White Paper

On

Ecosystem – Based Fishery Management

For

New England Fishery Management Council

Prepared by

Scientific and Statistical Committee
NEFMC

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TABLE OF CONTENTS

INTRODUCTION

In late 2008, the Scientific and Statistical Committee (SSC) of the New England Fishery Management Council (NEFMC) was informed of the Council's desire to have an Ecosystem–Based Fisheries Management (EBFM) Plan developed and implemented over the next three – five years. This White Paper provides provide a conceptual framework for moving toward EBFM in the Northeast Region. It was prepared based upon discussions held at a 2009 workshop (SSC, 2010) as well as discussions both within the SSC and between it and the Council.

NEED FOR ECOSYSTEM – BASED FISHERIES MANAGEMENT

Over the past 20 year or so, it has become increasingly evident throughout the world that fisheries management focused on single stocks in isolation of the broader ecosystem has been one of the factors leading to resource declines and damaged ecosystems with negative repercussions for fishing participants and communities. Single species management, despite its best intentions, has fostered the entrenchment of single species interests at the expense of broader practices that utilize and relate to the marine environment. Significant efforts have been made to include ecosystem considerations within single species management but these have generally been grafted onto existing management plans to address specific issues, leading to an increasingly complex and often unwieldy management system. This trend has motivated EBFM efforts to both address the broader ecosystem implications of fisheries and to be more flexible and adaptive to the ongoing needs of management.

Since the 1990s, the US has undertaken a number of initiatives and developed legislation in support of EBFM. Pursuant to the Oceans Act (2000), the Commission on Ocean Policy was established. In its 2004 report, the Commission recommended that:

> "*U.S. ocean and coastal resources should be managed to reflect the relationships among all ecosystem components, including human and nonhuman species and the environments in which they live. Applying this principle will require defining relevant geographic management areas based on ecosystem, rather than political, boundaries.*"

Species-focused management would be replaced or supplemented by governance systems that better connect human activities to defined ecological regions. The Commission further identified the need to understand the important relationships among parts of the system and how these respond to environmental factors. Finally, the Commission highlighted the need to understand the ways in which humans both influence and are affected by changes in the ecosystem.

Concurrently, the Pew Charitable Trusts established the Pew Oceans Commission, which released its report in 2003. The two reports contained similar recommendations and to unify their efforts, the members of the two Commissions came together in 2005 as the Joint Ocean Commission Initiative. In 2006, the Joint Initiative released a national ocean policy action plan for Congress, in which it identified priority areas including 1) enacting legislation to create incentives for EBFM and 2) reauthorizing an improved Magnuson – Stevens Fishery Conservation and Management Act (MSA) to rely more strongly on science to guide management actions for the long-term sustainability of U.S. fisheries. The MSA, along with the *National Environmental Policy Act* (*NEPA*), the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA) and the Coastal Zone Management Act (CZMA) now require resource managers to take account of the impacts of human activities on the ecosystem, as well as the impact of management on fishing participants and communities. The MSA specifically requires the councils to minimize the adverse impacts of fishing on essential fish habitat.

Most recently, in July 2010, the first national policy on the stewardship of the ocean, coasts and Great Lakes was established by an Executive Order. This policy lays out nine national priority objectives, one of which is the adoption of ecosystem-based management (EBM). EBM considers the many uses of the ocean beyond fishing, such as recreation, telecommunications, oil and mineral exploration and so on, and will require legislative and institutional changes beyond the mandate and ability of the regional fishery councils. Ultimately, EBFM initiatives by the councils will become a key component of regional EBM.

While having a sound legislative basis for EBFM is important, but it cannot be over-emphasized that there are genuine and significant benefits for the Council, stakeholders and fisheries governance generally to move to an EBFM, including:

- The potential for simplification of management structures with associated cost savings in moving from a system with a large number of species/stock-based management plans to one with a smaller number of integrated plans for ecological units defined by location
- More effective coordination of management actions for fishery management, protected resource species, biodiversity and habitat protection
- Comprehensive consideration of the effects of fishery interactions (e.g. bycatch in different fleet sectors and predator-prey processes) within ecological units, as well as consideration of the effects of fishing on biodiversity and coastal communities
- Consideration of the biological constraints on simultaneous rebuilding stocks to long-term target levels and evaluation of whether or not stock – specific recovery plans are compatible
- Consideration of the effects of environmental/climate-related change on productivity and biological reference points, as well as the consequences of these for fishing operations, and
- Increased stewardship and associated benefits from broader participation, as well as opportunities to enhance place-based governance and greater sharing of ecological and fisheries knowledge by invested participants

