How Have Institutional Barriers Impacted Implementation of Ecosystem Based Fishery Management in the US

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Abstract

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Ecosystem based fisheries management (EBFM) has been studied for over twenty years, but has rarely been fully utilized in practice. EBFM utilizes multispecies management and ecosystem information, including physical oceanographic information and predator-prey relationships, to better manage fisheries. Regional fishery management councils started incorporating ecosystem information for management on an ad hoc basis in the mid-1990s, and suggestions to use ecosystem information appeared in legislation in 2007 (18 USC § 1882). Since that time, implementation has increased slowly at a national level, and is still virtually unused in some councils. One possible reason for the slow implementation is that institutional barriers have prevented EBFM from being embraced by managers. These barriers can be in the form of

legislation and regulation, issues within the regional fishery management councils, judicial challenges, and budgetary or staffing shortages. The legislation has not been much of a barrier to EBFM, but regulations have been more troublesome for some regions. Institutional momentum may be one reason EBFM is not more common in US fisheries as regions face different levels of support for new management schemes due to factors like staffing, budget, and litigation.

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Introduction

Fisheries are the only remaining major source of wild-captured food. Over the past century, fishers and government agencies utilized many strategies to manage fisheries to produce an optimal economic output, while retaining stock levels that will provide ongoing fishing for future generations. As fishing industrialized after the 1940s, better equipment led to more efficient fishing, and modern industrial fisheries have the ability to fish a stock to near extinction in only a few years (Link et al., 2011). Depleted stocks and large foreign fleets led to the first effort to manage fisheries at the federal level, the Fishery Conservation and Management Act of 1976 (FCMA) (Macpherson, 2001). The Act had two goals: remove foreign fishing fleets from US coasts, and provide for regional fisheries management (Macpherson, 2001).

Since the initial concern for the biological sustainability of stocks targeted by a fishery that prompted the signing of the FCMA, a number of other concerns have arisen with the impact of fisheries on the marine environment. Some economically important fish are caught as bycatch by fishers catching other species, resulting in fewer fish available in the target fishery (Worm et al., 2009). Fishers have damaged important habitat areas through bottom trawls and dredges, reducing productivity of both target and non-target species, and in some cases harming endangered or overfished species (Brodziak and Link, 2002). Predator-prey relationships have

also complicated fisheries management due to difficulties in either retaining enough prey for a healthy ecosystem, or catching too many predators and destabilizing food webs (Pikitch et al., 2014). To deal with these issues, the Magnuson-Stevens Act was passed in 1996 to amend the 1976 law. It featured protections to habitat that would conserve vulnerable species and also limited fishing in high yield areas. While this addresses some of the above-mentioned ecological and economic concerns, it has sometimes created friction between fishers and managers (Rosenberg et al., 2006). Rosenberg et al. found that 45% of stocks in need of rebuilding were still seeing overfishing in 2006, despite the existence of rebuilding plans.[1] Management successes and failures caused some managers to start thinking explicitly about ecosystem interactions when managing fisheries to reduce conflict between stakeholders (Macpherson, 2001). As part of the 1996 amendments, Congress requested NMFS convene an Ecosystem Principles Advisory Panel, which issued a report in 1998 on how ecosystem principles were being used, and how they could be used in the future (Fluharty et al., 1998; Macpherson, 2001).

As more data was collected on both the natural and social aspects of fisheries, the move towards incorporating ecosystem considerations culminated in language within the 2007 Magnuson-Stevens Act Reauthorization, which explicitly allowed for ecosystem considerations

[1] The Magnuson-Stevens Act defines overfishing as "a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce the maximum sustainable yield on a continuing basis" (16 USC §1802(29)).

in fisheries management (16 USC §1882). Since that time, despite acknowledgement of the above concerns and legislative development to address them, the regional councils have incorporated ecosystem considerations at highly different rates and levels of management, with some councils barely doing anything, while one council has moved to ecosystem plans for all managed stocks. (NOAA, 2016a; Pitcher et al., 2009). It is unclear exactly why EBFM has not seen wider implementation, and there are many potential barriers. One possibility is a combination of institutional barriers within both the regional fishery management councils (RFMCs), and NOAA in general. These potential barriers include direct legislative and regulatory barriers, budgetary and personnel shortages, institutional momentum and hostility within the RFMCs toward EBFM, and legal disputes or confusion. It is also important to look at the language of the current (2015-2016) Magnuson-Stevens Reauthorization, as well as proposed regulatory changes, to see where potential barriers to EBFM and successful management in general might occur. This paper will examine these potential barriers to determine how they have impacted implementation of ecosystem based fisheries management.

Ecosystem based fisheries management is considered by some to be the next big step in US fisheries management, and has been for some time (Brodziak and Link, 2002; Fluharty et al., 1998; NOAA, 2016a). EBFM is an evolution of single species management that takes a holistic approach to management, and includes the environment, and people in decision making

(Brodziak and Link, 2002; Link, 2002). The fact that EBFM has been considered the next step in management for so long is telling as to its incomplete implementation (Pitcher et al., 2009). This would indicate one or more barriers have delayed implementation. In the US, fisheries management has mainly focused on single species management, with a few notable exceptions for multi-species stocks, like groundfish fisheries in which it is difficult to target one particular species (NOAA, 2016a).

Literature on fisheries management and modeling has increasingly contained parameters and criteria beyond the traditional criteria of recruitment and mortality (Levin et al., 2009; Link et al., 2010). Factors such as predator-prey relationships, current and temperature regime shifts or anomalies, and bycatch in non-target fisheries have led to more complex, and potentially more accurate stock assessments (Link et al., 2010). These factors are important not just for improving management now, but can provide solutions to potential management issues in the future, like predicting the impacts of climate change on certain fisheries (Link et al., 2010). Scientists have also studied the impacts of fisheries on other ecosystem services, including the impacts on birds and marine mammals (Pikitch et al., 2014). However, due to various barriers, which this paper will examine in detail, many of these advanced stock assessment techniques have remained in academia, while older, more basic assessments are actually being used to determine annual allowable catch (Link et al., 2010; Townsend, 2016).

On the social and economic sides, more efforts have been made to understand who benefits from various policies, and how changes may impact fishers, their communities, and social institutions. Rationalization of fisheries, including Bering Sea Crab and Pacific groundfish, have increasingly looked at economic equity in determining how to allocate fish shares (Abbott et al., 2010). These efforts have brought together resource management and social analysis, in ways that had previously been ignored (Abbott et al., 2010). While resource economics have always been considered in fisheries management, sometimes to the detriment of ecological systems, analysis had focused on the total dollars produced, did not consider the distribution of benefits, and did not even consider whether local stakeholders benefited at all (Hilborn, 2007). When the immediate local stakeholders benefit, they are more likely to support management policies that ensure the long term viability of natural resources, and are less likely to exploit a resource or ecosystem to the point of collapse (Christie, 2004). US fisheries management has included stakeholders as an integral part of the management process, with a possible assumption that the fishers are local to the fisheries.

