2010; Large et al. 2013) and simulation (Fay et al. 2011) efforts to establish thresholds and harvest control rules for a broader suite of indicators than just typical B_{msy}/F_{msy} (biomass that supports maximum sustainable yield [MSY]/level of fishing mortality that will keep harvests at MSY) types of biological reference points. These operational capabilities are conducted well within existing mandates.

Although additional or revised mandates would help clarify the roles of management agencies in implementing EBFM, managers and scientists have ample mandates and the discretionary authorities to advance EBFM. Several experts have noted that implementing EBFM is an adaptive or evolving process (e.g., McFadden and Barnes 2009; Hilborn 2011; Fogarty 2014), so rather than waiting on the perfect mandate to move forward with EBFM, managers, scientists, and policymakers can and should move forward within current authorities.

MYTH #3—EBFM CAN ONLY BE IMPLEMENTED IN REGIONS WHERE WE HAVE COPIOUS DATA, AND THE COROLLARY, DOING EBFM REQUIRES MODELS THAT ARE TOO COMPLICATED

A common misconception about EBFM is that it can only be implemented in data-rich regions where certain types of information are available and that it needs to be done in the context of horrendogram-style food webs and Frankensteinish-level models (Browman and Stergiou 2004 and references therein). Prominent among these assumed requirements are a food web model, information on habitat quality, or an understanding of the detailed mechanistic climate impacts on the environment.

As noted in prior calls for EBFM, Pikitch et al. (2004) and Hobday et al. (2011) clearly recognized that EBFM can and needs to be conducted in data-poor situations and especially in the developing world. Critics of EBFM argue that attempting to manage something as complex as an ecosystem is effectively an insurmountable challenge given the difficulties we have faced just trying to understand single populations (Mace 2004). Such critics posit that managing entire ecosystems on a scientific basis is bound to be nearly impossible given our present lack of knowledge about the dynamics and emergent features of marine subsystems (Mace 2001; Browman and Stergiou 2004). However, which is more complex—a single-species model with an age-structured, time-varying catchability, dynamic fleet representation, and variable recruitment responses, or a three-species production model with a simple interaction and fishery removal term? The point is that one can construct models as complex as one can think, but the range of topics being modeled can vary. Just because one is including an additional process does not necessarily make it a more complex model; it depends on the factors being modeled (Link et al. 2010). How one addresses uncertainty is not necessarily a function of model complexity but also has structural and process considerations as well (Link et al. 2012).

This myth was also addressed by Murawski (2007; 686), who noted that while food web models

> *"are useful for managing species that have predator–prey or habitat interrelationships, even a qualitative understanding of these relationships (e.g., 'who eats whom,' spatial distributions of key species, and human-use 'footprints') can be used to establish cautionary management accounting for these potential interactions."*

For instance, loop analysis and related approaches can inform this element (and similarly for habitat or climatic factors) and be just as robust (Dambacher et al. 2003).

The reality is that EBFM is being done in data-poor situations now (Smith et al. 2007). The methods being used range from qualitative to semiquantitative to fully analytical, depending upon the salient information and data available and on the need to consider this material across a range of factors. Hence, ecological risk assessments, or some other form of triage (Levin et al. 2009; Link 2010; Hobday et al. 2011) to denote which processes are important and which can be treated in a more cursory manner, are a critical part of EBFM. The point is to not necessarily include more complex data or analytical approaches but rather to be more comprehensive in the range of factors being considered to manage a fishery. Just as in single-species stock assessments, the methods continue to develop to handle this range of considerations.

MYTH #4—EBFM ALWAYS RESULTS IN TOO CONSERVATIVE AND RESTRICTIVE ADVICE

The perception is that implementing EBFM would universally and categorically result in a reduction in allowable catch. This perception often stems from aggregate surplus production models, which show that system-level harvest levels can be approximately 25% less than that produced by single-species management (Fogarty et al. 2012; Gaichas et al. 2012). Other reasons may include stakeholder perceptions that EBFM would require more precautionary catch limits to account for the scientific uncertainty in complex ecosystem models or that EBFM would result in more restrictive fishing regulations to protect threatened and endangered species or, more generally, nontarget species. Therefore, why would stakeholders ever want to move from single-species fisheries management to EBFM?