Currently, the NEFMC has lead or shared authority for nine fishery management plans. Of these, six are single-species plans and the remaining three include multiple species (although interactions among the species are not directly considered). The Northeast Multispecies (Groundfish) plan covers 13 species (and a total of 20 stocks) while the Small Mesh Fishery Management Plan includes three hake species. The Skate Fishery Management Plan covers seven species. Adopting EBFM would substantially consolidate the number of individual fishery management plans administered by the Council and would facilitate consideration of important interactions among species and fisheries now under separate management plans. To the extent that fishery interactions and climate change effects are important but not directly taken into account in current management, issues such as the simultaneous rebuilding of stocks and the choice of long term target levels remain in question. Adoption of EBFM would allow these issues to be addressed within an integrated framework.

The Council is not alone in its desire to move towards an EBFM. Several forms of EBFM have been implemented in other regions of the world and are being pursued by the other fisheries management councils. Most efforts are in their initial stages, highlighting the need for and benefit of on-going dialogue amongst the councils on their EBFM implementation efforts. In particular, it will be important for the NEFMC to be directly involved in parallel EBFM efforts of the MAFMC and the ASMFC as these have implications for shared resources and their management. It will also be important for the Council to learn what can and cannot be achieved using EBFM under the current legislative environment.

It is important for the NEFMC to recognize and be engaged in EBM initiatives in the Northeast Region. A number of the states have or are in the process of drafting EBM plans for their coastal waters. As well, the Northeast Regional Ocean Council (NROC) has drafted a 2010 work plan to develop measures of ecosystem health and facilitate marine spatial planning, a concern that has also led to an Interim Framework for Marine Spatial Planning issued by the White House Council on Environmental Quality. Having an EBFM planning framework will allow the NEFMC to better engage with these related EBM activities.

THE HUMAN DIMENSIONS OF EBFM

Ecosystem-based approaches to management consider humans to be a fundamental part of the ecosystem. This means that humans not only impact the environment, but more broadly interact with it, having both positive and negative effects, and engaging with it on the basis of a diverse suite of sociocultural values and meanings. Many different approaches in the social sciences have studied these human dimensions of the ecosystem, including ecological and environmental anthropology, human geography, environmental history, ecological economics, and so on. Social scientific contributions to EBFM have generally been limited to understanding stakeholder involvement in decision-making, often neglecting understanding of the ways humans more broadly interact with ecosystems (Endter-Wada et al., 1998). The latter could span from macro-level analyses of social, cultural, political, and economic values, behaviors, and trends to micro-level analyses of individual and group attitudes, values, and behaviors. The importance of such analyses lies not only in gauging the acceptance of management or the broadening of management to governance, but of accounting for variability in human resource use, projecting future needs or changes, and assessing the vulnerability and resilience of coastal communities.

The change from single species management to an EBFM will necessitate a change in how the human dimensions to fishing are considered. Social scientific analyses will become critical to evaluating progress towards goals and understanding impacts on fishing participants and communities. The shift to EBFM will also see a greater role for participant involvement in decisions involving trade-offs between fisheries. If the biological inputs to EBFM focus more on the total production constraints on fishing, socially-based decisions will be the primary basis for determining the mix of species fished. This involves not only a greater degree of co-management than has been the case in single species management, but also a shift in philosophy that will require understanding about what people value and why (Wallace et al. 1996) and a more adaptive and flexible connection between management and fishing activities (Clay and Olson 2008).

IMPLEMENTATION PLAN FOR EBFM

Contemplating the move to a very different management system is understandably daunting given the demands and responsibilities that the Council faces in a very challenging management environment. The SSC recognizes the critical role that a well developed implementation plan can play in this process. This plan must acknowledge the on-going requirements of fisheries management while at the same time develop the building blocks for full EBFM. Consequently, the approach advocated by the SSC is to develop elements of a full EBFM strategy to inform current Fisheries Management Plans (FMPs) during a transition period. Developing each element will require full and transparent stakeholder involvement and consideration of the social values of marine resources.