There are many potential barriers to EBFM implementation. Political barriers are the first that must be overcome, and while some may remain on a regional level, the repeated passing of legislation over the past 40 years is proof that the national level political barriers have been overcome. The legal backdrop of fisheries management may appear to be the most likely culprit

for barriers because it creates the management regime. Next, the regulatory framework will be examined as it provides many of the specifics, some of which may have unintended consequences on the implementation of EBFM. In regards to potential barriers from both legislative and regulatory sources, the effect of the political process on EBFM will also be examined. The regional fishery management councils (RFMCs) provide the forum for stakeholder involvement, and produce the management plans, so differences between the regions will have to be examined, insofar as the differences effect their different rates EBFM implementation. Finally, the budgetary process within NOAA provides a potential barrier to EBFM, as any changes in management will require additional resources so that the current system can create FMPs, while also researching potential changes. Litigation will be considered as part of the regional differences, as litigiousness may impact adoption rates. Finally, there may be scientific barriers to EBFM. These could arise from incomplete data on ecosystems and from the limits inherent in stock assessment models to simultaneously predict large-scale ecosystem changes as well as individual stock numbers. I will examine each potential barrier individually, and how it has impacted implementation of EBFM.

Methods

The primary method utilized was legal analysis. I went through public laws, annotated code, Federal Register, Code of Federal Regulations, budget documents, and agency policy documents. I also read stock assessments and management plans to get a sense of what kinds of ecosystem information appeared in science center and management council documents. Literature review was the primary means of gathering background information on EBFM and the history of EBFM in the US. This also included general review of EBFM challenges throughout the world to get a sense of what kinds of challenges might apply in the US context. Finally, I spoke to a number of people involved in the fisheries management process. These were informal conversations, as well as question and answer sessions at a meeting. Interviewees included current and former FSC staff, RFMC staff, RFMC members, RFMC fishery committee and subcommittee members, SSC members, and NOAA staff.

What is EBFM?

Before looking at barriers to implementation, it is essential to define ecosystem based fisheries management. EBFM has been proposed as a holistic way of managing fisheries, which considers the complex dynamics between target and non-target species and the greater social-ecological system (Basurto 2009; Brodziak and Link 2002; Janssen 2000; Ostrom 2009).

Definitions of EBFM have evolved somewhat over time, with many experts on fisheries science and management suggesting best practices for ecosystem approaches, however there is not one single agreed upon definition (Francis et al., 2007; Patrick and Link, 2015; Pikitch et al., 2004; Sainsbury and Sumaila, 2003).

Table 1: Types of management and what is included in each.

Management Type	Sectors	Number of Species Managed	Ecosystem Considerations	Human Dimensions
Single Species Management	Fisheries	One	No	No
EAFM	Fisheries	One	Yes	No
EBFM	Fisheries	Multiple	Yes	No
EBM	Fisheries plus anything that may interact with fisheries	Multiple	Yes	Yes

As the name implies, EBFM is specific to fisheries management and considers multiple species within one management plan, as well as physical or chemical oceanographic considerations through integrated stock assessments. (Link and Browman, 2014) Ecosystem information can include just about any variable that might lead to a better understanding of what fish populations are doing, including temperature, currents, oceanic oscillations, habitat, predator-prey relationships, and interactions between competitive species. EBFM does not generally look at social or economic concerns or sectors other than fisheries (Link and Browman, 2014). Ecosystem based management (EBM), is even more inclusive, particularly in regards to human dimensions, and includes non-sector specific management. This paper will include human

dimensions as part of EBFM because the human dimensions are already implemented within the US fisheries management system through the National Standards set forth in the Magnuson-Stevens Act. This paper will also include ecosystem approaches to fisheries management (EAFM), which is distinguished from EBFM in that it manages a single species at a time, as opposed to multiple species, using ecosystem data to set catch limits (Patrick and Link, 2015). Arguably, the most important reason to utilize EBM is to improve ecological, economic, and social outcomes, so determining which box any particular measure fits in is less important than whether or not additional ecosystem measures are utilized to improve management.

Effective EBFM requires a number of management components, some of which are specific to EBFM, and some of which are part of good management approaches. Stakeholder involvement is important for effective management, and critical in natural resource management (Pitcher et al., 2009). Using a regional management system is useful in creating techniques that will work at the local level, as well as having the people impacted by management have a clear voice (Jentoft et al., 1998). It is important to make decisions based on science, and to incorporate new data into management as it becomes available (Sullivan et al., 2006). Effective enforcement is of the utmost importance, as is a way towards species recovery, if stocks are overfished, that utilizes clear rules and timetables (Raakjær Nielsen, 2003; Rosenberg et al., 2006). Finally,

habitat has to be considered when applying fishing regulations so that stocks have the ability to reproduce, grow, or recover (Rosenberg et al., 2000).

Federal Fisheries Management Legislative History

Fishery management at the Federal level starts with the Magnuson – Stevens Fishery Conservation and Management Act (16 U.S.C. §§ 1801-1884). Prior to this, fisheries management occurred primarily at the state level, and at an international level through treaties. The Act was originally passed as the Fishery Conservation and Management Act of 1976, and has since undergone major revision in 1996, and in 2007. As of 2016, there is a reauthorization under review that would again create major changes in the law if passed as written.

The 1976 Act produced two items that were revolutionary in US fisheries management. First, Federal jurisdiction was extended to 200 nautical miles, from a previous limit of 12 (Macpherson, 2001). The 200 NM limit was due to the ongoing negotiations for a new international treaty on the law of the sea, which would later establish the notion of a 200 NM exclusive economic zone for all coastal nations as a matter of international law (Allen, 2014). Of note, while the US never ratified this treaty, identical seaward boundaries were declared by the US, and recognized for all other nations by President Reagan (Allen, 2014; Macpherson, 2001). The 200 mile boundary did nothing to extend state jurisdiction, which is most commonly limited

to 3 NM[2], and thereby established an enormous area that could be managed solely by the Federal government. The EEZ, also had the effect of eliminating foreign fishing off the US coast, making it easier to track the number of fish caught, as well as protecting the economic interests of US fishers.

Another major management revolution was in the formation of regional fishery management councils (RFMCs), which provided regional stakeholder input into the management process. Since that time, the notion of stakeholder involvement in management decisions has become one of the best ways to ensure local support, and has the effect of reducing local opposition, and increasing enforcement. The early RFMCs, were largely able to manage however they wanted, and this did result in ineffective management, and a number of stock collapses. At this time, fishers saw little incentive in reducing catches for lucrative species, and had very little trust of fisheries scientists who were suggesting lower catches.

Finally, the 1976 Act provided a set of 7 National Standards by which fisheries should be managed. The most important in terms of EBFM was National Standard 2, which required the use of scientific information when making management decisions.

[2] Texas, Puerto Rico, and the Gulf coast of Florida have historically had jurisdiction out to 9 NM, and Louisiana's, Mississippi's and Alabama's limits were extended to 9 NM in 2016 (Pace, 2016).

Table 2: The National Standards as currently formulated (16 USC §§ 1851(a)(1-10)).

National Standard 1	Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry.
National Standard 2	Conservation and management measures shall be based upon the best scientific information available.
National Standard 3	To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.
National Standard 4	Conservation and management measures shall not discriminate between residents of different states. If it becomes necessary to allocate or assign fishing privileges among various United States fishermen, such allocation shall be (a) fair and equitable to all such fishermen; (b) reasonably calculated to promote conservation; and (c) carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privilege.
National Standard 5	Conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose.
National Standard 6	Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.
National Standard 7	Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.
National Standard 8	Conservation and management measures shall, consistent with the conservation requirements of this Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities by utilizing economic and social data that meet the requirement of paragraph (2) [i.e., National Standard 2], in order to (a) provide for the sustained participation of such communities, and (b) to the extent practicable, minimize adverse economic impacts on such communities.
National Standard 9	Conservation and management measures shall, to the extent practicable, (a) minimize bycatch and (b) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch.
National Standard 10	Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea.