A better question might be why would stakeholders ignore the best available science and jeopardize the resiliency of the stocks and ecosystem? Fisheries scientists over the last half century have criticized the concept of maximum sustainable yield for single species because of the impossibility of MSY for all species simultaneously (Larkin 1977; Mace 2001). Predator–prey demands, fluctuating environmental conditions, the selectivity of the fishing fleet, and other factors regulate the population abundances of living marine resources above and below theoretical MSY levels. This is one reason why EBFM came to the forefront in the 1990s as a more holistic approach to management and was adopted by the United States and other countries (cf. Myth 2). Multispecies or system-level reference points provide a more realistic view of the system-level productivity.

The perception that ecosystem level reference points result in lower yield is predicated on the review of individual species, not the aggregate. This is because system-level models account for multispecies interactions, so the allowable catch for any given species at any given time may be less. However, if one focuses on aggregated landings—and value thereof—across all targeted species in an ecosystem, studies and summations of fisheries performance metrics have shown that the total biomass landed is actually quite similar to landings based on single-species management (Lucey et al. 2012). Plus, the economic value may stay the same or actually increase, given that the attendant benefits of some fish groups recovering may actually lead to an increase in overall landed biomass of certain subgroups over time. Beyond that, there is also a stability component when considering a system-wide view. There is biological stability from conserved, emergent ecosystem properties and functional redundancies that have not been utilized. Such constancy can lead to both regulatory and economic stability, which promote better business planning.

MYTH #5—EBFM IS A PIE-IN-THE-SKY PANACEA FOR AN ALREADY DIFFICULT SOCIOECONOMIC SYSTEM

The perception is that EBFM is viewed by enthusiasts as a cure-all to the ills of fisheries management, whereas critics see EBFM as a naïve attempt to describe the complex realities of a contentious and political allocation system for public natural resources (e.g., Fitzsimmons 1996; Browman and Stergiou 2004; Blomquist and Schlager 2005). Even apart from the biogeochemical, biophysical, oceanographic, and ecological complexities, EBFM is viewed as an approach that simply does not account for all of the permutations and realities facing a participatory decision-making process. Critics of EBFM express skepticism that implementing EBFM will better solve problems with inherent and significant socioeconomic, cultural, emotional, and political challenges (see Browman and Stergiou 2004).

This is a lot like saying to financial investors that choosing multiple stocks in which to invest is impossible, because the market is too complicated and risky. However, we know that investors often select a blend of stocks that represent multiple sectors of the market, minimize overall levels of risk simultaneously, maximize returns, and do so to address a balance across multiple investing objectives (Graham et al. 2008). Why not be transparent about the objectives of various sectors within a fishery to afford an opportunity to explicitly compare and contrast tradeoffs to optimize yields? In effect, this is what EBFM aims to do.

Certainly, it is difficult for managers to evaluate multiple objectives in a highly charged political context. Yet EBFM is about tradeoff analysis, explicitly examining what options meet the most objectives as an integrated system (Link 2010). It is actually quite pragmatic in that it provides a context within which multiple objectives can be evaluated simultaneously with transparency. Ignoring tradeoffs, or the existence of such multiple objectives, does not make them go away (Fogarty 2014). The risks of not considering the full suite of ecosystem factors have, for a long while, outweighed the risks of attempting to address them. Certainly, governance structures or processes may need to adapt to accommodate this broader set of scientific evidence (cf. Myth 2), but if modified or constructed with a suite of tradeoff measures in mind, the more robust decisions for the overall fishery system can become more apparent in an EBFM context. Analytical tools, like management strategy evaluation framework (Fulton et al. 2014), are specifically designed to help identify the most viable management options across this range of challenges.