During this transition period, focus will be placed upon:

- Defining Ecosystem Production Units (EPU) which will serve as the basis of EBFM management units
- Identifying issues associated with the ecosystem components of each EPU that require attention under EBFM,
- Defining the EBFM objectives to be achieved for each EPU and the risks of not achieving these
- Designing management strategies to achieve the EBFM objectives and the processes to facilitate consensus
- Developing assessment tools required to monitor progress towards EBFM objectives

Each of these elements is discussed below. Some build upon existing initiatives while some will be new. In all cases, the transition period should be seen as an opportunity to learn by doing and allowing flexibility to adapt as experience grows. During this transition period, a transition strategy will be adopted to achieve the objectives of EBFM. This will lead to a full EBFM strategy. While it is too early to be definitive on what form the latter will ultimately take, an outline of how stock productivity in each EPU may be managed under the full EBFM strategy is provided in the next section.

Ecosystem Production Units

Both current management practices and EBFM involve important spatial considerations – stock structure and distribution for single species management and the identification of ecological regions for EBFM. Spatial considerations also allow governance processes to tie fishing participants and communities to their fishing grounds and resources. A second area of shared importance is the concept of biological production. The production of individual species/stocks is a function of growth, mortality and recruitment. Production of ecological regions starts at the base of the food web and underlies that at the species/stock level. The common currency of space and production serves as a bridge between the current management system and EBFM based on ecologically-defined spatial units.

Research at the Northeast Fisheries Science Center (NEFSC) has focused on defining ecological units based on patterns of depth, bottom type, basic oceanographic conditions related to temperature, salinity, and stratification (layering) of the water column, and conditions at the base of the food web that control the production potential of a region. This work provides an objective definition of ecological regions of the shelf system that can be periodically re-evaluated for environmentally-driven changes in the extent of the individual subsystems (which may become a critical issue in the face of climate change).

The NEFSC analysis has identified four major EPUs (figure 1):

- Western-Central Gulf of Maine (GoM)
- Eastern Gulf of Maine-Scotian Shelf (SS)
- Georges Bank-Nantucket Shoals (GB) and
- Middle-Atlantic Bight (MAB)

Three of these EPUs fall within U.S. waters (the Eastern Gulf of Maine-Scotian Shelf is primarily in Canadian waters) and two of these, the Western-Central Gulf of Maine and Georges Bank-Nantucket shoals are in the area of responsibility of the NEFMC. The analysis also highlights important considerations related to deep water areas at the edge of the continental shelf and to the shallow water regions along the coast. Because immediate coastal regions are subject to a broader spectrum of human interactions and impacts—including coastal development, habitat loss, pollution, recreation and aquaculture - consideration of special areas within adjacent management units may be justified. These subregions would be nested within the broader EPU. Similarly, deeper-water regions at the shelf-slope break are recognized in the analysis as important ecological zones. The regions at the edge of the continental shelf might also be considered as special units of the adjacent continental shelf.