There were reauthorizations and amendments made in the 80s to the Act, but these had relatively small impacts on management, particularly EBFM. The 1996 reauthorization, known as the Magnuson-Stevens Act, contained stronger language on rebuilding overfished stocks, setting a 10-year timetable for rebuilding, but failed to limit the timeframe that a fishery could be subject to overfishing prior to rebuilding. As a result stocks were either actively overfished, or failed to recover due to continuing fishing pressure (Rosenberg et al., 2006). The 1996 version

also amended the National Standards, adding three new standards, two of which had a direct bearing on EBFM. National Standard 8 required the use of economic and social data to ensure economic sustainability of the fishery. National Standard 9 required bycatch be minimized, providing the first legislation for non-target species.

The final amendment from 1996 that affected EBFM, was the provision for identifying and protecting essential fish habitat (EFH). The EFH provision provided a rationale for limiting certain gear types for reasons other than effort control. MSA requires the identification of EFH for targeted species, and recommendation on how to conserve habitat to ensure that stocks remain viable (16 USC §1802(10)). To execute the EFH provisions, each council created a habitat committee that could review the science and adjust fishing plans as needed.

The 2007 reauthorization contained some new, and important, provisions. First, the idea that ecosystem factors could be considered in the development of a fishery management plan (FMP) was introduced into the legislation. Ecosystem considerations flow out of the EFH provisions that had been introduced 10 years prior, but allowed for a broader set of considerations than physical habitat. This built on efforts from academic fisheries management literature, and also the implementation of an ecosystem sub-committee in the North Pacific council. The other major revolution in the 2007 reauthorization was the requirement that overfishing end immediately. This forced the RFMCs to more tightly limit overfished stocks, and

required fishers to reduce short term catches. Since this reauthorization, the number of overfished stocks has been drastically reduced (NOAA, 2015; Rosenberg et al., 2006).

Are Regulations a Barrier to EBFM?

NOAA, through the Secretary of Commerce is authorized to create regulations arising from MSA. These are primarily contained in 50 CFR Chapter VI, though some other pieces are present in other parts of Title 50, such as regulations regarding marine mammals and endangered species, which can impact FMPs. The definitions of the National Standards, contained within 50 CFR §§600.305-600.355, have the greatest impact on EBFM, as these sections detail the considerations that must be made in managing fisheries.

NOAA has promulgated a rule that National Standard 1 (NS1) has primacy over all other National Standards (74 F. Reg. 3204). The legislation reads: "Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery for the United States fishing industry" (16 USC § 1851(a)(1)). The requirement for optimum yield (OY) is the primary means by which fisheries are managed by the RFMCs. All fisheries must calculate the OY, and can then subtract catch for various factors. Arguably the most important aspect of OY calculations is that OY cannot be greater than the maximum sustainable yield (MSY) for a stock. The actual catch limit (ACL) reduces the amount

that can be caught based on factors like the stock's bycatch mortality from other fisheries, scientific uncertainty as to natural recruitment or mortality rates, and whether the stock is in an overfished status. These can forward EBFM goals, however in cases where the management process is highly contentious, the possibility exists for OY to be used to deny the use of ecosystem information as too uncertain. OY is a balancing act between economic and biological factors, and past management has tended to side with economic concerns, sometimes with disastrous consequences for both the stock and the fishers.

I heard from a number of current and former council and SSC members at a meeting in which a number of people viewed NS1 as a barrier to EBFM. There appeared to be a difference between how mangers from the east and west coasts viewed this, and it shows in how RFMCs in the Pacific have been quicker to embrace ecosystem considerations. The argument that NS1 is a barrier is based on the idea that non-requisite criteria that are included in OY calculations will lead to catches that are lower than the actual optimum. This argument may be based on the challenges that some councils have in making any changes to the OY calculations, and so it is easier, and possibly a better use of limited resources, to retain older methods that will not be challenged.

In order to increase EBFM implementation, the NS1 barriers will need to be removed, whether they are true regulatory barriers, or only in the minds of managers. Any change will

likely require rewriting NS1, and possibly additional national standards as well because there has already been so much litigation on the existing regulations that NOAA is unlikely to offer much clarification. In fact NOAA already has proposed new language for NS1, which if promulgated, may allow for easier EBFM implementation. These proposals will be analyzed in detail later in this paper.

Is the Regional Management Council System a Barrier to EBFM?

The regional council system both creates and removes barriers to EBFM, and also illuminates barriers that are not universal. The MSA provides for the size and certain aspects of the composition of each of the regional fishery management councils (RFMCs) (16 USC §1852). Each council includes the head of the regional NMFS office (or a nominated representative), and also includes the person in charge of state (or US Territory or Protectorate) fisheries for each included state, plus at least one additional person from each state (obligatory state representative). The additional voting member from each state tends to be a representative of either the recreational or commercial fishing sector. The councils also have additional spaces that are filled by at-large members. The governors nominate all voting members as part of a list of potential candidates, and the Secretary of Commerce can choose among the options to fill both obligatory and at-large positions.

The Pacific council is unique in that it has two requirements that no other council has. First, there must be a Tribal member on the voting council, and second, Alaska gets a non-voting member present. This is the only case where a representative of a state from outside the regional council is required to be included. Each of the councils includes the regional head of US Fish and Wildlife and the ranking officer for a regional Coast Guard district as non-voting members. These non-voting members are present to coordinate with inshore or inland fisheries management, as well as cross agency enforcement efforts. As an example, Idaho is included in the Pacific council because salmon runs end in Idaho's tributaries and rivers. The federal management in Idaho is led by US Fish and Wildlife, as they have jurisdiction over Federally regulated freshwater fisheries, included salmon recovery efforts.

Aside from these overarching requirements, it is up to the states to nominate people to serve the additional spaces, and up to the Secretary of Commerce to appoint them. This has the potential to lead to political differences when governors are from different parties, and when states have differing priorities in balancing commercial, recreational, and natural uses and users. Each RFMC has the ability to appoint advisory councils on the subjects they wish, and appoint whomever they wish to staff the discretionary advisory councils. All of the RFMCs have a requisite scientific advisory council, and it must be filled by "Federal employees, State employees, academicians, or independent experts and shall have strong scientific or technical

credentials and experience" (16 USC §1852(g)(1)(C)). There is also a required fishing industry advisory committee, which must consist of seven people who are knowledgeable about the specific fishery being managed. While the RFMC must abide by a general standard not to make arbitrary or capricious decisions, there is no specific standard on how to weigh the advice of the two committees, especially important if they come back to the RFMC with opposing positions on how to manage a fishery (*Chevron U.S.A., Inc. v. Natural Resources Defense Council, Inc.*, 1984).

The result of the leeway in the use of the advisory committees, and some leeway in the makeup of the actual councils, may provide for differing EBFM implementation results between regions. These differences may be institutional, or they may be due to the availability of data in a certain region, which is beyond the scope of this paper. By analyzing the institutional differences between RFMCs, it may be possible to identify how and why progress has been faster in some regions than others regarding EBFM implementation.