Moving forward, we need to consider the suite of information that best captures the socioeconomic tradeoffs across all fisheries in a given location. Several participatory approaches have been used to elicit what are the main objectives for all stakeholders involved in the full fisheries sector in a given location; these should certainly be used (Levin et al. 2009; Fulton et al. 2014). The salient point is not to ignore that different stakeholders have different and often competing interests. Instead, managers need to acknowledge these differences and identify management options that best optimize the full range of interests—particularly noting that many robust strategies can often meet multiple objectives of interest to multiple parties—such that no one stock, fishery, sector, economy, or community is unknowingly depleted at the expense of another. Such methods exist, such options have been and are continually being explored, and such options are beginning to coalesce around common themes that can be applied appropriately. The utility of EBFM is facilitating these tradeoffs across and within fisheries in a transparent and quantitative manner.

MYTH #6—WE DO NOT HAVE ENOUGH RESOURCES TO DO EBFM

The perception is that how are we ever going to do EBFM when we do not even have enough resources to fully implement single-species fisheries management (Link 2002; Riggs 2001). Currently, within the United States, approximately 300 of the 478 federally managed stocks are assessed on a regular basis to provide estimates of biomass and fishing mortality rates (NMFS 2014). The perception is that surely the implementation of EBFM would require more stocks to be assessed and with more sophisticated models that require more funding, more data collection systems, and a larger workforce.

However, the gains in efficiencies of doing EBFM are too easily overlooked. Fogarty (2014) suggested that fully implementing EBFM may actually reduce the administrative complexity of managing fisheries. Single-species management systems are immensely complex processes. Domestic fishery agencies and international bodies support a very large number of working groups, each with several representatives charged with developing regulations or assessments for individual species. Furthermore, each assessment often goes to additional workgroups to determine its adequacy for making management recommendations. Over the long term, EBFM is expected to reduce the number of workgroups and modeling structures into a much smaller integrated assessment process, using multispecies and aggregate approaches and indicators to monitor stock status for more species simultaneously (Fogarty 2014).

Ecosystem-based fisheries management gains efficiencies from prioritization efforts to triage key drivers of a system. Overall this prioritization and aggregative approach builds on increased stability in system productivity, compared to more dynamic productivity on a stock-by-stock basis (Fogarty et al. 2012; Gaichas et al. 2012). Ecosystem-based fisheries management takes a macrolevel look at system-level productivity, while protecting against overfishing, to smooth out the variability that occurs at the individual species level. This is analogous to managing for a portfolio of stocks, in a financial context. The results of this broader view and more stable system provide for better regulatory and biological stability, again resulting in better business planning (Smith 1996; Baumgärtern and Strunz 2014).

SUMMARY

These myths lead to the false perception that EBFM is too complex and thus poorly defined. Whether models, data, or even basic understanding, the criticism is that fishery managers and scientists simply do not know enough to take action. Consequently, we will never fully understand ecosystems; therefore, comprehensive management of their use is impossible. Does that mean that we stop trying to understand ecosystems or abdicate our mandated responsibilities to manage them and their associated trust species?

The challenge has been to determine the relative importance of those processes (usually by partitioning variance in some multivariate sense) as they influence the dynamics of marine ecosystems and tracking their associated dynamics over time and space. For instance, overexploitation generally leads to depleted fish stocks, fluctuations in primary production can be driven by large-scale oceanic phenomena, fishers tend to target easier-to-access and more abundant stocks, species that migrate from one area to another have impacts in the systems they migrate from and to, the interplay between predators and prey remains dynamic and challenging given the complexities of marine food webs, etc. The point is that there already exist a wide range of patterns, processes, and principles whose general directionality and outcomes we can use to inform and guide our management.

We assert that one does not need perfect knowledge of every process to implement EBFM. We reiterate that the knowledge base to do so exists. We also reiterate that doing EBFM is feasible with information, tools, and approaches that are currently available. However, as we continue to move toward EBFM, several challenges remain, and we very much recognize them. Yet, we also assert that by building upon the knowledge base we have and the examples of implementation to date, we are poised to more fully implement EBFM. The key point is to address this broader range of issues, issues that have been often overlooked, and issues that are known to impact living marine resources. We trust that helping to disprove these myths will at least further the debate on the topic and lead to even further implementation of EBFM to better manage our fisheries.

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