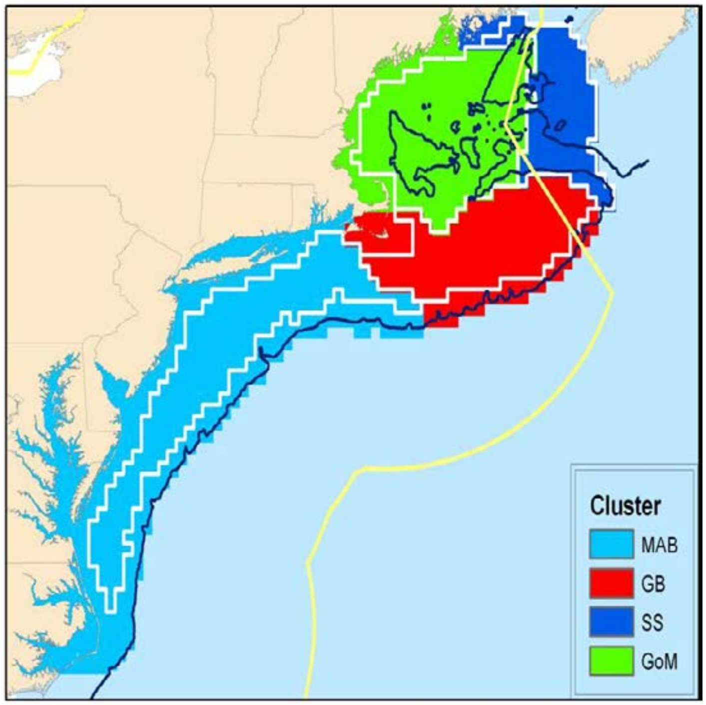

Figure 1. Proposed Ecosystem Production Units for EBFM on the Northeast Continental Shelf including the Middle Atlantic Bight (MAB), Georges Bank-Nantucket Shoals (GB), Gulf of Maine (GOM) and Scotian Shelf (SS); Subareas for special consideration within the MAB and GB regions at the continental shelf break are delineated in white; Subareas for special consideration in coastal waters of the MAB and GOM are demarcated by white border

Identification of boundaries for the EPUs does not imply that these systems are considered closed. They are dynamically linked by oceanographic and ecological factors, including the movement and migratory paths of marine animals which must be taken into account in management plans. As well, these boundaries may change as environmental and ecological conditions change. The intent here is to provide a starting point for discussion by the Council on the definition of EBFM Management Units, the boundaries of which may or may not precisely coincide with the EPUs. As biological stock boundaries are analogous to EPU boundaries, so too are stock management unit boundaries analogous to EBFM Management Unit boundaries. One is based upon biology while the other is based upon the governance needs of management. The latter implies that considerations of fishing patterns and associated factors also influence the selection of EBFM Management Unit boundaries.

If this schema were to be followed, NEFMC might have the lead responsibility for two EPUs while the MAFMC might have the lead responsibility for one EPU. As noted earlier, close interaction and coordination among the New England and Mid-Atlantic Fishery Management Councils and the Atlantic States Marine Fisheries Commission (ASMFC) will be crucial. For instance, the ASMFC would play an important bridging role with their expertise and focus on coastal species in the nearshore zones.

The EPUs can provide the focus of efforts to manage and monitor the cumulative impacts of fishing across fleets and species, as well as better reflect how different groups of fishermen interact with different fisheries. Concerning impacts, for example, the NEFMC is required to summarize the effects of fishing on habitats, conclude whether and how fishing adversely affects EFH, and take steps to mitigate those impacts. The Habitat Plan Development Team (PDT) has completed work on a swept area seabed impact (SASI) model, the analytical tool that will be the basis for evaluating impacts and developing management alternatives. The SASI model might provide an additional metric by which management alternatives are assessed and thresholds or targets for reducing impacts set. The SASI model can be used to define areas that require special protection nested within the EPUs. These efforts can be used to determine and manage the cumulative impacts of fishing on the habitat of each EPU.

Fishing communities are also impacted by and interact with fishery resources within each EPU in ways that extend beyond impacts per se. Evaluation of these interactions will be facilitated through adoption of EPUs.

Objectives and Issues for EBFM

The specification of the objectives for EBFM falls within the purview of the NEFMC. Experience suggests that while agreement on objectives may be difficult, it is essential, especially for the evaluation of the impacts of fishing on the ecosystem, and sociocultural and economic dimensions of the fishing fleets and communities. As well, a process for defining these objectives that includes relevant stakeholders should be considered and defined early in the implementation of EBFM.

The definition of objectives typically starts at the high, conceptual level and then is translated into more specific operational objectives upon consideration of the issues that require priority attention (e.g. Fletcher et al, 2010). High level conceptual conservation objectives typically make broad statements on the need to conserve the productivity, biodiversity and habitat of an ecosystem, often organized in a hierarchy of ecosystem components (see DFO, 2004 for an example). High level socio – economic objectives are also in evidence elsewhere, such as the MSA's National Standard 8's mandate to provide for the sustained participation of fishing dependent communities. Processes instituted to establish objectives and issues might identify one such overarching management goal as:

- *Protect ecosystem structure and function to allow optimal harvest for fishing communities and future generations*

This simple statement recognizes that to protect fisheries and fishing communities and to address other societal needs and values, we need to protect the ecosystems on which these communities depend. Many other alternative formulations of course can, and undoubtedly will, be framed in the discussion of the way forward.