The RFMCs each have a staff that can support the members and committees, and each council also has the support of regional fishery science centers (FSCs). The FSCs are part of the National Marine Fishery Service (NMFS), and consist primarily of scientists who provide stock assessments to the RFMCs. Stock assessments contain all of the information necessary to create an FMP, and are essential components of EBFM. This is where any information about a stock's

ecosystem can enter into the management system. In theory, the FSCs should be able to utilize ecosystem models that are appearing in the literature. However, the reality can be different, and is dependent upon the region. In some cases, multiple regions share one FSC, and one region can have multiple FSCs. Where there are eight councils, there are six FSCs. Alaska and the Western Pacific have dedicated FSCs, the Pacific Council has the support of two FSCs, the Gulf Coast, South Atlantic, and Caribbean councils all share one FSC, and the New England and Mid-Atlantic share one FSC. Unfortunately it is difficult to examine whether the number of FSC staff available to work on a particular management plan varies from region to region, as this would be the best metric to determine the extent to which the difference in FSCs creates barriers. However, the fact that the Northeast FSC is responsible for 17 stocks, while the Pacific Council has two FSCs to mange 5 stocks, may point to possible barriers due to time and personnel.

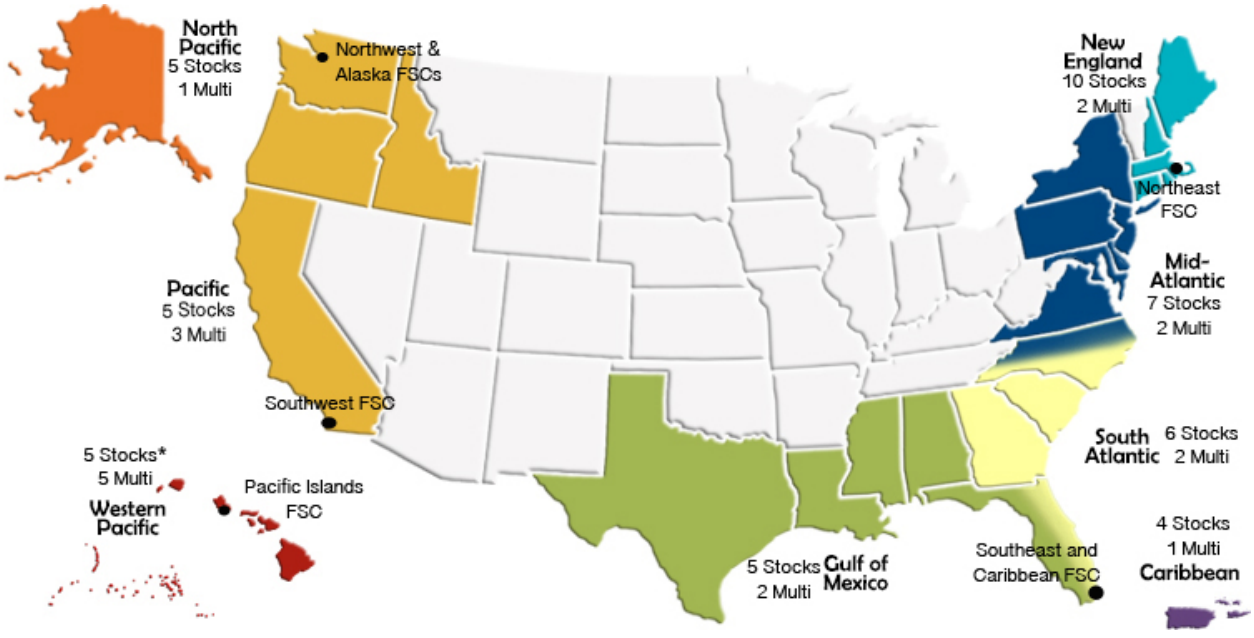

Fig. 1: The 8 regional councils and the location of the headquarters for each FSC. Each council is annotated with the total number of stocks that are managed, as well as the number of multispecies stocks, a component of EBFM. *The WPFMC moved to all FEPs, but based on geography rather than species for 4 plans, and a single pelagic FEP. (Base map from NOAA)

RFMC differences that may affect EBFM outcomes can be split into several categories. There are wider scale regional differences that may not be specific to fisheries management, but impact attitudes across a wide spectrum of topics, including attitudes regarding management and government. There are differences in how the RFMCs are set up through legislation, such as how the region is defined and how many states and fisheries are involved. Finally, there is an issue of institutional momentum, which is affected by the differences, but different types of momentum also feedback into EBFM outcomes.

In general, the three pacific regions have been quicker to embrace EBFM than the Atlantic regions. The Western Pacific changed from an FMP system, to an FEP system, with plans for each island group, plus one plan for pelagic stocks. As mentioned earlier, the North Pacific Council implemented an ecosystem committee in 1996 to review plans and provide a source of information on ecosystem impacts, though the nature of the federally managed fisheries has limited multispecies plans to only the groundfish fishery. The Pacific Council has a majority of its plans managed as multispecies complexes, the only council other than the Western Pacific to have that much. Multispecies management is a cornerstone of EBFM, and in

looking at the federally managed stocks, nine of the fifteen (60%) stocks in the three Pacific councils were managed as multispecies complexes. This can be compared to the Atlantic, Gulf, and Caribbean, where there are also nine stocks managed as multispecies complexes, but it is out of thirty-two total managed fisheries.

The Western Pacific Council (WPFMC) has arguably done the most to embrace EBFM, as they have transitioned away from fishery management plans to fishery ecosystem plans (FEPs), as allowed by the 2007 MSA reauthorization. The WPFMC is unusual in that tuna dominates commercial fishing in the region. The balance of the fishing industry is small scale, near shore, and reef fishing, as well as recreational fishing in some areas, like Hawai'i. The tuna fishery is primarily managed by intergovernmental tuna organizations, which operate by treaty, so the WPFMC only has the ability to distribute a preset quota. The rest of the fisheries do not target specific species, and so it makes a certain amount of sense to manage stocks at an ecosystem level. This can be particularly useful for reef fisheries, or subsistence fisheries, where the commercial value is far less important than the nutritional value. As good as the WPFMC looks, the FEPs are not very different from the FMPs used previously since FMPs were also based primarily on geography. None of the other councils share the geographic area, or the limited types of fishing that the WPFMC has. The Caribbean council is in some ways the most similar, but it lacks a major commercial fishery, and the proximity of other nations' waters may

reduce the perceived importance of EBFM. The Caribbean is dominated by small-scale reef fishing, with very little commercial fishing exported beyond the island the fish are caught at.

The remaining Atlantic and Gulf of Mexico councils are some of the most regionally diverse, and have fisheries and habitat that span up to three councils. The large numbers of stakeholders can make consensus more difficult, and it only takes one unhappy stakeholder to disrupt management change through litigation. New England in particular has a reputation for council meetings that resemble town halls, with more arguing and back and forth discussions than other councils. This is partially a product of regional attitudes, and may also reflect the entrenched nature of the fishing industry. Commercial fishing has been taking place in New England since the first colonies were established, and the fishers in that region seem to be more wary of management than in other areas. New England fishers have a well established record of fighting both scientists and managers (Hartley and Robertson, 2006). There has been mismanagement, like with groundfish, which has certainly not helped the relationship, but changes to MSA seem to reflect problems and lawsuits that have occurred in New England, more-so than other councils (Hartley and Robertson, 2006).