More specific guidance on how to implement such a broad vision statement is required to guide management actions. Experience elsewhere (e.g. Fletcher et al. 2010; DFO, 2007) indicates that this is based upon identification of the ecosystem components in each ecosystem being impacted by fishing and an evaluation of the risk (to stated objectives) that fishing represents. Risk assessment is recognized as a critical step in

EBFM to identify sensitive ecosystem components, for which there are a growing number of tools available (e.g. Fletcher et al, 2005; Hobday et al., 2007).

An example of an operational or tactical management objective associated with the above conceptual objective might be:

- *Optimize yield or economic returns subject to constraints designed to protect ecosystem, social, and economic structures and processes in specified spatial management units*

The choice of optimizing yield or economic returns would potentially lead to very different management strategies, and ultimately the choice would need to be based on a participatory governance process to insure broad reflection of societal and participant values. This is also consistent with Principle 2 for EBM included in the Convention for Biological Diversity (CBD) regarding subsidiarity. This also implies the need for socio-economic analyses, such as surveys or other tools, to monitor and evaluate progress towards these objectives.

It is proposed by the SSC that these objectives be identified during the transition period. The examples above are provided to initiate discussion of possible EBFM objectives. Specification of an EBFM strategy is contingent on the ultimate selection of the set of goals and objectives chosen by the Council. It is also proposed that during the transition period, an evaluation of how current FMPs address priority issues identified during this exercise be undertaken. This would provide a valuable ‘cross-walk’ from existing plans to EBFM and identify to the Council what gaps need to be addressed under the new management approach.

EBFM Management Strategies

Once EBFM objectives have been defined, it is necessary to develop management strategies to achieve the objectives. Without pre-judging what the objectives and priority issues might be, there are some that the current management system is not well configured to address. These relate to the management of the biological and technological interactions amongst the fishery management plans (FMPs).

The importance of considering biological interactions stems from the recognition that changes in the abundance of prey will affect the productivity and harvest potential of predator stocks, and vice versa. Similar considerations hold for species that are competitors. Multi-species models that capture these dynamics can inform management planning by having strategies for either the predator or prey species that partially depend upon the status of the other. Considering these dynamics can have a wide range of implications for management decisions. For example, if the status of multiple prey stocks is determined to be robust, any one might be able to withstand higher harvest rates. On the other hand, high biomass of multiple predator stocks might call for lower harvest of prey stocks to sustain that abundance and maximize ecosystem-wide fishery production. The nature of these predator-prey relationships and resulting management changes could be captured in FMP amendments that, although not applied to all FMPs, would be held in common between those covering the relevant interacting species.

Similarly, technological interactions, notably by-catch, are critically important. Multispecies approaches to managing bycatch and optimizing multiple objectives have been successful in other regions and could be implemented by the Council. A particularly interesting and important example relating interactions among the scallop and yellowtail flounder fisheries is provided in Box 1. This concept can be expanded to include habitat and other ecosystem utilities.

It is important to note that many stock assessment documents for the Northeast region now contain an Ecosystem Considerations section that provides an important ecological context for these assessments in ways that extend traditional stock assessments. In addition, environmental and climate related information is now provided for the region through Ecosystem Status Reports (EcoAP 2009) and web-based Ecosystem Advisory Reports (http://nefsc.noaa.gov/omes/OMES/). Further, the NEFMC had tasked its Interspecies Committee to consider cross-FMP issues and the feasibility of managing species groups (e.g. all demersal fishery resources: groundfish, monkfish, skates). However, it is proposed that a dramatically different approach to the management of fisheries and their interactions be explored during the transition period.

The following example illustrates a possible path toward a full EBFM strategy for fisheries by the Council (Figure 2). A hypothetical system of several species/stocks with associated FMPs that occur within two distinct ecological units (designated north and south for the purposes of this illustration) is shown. Under the current management strategy, the ecological units themselves are not explicitly recognized. The spatial stock structure however is taken into account (left hand panel of Figure 2).

During the transition period, the management objectives and regulatory and legal requirements under existing management plans would remain in place. Under this transition strategy, existing FMP structures would be used but would begin to incorporate factors such as potential interactions among species and fisheries covered by FMPs within the EPU. The effects of climate and environmental change that are important in the production dynamics of the species (middle panel of Figure 2) would also be examined. Climate forcing can be expected to differ substantially among ecological units in our area. At present, harvest planning is based largely on near-term (typically 3-year) projections in stock assessments that incorporate present day demographic rates to determine stock productivity. Demographic rates change through time due to both effects of fishing and environmental factors such as temperature, current regimes, ocean chemistry, and primary production. Changes in these environmental factors are unlikely to be significant enough to affect stock dynamics over the timeframe of projections in the assessments. However, over timeframes longer than current management horizons, environmental change can and likely does affect stock productivity.

The full EBFM strategy involves the development of integrated Ecosystem-Based Fishery Management Plans for the EPUs (right hand panel of Figure 2) which is more fully described in the next section.

Box 1. Achieving optimum yield in the scallop fishery by confronting yellowtail flounder bycatch. Summary of paper by O'Keefe, C., G. DeCelles, J. Breton, D. Goethel, S. Cadrin and D. Georgianna. School for Marine Science and Technology.

Annual rotational management of open access and closed access areas has been successful for the scallop fishery. Scallops are not overfished (stock biomass is above the threshold reference point), and overfishing is not occurring with landings currently at historically high levels. The scallop catch from the closed access area fisheries, however, often falls below the allocated Annual Catch Limits (ACLs) due to early area closures resulting from exceeding the allocated bycatch ACL for yellowtail flounder. Unharvested scallops may suffer high natural mortality rates, as these scallops are typically large, older animals. Early closures of closed area access fisheries shift fishing effort to open areas where CPUE for scallops is lower, resulting in increased area swept and potential habitat impacts.

An Individual Transferable Quota (ITQ) system for yellowtail flounder bycatch applied to Limited Access scallop permit holders is a possible solution to harvesting less than the optimal yield from the closed areas access fisheries[1]. This system would allow leasing of yellowtail flounder quota between scallop permit holders, as well as leasing from groundfish sectors for use in the closed access area fisheries. Permit holders who oppose ITQ systems for target species would probably favor ITQ systems for bycatch because the entire fishery gains from longer access to the scallop resource in the closed areas.

An ITQ system for yellowtail flounder bycatch would require additional management decisions, more complete science, and increased monitoring. In addition to the current regulations for ACLs, access area time specifications, and scallop trip limits, an ITQ system would require initial allocations of bycatch quota and regulations for transfer of quota and quota caps. Improvements in scientific investigation include annual assessments of yellowtail flounder in the closed areas, temporal range of yellowtail movements in and out of the closed areas, shell height to meat weight ratios for scallops by area and time, and mortality rates for scallops by area.

Any ITQ system requires near 100% monitoring of fishing trips. Currently, scallop vessels in the access fisheries are monitored by at-sea observers at a 10% coverage rate. At-sea observers provide accurate data in a timely manner. However, the costs of carrying an observer are very high (~900$/day) and increased coverage requires a compromise to defray some of the costs to the fleet. Electronic monitoring may provide a cost effective way to monitor scallop vessels due to differences in appearance between scallops and yellowtail flounders. Electronic monitoring systems (i.e. video cameras) have been effective in other fisheries around the world. For scallop and yellowtail flounder monitoring, mounted cameras must be able to quantify scallop catch, as well as bycatch species accurately. Performance of electronic monitoring and analysis equipment can be validated through comparison with data collected by at-sea observers.

An industry-based bycatch avoidance system, which includes spatially-specific, real-time data collection and information exchange could be employed in conjunction with an ITQ system. An avoidance system would complement the ITQ system because vessels that avoid bycatch areas will not have to purchase as much bycatch quota and may be able to lease excess quota.