The number of states present in each council is a potential barrier, as the WPFMC and NPFMC have fewer states or territories that need to agree on plans. There are fewer issues with jurisdiction, and reduced territorial pressures so that the council can issue FMPs without

worrying about disagreements between fishers from different states. However, this decreased competition may also result in underutilized resources compared to more competitive regions, which could be contrary to the economic and social goals of the National Standards, and also the notion of humans as part of the ecosystem.

Regions also have different relationships between the three primary groups in fisheries management, which are fishers, managers, and scientists. There are examples of every combination of cooperation and opposition between those three groups. Additionally, states will also interject themselves into management decisions as parties in lawsuits in which they think the national management is counter to a state's objectives. When attempting to implement EBFM, it may not be clear who will oppose certain policies, or even why policies might be opposed. This uncertainty disincentivizes changes in management and adoption of new techniques or styles.

The final reason that the regions may enable or hinder EBFM implementation is institutional momentum. Institutional momentum is the idea that institutional structures lead to certain processes, and making changes can be difficult because people work within the institution in a certain way. This can either enable EBFM implementation, or hinder it, depending on how the region is structured, how priorities are made, and how the council proceeds with business. All of the above regional issues feed into the idea of institutional momentum. The regions that have implemented other changes may be more likely to implement EBFM on a shorter timescale.

Likewise, regions that have resisted changes of any kind, and in which there are entrenched factions, are less likely to embrace new types of management, not because there is anything wrong with the technique, but because changing anything at all is difficult.

Is the threat of Litigation a Barrier to EBFM?

In examining the differences between the councils, one item that stands out is the level of litigation over FMPs and management decisions (Barnea, 2014). While this is not a barrier to EBFM implementation everywhere, the more litigious regions will be slower to adopt management changes that are not inherent to legislation. This may be borne out when examining each region. The Atlantic regions seem to have resisted ecosystem considerations much more than the Pacific regions, and they also seem to have a higher number of legal challenges to changes in management (Issenberg, 2013). Barnea (2014) found that the number of lawsuits dropped as legislation matured, and this may cause managers to stay the course on management and not risk new suits. It is important to note that litigation is not just a threat when the council is sure to win. Every suit, even those in which the councils prevail, must be defended which means scientists and managers will be deposed and must prepare documents for the proceedings. Every hour a manager or fishery scientist is preparing for a court case is an hour they cannot spend on their primary duties. In regions where staff is stretched thin, this has two results. First, managers

may take a conservative approach to new management techniques, and only attempt implementation once there are no other options, or they may get sued for failing to utilize best science. The second result is that even if the managers wanted to implement new techniques, they may be unable to do so because their staff is too busy fighting lawsuits.

Is Jurisdiction a Barrier to EBFM?

An artifact of the United States' fisheries management system is the multiple jurisdictions faced by resource managers. Jurisdictions do not follow or reflect ecosystems, potentially splitting resources between different managers. MSA attempted to relieve some of these issues by placing state managers on RFMCs, as well as provide mechanisms for stocks that are split between two or more councils. This works for managing single species stocks, but is more complicated when multiple species are included, especially non-target species. While MSA is the primary means of managing federal fisheries, there are a few species, like halibut and tunas, which are primarily managed via treaty organization. Bycatch of species managed by a different organization may be a substantial barrier to EBFM, as complete ecosystem data may not be available. This could be due to lack of data, but could also be from differences in recording data that would make analysis difficult.

Anadromous fish offer another problem in that riparian resources and marine resources are not just managed by different agencies, but by agencies in different Departments. EBFM could be a useful tool in salmon recovery because they rely on multiple different ecosystems and services, so that isolating one area for management may be irrelevant to an endangered salmon stock's recovery. The lack of EBFM has even caused problems in recovery efforts because judges tasked with enforcing recovery do not seem to understand how different aspects of different ecosystems relate to overall stock health and biomass (*National Wildlife Federation v. NMFS,* 2016). In this case the judge rejected biologic opinion, in part, because it failed to find that regulating the flow of water through dams on the Columbia River would be an effective recovery tool for endangered salmon populations. This case also illustrates how unsuited the system may be to recovery in a complex system because dams are highly regulated and operations can be changed based on a court order. Recovery through habitat restoration is much more complicated as it would require the cooperation of many public and private entities, and could adversely impact many sectors. Both of these fixes may be entirely moot if oceanic or atmospheric conditions are responsible for low salmon returns. In 2015 returns to spawning areas were low due to high water temperatures above the dams, which was due to very low snow melt and higher than average air temperatures that year (DeHart, 2015).

Management is also limited by the fact that jurisdiction only extends out 200 NM from the coasts, even though the ecosystems observe no boundaries. This can be seen in NOAA's own documents, which look at "Large Marine Ecosystems," which are sometimes bounded by RFMC jurisdictions, but seem to universally extend beyond the 200 NM EEZ. In some of these areas, there is little fishing pressure, but in others, like in the Western Pacific, ecosystem management will ultimately rely on other countries' management success, and support and adherence to international treaties regarding pelagic fish like tunas.

Funding

If lack of time, personnel, and science are barriers to EBFM, then budgetary constraints are partly to blame. Time and personnel are really the same problem, as they both come down to the number of hours someone is working on a given project. Increasing the budget allows more people to be brought in, which in turn makes it easier to overcome these barriers. Similarly, at least some of the scientific barriers can be overcome with more people working on collecting data and creating models.

Virtually everyone I spoke to who worked in the management process talked about how little time they had to get things done for the next meeting or report. This included three directors of RFMCs, 2 RFMC staff members, multiple RFMC members, multiple past and current SSC

members, and three or four scientists who worked at FSCs. While some of that is just due to when deadlines are, and the nature of quarterly meetings, for some it may indicate room for additional people to work on implementing new management techniques, such as EBFM. This is particularly true for the FSCs, where all of the science for fishery plans comes from.

The budget for fisheries management has been increasing since the budget sequestration in 2014, and the proposed budget for 2017 is larger than 2016. Included in the proposed budget are substantial increases for Protected Resource Science and management, and Fisheries Science and Management, both of which could encompass EBFM implementation. NOAA Fisheries specifically requests almost $6 million for "ecosystem solutions for fisheries management" which will be used to improve understanding of ecosystems, and also how coastal communities interact with ecosystems (NOAA, 2016b).

Future Potential Laws and Regulations and How They May Impact Implementation

The MSA is currently being considered for reauthorization and amendments, and HR 1335 passed on June 1, 2015 on a party line vote. (Roll Call 267) The bill, titled "Strengthening Fishing Communities and Increasing Flexibility in Fisheries Management Act" seeks to change a number of key provisions of previous versions of the law. Of these, two are of particular interest

as potential institutional barriers if the Senate as passes this bill written. The first provision, Flexibility in Rebuilding Fish Stocks, amends Section 304 of MSA (16 USC 1854(e)). This section eliminates the requirement that stocks are rebuilt within 10 years under the auspices of biological differences among species. The second section that has the potential to impact institutional barriers is Section 303, Fishery Impact Statements (16 USC 1853). This section contains explicit requirements for impact statements any time a fishery management plan is amended.