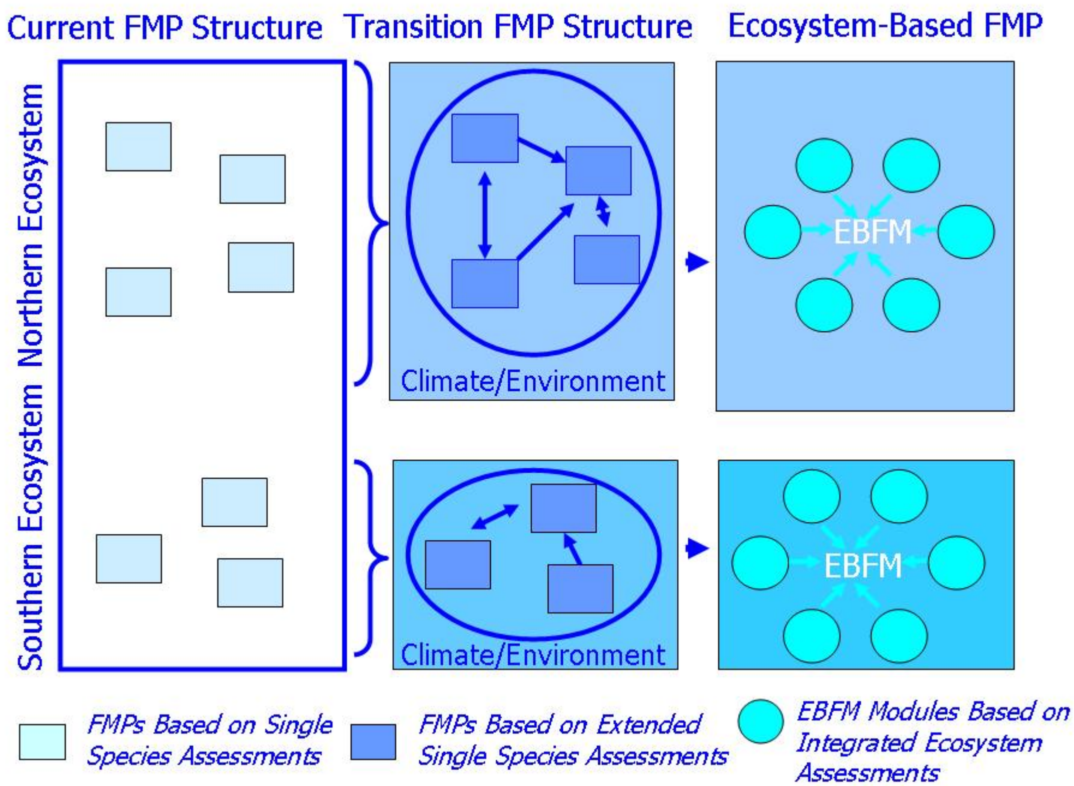

Figure 2. Pathways to development of a full Ecosystem-Based Fishery Management strategy (right panel) from the current strategy in which separate fishery management plans are implemented for individual stocks or groups of stocks (left panel), through a transition strategy (middle panel) which retains the individual FMP structures but begins to take into account biological and technical interactions and environmental/climate factors that cut across FMPs within defined EPUs (indicated by arrows where there are one or two-way interactions among some FMPs) (or within FMPs where multiple species are included in the management unit)

Ecosystem Assessment

An EBFM will require both new and updated assessment tools to allow monitoring of progress against objectives. Stock status reports produced by the NEFSC will be much as they are now. There will also be a need to assess ecosystem health and progress toward meeting sociocultural and economic objectives.

Overview documents for the selected ecological regions will be required to provide general ecological context for management decisions within the specified EPUs. These reports would incorporate many of the elements advocated by the NMFS Ecosystem Principles Advisory Panel in what they referred to a Fishery Ecosystem Plan (FEP). Similar approaches are currently used in Canada for the development of

Ecosystem Overview and Assessment Reports. The Department of Fisheries and Oceans Canada and the Northeast Fisheries Science Center have collaborated on the development of an Ecosystem Overview Report for the Gulf of Maine which is now in review. This report includes the Gulf of Maine proper, Georges Bank, and the Bay of Fundy within its spatial domain. Information contributed by NEFSC and contained in this report is relevant to development of the overview documents.

More detailed assessment reports which monitor indicators of ecosystem health and cumulative impacts against reference points will be required in the longer term. These Integrated Ecosystem Assessments (IEA) would be the principal analytical vehicle supporting the development of EBFM management plans. An IEA plays a role directly comparable to single species stock assessment but set within a broader ecosystem context. For an overview of the structure and development of an IEA, see Levin et al. (2009).

The SSC proposes that the suite of documentation (assessment documents and management plans) required to support EBFM be designed during the transition period.