At first glance, the amendments to Section 304 appear to be designed to allow managers to take different life-cycles into account when designing plans to rebuild overfished and depleted fisheries. The current law requires all rebuilding plans have a maximum recovery time of 10 years, and be as short as possible (16 USC 1854(e)(4)). The 10 year limit appeared in the 1996 reauthorization, and includes provision for extending the rebuilding time if necessary for biological reasons. While there has been substantial success 20 years later, there are still eight stocks that are subject to overfishing, and are not rebuilding (NOAA 2015). It should be noted that all of the stocks that are subject to overfishing are in the Atlantic, and the New England FMC manages all but two. An attempt to remove the 10 year limit could potentially have the effect of stretching out the recovery times longer than they need to be, by citing biological issues. If this were to pass, increased research into changes in recruitment or mortality due to ecosystem

changes may be challenged. As New England has a history of challenging changes to management, this is most likely to impact EBFM implementation in that council specifically, though it may lead to reduced ecosystem research in other councils as well.

Section 303 is the more troubling section, in regards to EBFM implementation. Again, this section appears to encourage increased data collection, and improve management by forcing managers to consider more variables when crafting FMPs, and would create new alternative rules from the National Environmental Policy Act (OMB, 2015). The results of the amendments to the FMP process would be to effectively freeze any and all changes, and would result in severe delays in any change to an FMP. Environmental impact statements have historically been one of the most litigated areas in all of environmental law, and requiring a specific impact statement for all changes to FMPs would effectively stop adaptive management. The legal process can take years, and in the interim, there is a possibility that managers would be forced to revert FMPs to the last approved version, as irreparable harm to the interests of fishers may result in new management plans.

Overall, the current legislation does not appear to be much of a barrier to EBFM, to the contrary, the language in the legislation would seem to encourage ecosystem considerations. However, some major hurdles would be erected if the proposed amendments to MSA are

enacted. Since the House passed this bill in June 2015, the Senate has taken no action on it, and it never received a floor vote.

From a regulatory standpoint, there is a proposed rule to change the definition of OY in NS1. As of June 2016, NOAA is reviewing comments from the initial proposal, but has yet to issue a final rule. The proposed rule has few portions that could impact EBFM implementation. First, RFMCs will need to review FMPs periodically to determine whether the objectives of the fishery have changed. This is a major departure for some regions, as there are some FMPs that have never been fully reviewed in decades. Instead, regions will amend FMPs with new rules but will not touch the overall objectives. This could encourage EBFM by incentivizing ecosystem research to aid in updating FMPs. By combining fisheries that have strong trophic connections, science can be reviewed once, and plans can be put forward more efficiently.

The second proposed change speaks directly to the ecosystem. The rule would require any stock that might need conservation and management to have an FMP, as opposed to the current rule which only requires plans for stocks that are being fished. While the exact wording of this is likely to change after the comment period, this rule would be very helpful in EBFM implementation if it survives. By looking at stocks that are impacted by fishing or changing environmental conditions, whether or not they are actively fished, the regions will need to take a more holistic view of management. It could also require reducing catch limits on target species

due to ecosystem concerns. This is novel in that it bypasses multi-stock fishery plans, but still may get the same ecosystem results through single species management.

The third proposed change makes it easier to create stock complexes by removing the requirement that species are sufficiently similar to manage as a unit. Instead, it will allow species that may share a specific vulnerability to be grouped together, even if they have very little in common. Here again, this rule should encourage EBFM by making it easier to implement multi-species management for fisheries that may not have been sufficiently similar to other fisheries in the same region. The next proposed change is related in that it also changes how multi-species stocks are managed. The rule would allow aggregate MSY calculations for a multi-species stock, as opposed to species level MSY calculations. This is an important piece of EBFM implementation for certain stocks like forage fish and groundfish. For forage fish, the exact species being caught may be less important than the total amount of forage fish caught in a region. Aggregate MSY will also make it easier to adapt a plan to the natural variation in species levels for fish like sardines and anchovies. For groundfish, this is useful because it allows for the recognition that species level management can result in suppressed economic and social benefits, without corresponding ecological gains. Groundfish complexes are often limited by certain species at a regional level, even though abundance may vary considerably over the entire range. As long as protections are in place to protect species that require conservation, an aggregate

MSY approach should allow some fisheries to see increased catch rates without resulting in overfishing.

There are a number of proposed changes to how overfishing and overfished are defined, including the addition of the term depleted. This would allow consideration of environmental factors in determining how quickly a stock can be rebuilt, even when there is not, and has not been any fishing pressure. The definition of overfishing would be amended to allow for a multi-year approach. Overfishing is currently considered on an annual basis, and if the catch reaches a certain point, overfishing has occurred. The new approach would allow overfishing to be avoided if there is no impact to long-term productivity given fishing pressures on a 1-3 year time-scale. In terms of EBFM, this recognizes that different species have different sensitivities to overfishing on an annual basis, and will potentially help with economic outcomes for some fisheries.

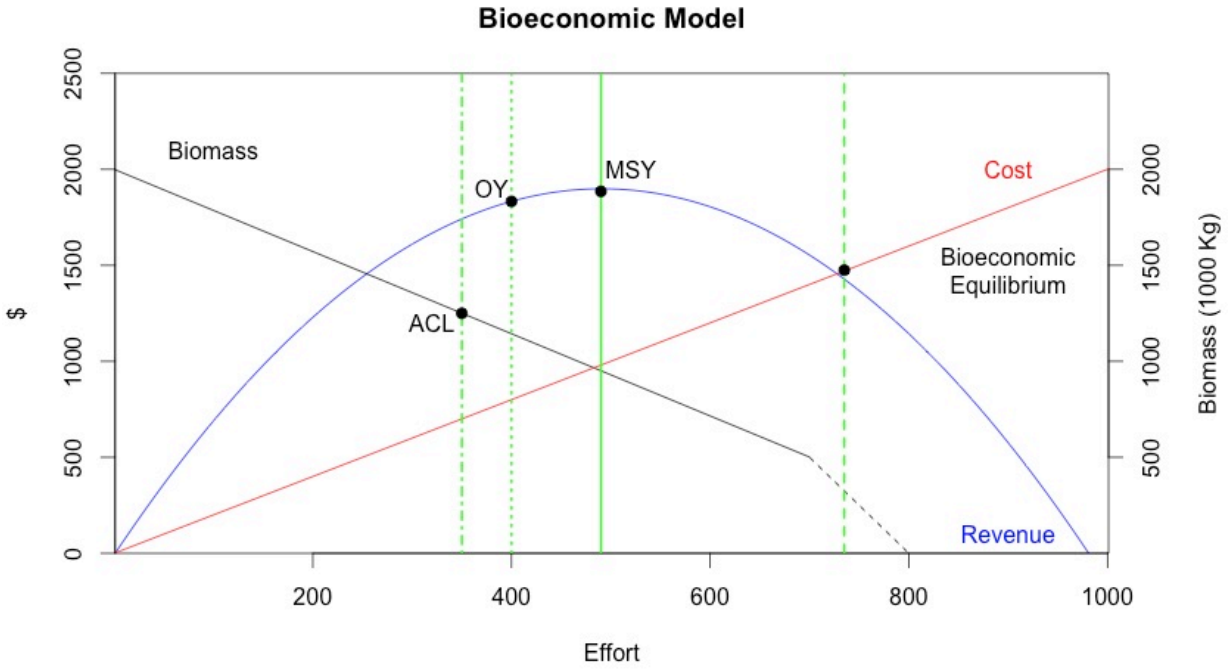

Figure 2. Simplified Bioeconomic Model used for fisheries management. Numbers are arbitrary. MSY is the point at which revenue is highest while still having enough biomass to repopulate each year. OY is optimum yield, which must be to the left of MSY, with lower revenue, and higher biomass levels. The actual catch must be further to the left still, providing a margin of error for imprecision, lower biomass than expected, or fishing beyond the ACL. Bioeconomic equilibrium is the point at which fishing effort will occur if there is no management.

The final pieces of the proposed rule that impact EBFM implementation are changes to the way OY is defined and implemented. The primary change to OY calculation is the inclusion of qualitative economic, social, and ecological factors, where only quantitative values are allowed under the current system. Some of these factors can be very hard to specifically quantify, either due to the social nature of the information, or uncertainty due to lack of data, or a wide range of possibilities. For example, this change to OY could allow impacts to a small

community of local fishers be considered, even where no one has spent the time or money to find the exact monetary value of that small fishery.

In May 2016 NOAA released a new EBFM Road Map, that outlines the various efforts that have been made in the past, and how they can be built upon. The road map is primarily a guide for the regional councils, and it does not suggest specific steps to take. It breaks up goals based on the time frame of implementation, which will hopefully build momentum for increased implementation.

The road map is aided by the 2016-2017 budget request that asks for money to be used for ecosystem science (NOAA, 2016b). While these have to be approved by congress, the increased budget for EBFM makes it more likely that implementation will occur. Increased funding may also aid in decreasing some of the scientific barriers, by providing more money for research, and potentially more scientists that can work on collecting ecosystem data, as well as working on improved models that can make use of ecosystem considerations and still be useful for calculating OY. The justification for the increased budget is for improved fisheries and protected species management (NOAA, 2016b).

Policy vs. Law

From speaking to managers in an informal setting, it became clear that some confusion exists between legal barriers and policy barriers. In particular, the ability to change the details of National Standards via regulation was considered a legal barrier to EBFM implementation. It is important to distinguish between changes that can only be made by legislative action, or court intervention, and changes that can be made through executive action alone. While the proposed amendments to MSA would constitute a potential legal barrier to EBFM, the complaints about NS1 represent a policy barrier. While the effect of both legislation and regulation on RFMCs and NMFS represent potentially real barriers to EBFM, the mechanisms for removing those barriers are drastically different, especially considering the political climate in 2016. When an agency can unilaterally propose a rule change that would alter barriers to EBFM implementation, that is a policy decision from the executive branch. While it may be possible to fight proposed changes in court, courts do tend to allow substantial agency discretion in rulemaking, provided the agency has complied with the *Chevron* standard (Easterbrook, 2004). Agencies are likely to win when only changing how details are defined, or what criteria the agency wants managers to consider, unless there is a failure to follow the agency's own standards under the law at issue or another law (Administrative Procedures Act or NEPA), discriminatory action, or lack of due process.

Summary of Barriers

Regional differences and institutional momentum have the greatest impact on raising or lowering institutional barriers. Given the wide range of implementation, regulatory and legislative impacts cannot be very important barriers because every region is operating under the same laws and regulations. To the contrary, the legislation appears to have done a good job in some regions in encouraging EBFM implementation. Regulations have likewise not hindered EBFM implementation overall. The only difference is how they are applied, which comes down the differences between regions. Institutional momentum is likely responsible for some of the divergence between regions over time, and likely results from regional differences in attitude, litigation levels, and personnel constraints. Funding is likely responsible for some of the relatively slow movement on EBFM overall. Jurisdictional problems may play a role for certain fisheries, but overall there does not seem to be much interregional friction for straddling stocks or highly migratory species.

Conclusion

EBFM is a relatively old idea that has yet to come to fruition. Over the past 20 years many elements have been introduced, but the majority of fisheries are still managed as single species, and do not utilize physical oceanographic factors or predator-prey relationships. Every

management plan has to consider economic and social impacts, but the way NS1 has been interpreted has meant that these standards are less important than stock levels and calculating catch limits based on biological factors. The Magnuson-Stevens Act has consistently included language that encourages elements of EBFM, from stakeholder inputs, to essential habitat provisions, to language specifically on ecosystem considerations. The regional differences in implementation highlight how EBFM has been constrained at a regional level, and not at the national level. Proposed changes in regulations may help lower some of the remaining regional arguments against EBFM, and increased funding will provide more people to help with the science of EBFM. The science of EBFM may be the largest barrier moving forward, as data poor fisheries will make implementation difficult, and stock assessment models are not robust enough to utilize ecological inputs to provide a useful annual catch level.

NOAA is making an effort to reduce the current barriers through the new road map, proposals for increased funding, and reports that have highlighted how NOAA Fisheries is working to implement EBFM. It remains to be seen whether the funding will actually continue to increase, and whether the proposed changes to regulation are effective in practice. Equally important will be whether the language in the 2015 MSA amendment is passed or makes it into any future legislation. EBFM looks like it will become an increasingly popular tool that will help manage fisheries in an uncertain future. As ocean conditions change due to climate change it will

become more important to take a holistic look at marine ecosystems to ensure sustainable stocks of target species, as well as sustainable livelihoods for fishers.

Bibliography

50 C.F.R. § 200-299 (2016)

50 C.F.R. § 600-699 (2016)

Abbott, J.K., Garber-Yonts, B., Wilen, J.E., 2010. Employment and Remuneration Effects of IFQs in the Bering Sea/Aleutian Islands Crab Fisheries. Mar. Resour. Econ. 25, 333–354. doi:10.5950/0738-1360-25.4.333

Allen, C.H., 2014. International Law for Seagoing Officers, 6th ed. Naval Institute Press, Annapolis.

Barnea, R., 2014. Fisheries from the Bench or Business as Usual? The National Marine Fisheries Service and Federal Courts since 2000. Masters Thesis. University of Washington.

Brodziak, J., Link, J., 2002. Ecosystem-based fisheries management: what is it and how can we do it? Bull. Mar. Sci. 70, 589–611. doi:c:\docs\qual

Chevron U.S.A., Inc. v. Natural Resources Defense Council, Inc., 467 U.S. 837. 1984.

Christie, P., 2004. Marine Protected Areas as Biological Successes and Social Failures in Southeast Asia. Am. Fish. Soc. 42, 155–164.

DeHart, M., 2015. Fish Passage Center, Columbia Basin Fishery Agencies and Tribes.

Easterbrook, F.H., 2004. Judicial Discretion in Statutory Interpretation. Oklahoma Law Rev. 57.

Fishery Conservation and Management Act of 1976. Pub. L. No. 94-265. 90 Stat. 331. 1976

Fluharty, D., Aparicio, P., Blackburn, C., Boehlert, G., Coleman, F., Conkling, P., Costanza, R., Dayton, P., Francis, R., Hanan, D., Hinman, K., Houde, E., Kitchell, J., Langton, R., Lubchenco, J., Mangel, M., Nelson, R., O'Connell, V., Orbach, M., Sissenwine, M., Cyr, N., Detlor, D., Morgan, A., 1998. Ecosystem - Based Fishery Management, National Marine Fisheries Service Ecosystem Principles Advisory Panel.

Francis, R.C., Hixon, M.A., Clarke, E., 2007. PERSPECTIVE: FISHERIES MANAGEMENT Ten Commandments for Ecosystem-Based Fisheries Scientists Diez preceptos para científi cos pesqueros que aplican el enfoque ecosistémico RESUMEN: Tratando de acelerar el cambio entre los paradigmas de manejo 32.

Hartley, T.W., Robertson, R.A., 2006. Emergence of multi-stakeholder-driven cooperative research in the Northwest Atlantic: The case of the Northeast Consortium. Mar. Policy 30,

580–592. doi:10.1016/j.marpol.2005.09.006

Hilborn, R., 2007. Defining success in fisheries and conflicts in objectives. Mar. Policy 31, 153–158. doi:10.1016/j.marpol.2006.05.014

Issenberg, A., 2013. Fisheries Litigation Update.

Jentoft, S., McCay, B.J., Wilson, D.C., 1998. Social theory and fisheries co-management. Mar. Policy 22, 423–436. doi:10.1016/S0308-597X(97)00040-7

Levin, P.S., Fogarty, M.J., Murawski, S.A., Fluharty, D., 2009. Integrated ecosystem assessments: Developing the scientific basis for ecosystem-based management of the ocean. PLoS Biol. 7. doi:10.1371/journal.pbio.1000014

Link, J.J.S., 2002. What does ecosystem-based fisheries management mean? Fish. 27, 18–21.

Link, J.S., Browman, H.I., 2014. Integrating what? Levels of marine ecosystem-based assessment and management. ICES J. Mar. Sci. 71, 1170–1173. doi:10.1093/icesjms/fsu026

Link, J.S., Bundy, A., Overholtz, W.J., Shackell, N., Manderson, J., Duplisea, D., Hare, J., Koen-Alonso, M., Friedland, K.D., 2011. Ecosystem-based fisheries management in the Northwest Atlantic. Fish Fish. 12, 152–170. doi:10.1111/j.1467-2979.2011.00411.x

Link, J.S., Fulton, E.A., Gamble, R.J., 2010. The northeast US application of ATLANTIS: A full system model exploring marine ecosystem dynamics in a living marine resource management context. Prog. Oceanogr. 87, 214–234. doi:10.1016/j.pocean.2010.09.020

Link, J.S., Ihde, T.F., Townsend, H.M., Osgood, K.E., Schirripa, M.J., Kobayashi, D.R., Gaichas, S., Field, J.C., Levin, P.S., Aydin, K.Y., Harvey, C.J., 2010. Report of the 2nd National Ecosystem Modeling Workshop (NEMoW II); Bridging the Credibility Gap - Dealing with Uncertainty in Ecosystem Models, NOAA Tech. Mem. NMFS-F/SPO-102.

Macpherson, M., 2001. Integrating Ecosystem Management Approaches into Federal Fishery Management through the Magnuson-Stevens Fishery Conservation and Management Act. Ocean Coast. Law J. 6, 1–32.

Magnuson-Stevens Fishery Conservation and Management Act. 18 U.S.C. § 1801 (2007).

National Wildlife Federation, et al., v. NMFS, et al., No. 3:01-CV-00640-SI, 2016 WL 2353647 (D. Or. May 4, 2016).

NOAA, 2015. Fish Stocks in Rebuilding Plans: A Trend Analysis.

NOAA, 2016a. Draft Ecosystem-based Fisheries Management Road Map.

NOAA, 2016b. Budget Summary.

Office of Management and Budget, 2015. Statement of Administration Policy: HR 1335 - Strengthening Fishing Communities and Increasing Flexibility in Fisheries Management Act.

Pace, N., 2016. Fisheries management in the Gulf: Who's regulating what? [WWW Document]. Mississippi-Alabama Sea Grant Consort. Staff Blog. URL http://masgc.org/news/article/fisheries-management-in-the-gulf-whos-regulating-what (accessed 9.8.16).

Patrick, W.S., Link, J.S., 2015. Myths that Continue to Impede Progress in Ecosystem-Based Fisheries Management. Fisheries 40, 155–160. doi:10.1080/03632415.2015.1024308

Pikitch, E.K., Rountos, K.J., Essington, T.E., Santora, C., Pauly, D., Watson, R., Sumaila, U.R., Boersma, P.D., Boyd, I.L., Conover, D.O., Cury, P., Heppell, S.S., Houde, E.D., Mangel, M., Plag??nyi, ??va, Sainsbury, K., Steneck, R.S., Geers, T.M., Gownaris, N., Munch, S.B., 2014. The global contribution of forage fish to marine fisheries and ecosystems. Fish Fish. 15, 43–64. doi:10.1111/faf.12004

Pikitch, E.K., Santora, C., Babcock, E. a, Bakun, a, Bonfil, R., Conover, D.O., Dayton, P., Doukakis, P., Fluharty, D., Heneman, B., Houde, E.D., Link, J., 2004. Ecosystem-Based Fishery Management. Science (80-.). 300, 2003–2003. doi:10.1126/science.1106929

Pitcher, T.J., Kalikoski, D., Short, K., Varkey, D., Pramod, G., 2009. An evaluation of progress in implementing ecosystem-based management of fisheries in 33 countries. Mar. Policy 33, 223–232. doi:10.1016/j.marpol.2008.06.002

Raakjær Nielsen, J., 2003. An analytical framework for studying: Compliance and legitimacy in fisheries management. Mar. Policy 27, 425–432. doi:10.1016/S0308-597X(03)00022-8

Rosenberg, A., Bigford, T.E., Leathery, S., Hill, R.L., Bickers, K., 2000. Ecosystem approaches to fishery management through essential fish habitat. Bull. Mar. Sci. 66, 535–542.

Rosenberg, A.A., Swasey, J.H., Bowman, M., 2006. Rebuilding US fisheries: Progress and problems. Front. Ecol. Environ. 4, 303–308. doi:10.1890/1540-9295(2006)4[303:RUFPAP]2.0.CO;2

Sainsbury, K., Sumaila, U.R., 2003. Incorporating Ecosystem Objeectives Into Management of Sustainable Marine Fisheries, Including "Best Practice" Reference Points. Conf.

Responsible Fish. Mar. Ecosyst. 343–361. doi:10.1079/9780851996332.0343

Sullivan, P.J., Acheson, J., Angermeier, P.L., Faast, T., Flemma, J., Jones, C.M., Knudsen, E.E., Minello, T.J., Secor, D.H., Wunderlich, R., Zanetell, B.A., 2006. Defining and implementing Best Available Science for fisheries and environmental science, policy, and management. Fisheries 31, 460–465.

Sustainable Fisheries Act. Pub. L. No. 104-297. 110 Stat. 3559. 1996.

Townsend, H., 2016. Ecosystem Science Program Review: Ecosystem Modeling.

Worm, B., Hilborn, R., Baum, J.K., Branch, T. a, Collie, J.S., Costello, C., Fogarty, M.J., Fulton, E. a, Hutchings, J. a, Jennings, S., Jensen, O.P., Lotze, H.K., Mace, P.M., McClanahan, T.R., Minto, C., Palumbi, S.R., Parma, A.M., Ricard, D., Rosenberg, A. a, Watson, R., Zeller, D., 2009. Rebuilding global fisheries. Science 325, 578–585. doi:10.1126/science.1173146