MANAGEMENT OF FISHERIES UNDER EBFM

Although ecosystem considerations can be incorporated into fishery management decision-making on a case – by –case basis as is the current situation, data limitations and expanding complexities will preclude incorporation of all ecosystem components. Layering more and more extensions on single-species assessment and management will ultimately lead to a fishery management system that is too complex and data hungry. The National Standard 1 guidelines already require that FMPs identify ecosystem component species for consideration as management units, a requirement that will be more effectively dealt with through a full EBFM strategy. In this approach, the current collection of FMPs for individual species or groups of species would be replaced by a fully integrated management plan for each ecological region. If the general outlines of the relevant ecological boundaries were to be selected by the Council, the nine FMPs administered by NEFMC would be eventually be replaced by two EBFM Plans, one for the Gulf of Maine proper and the other for Georges Bank.

The main steps (figure 3) required to implement EBFM were discussed in the previous section. If these are followed during the transition period, the boundaries of the ecosystem management units will have been developed as will have the objectives to guide EBFM for fisheries. The next steps are specific to the management of harvesting in an ecosystem context under the full EBFM strategy. The overall approach is based on the common sense recognition that an ecological region can produce a certain amount of fish and shellfish (and other important species) depending on nutrient supply, temperature, and other factors. Sustainable harvesting of some part of fishery production can be achieved if the appropriate safeguards are put in place and we are vigilant about changes in environmental and ecological conditions affecting production. If environmental/climate conditions change, reference points will need to be re-evaluated to reflect shifting productivity patterns. With this foundation, a way of determining how much of each species can be safely caught in this broader ecosystem context can be devised. The allocation strategy must recognize that different species hold different positions in the marketplace or may be valued by fishermen and consumers for other reasons that market price, differ in their vulnerability to fishing, and that catch levels of some species can also affect others through predator-prey interactions, competition, or simply through by-catch.

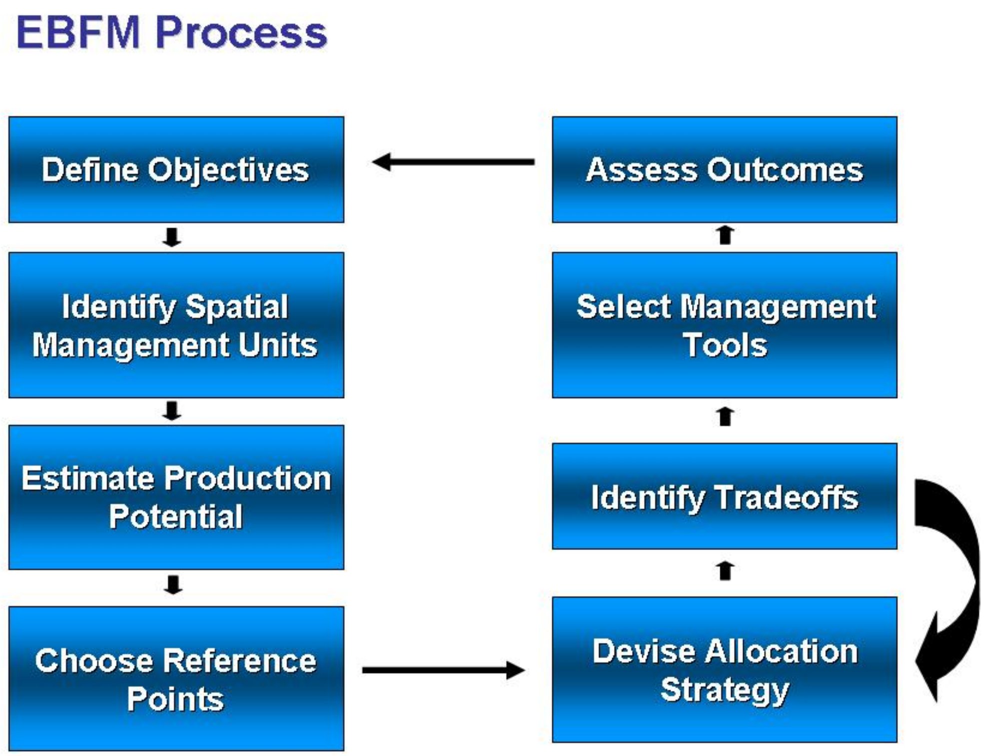

Figure 3. Steps involved in developing an Ecosystem-Based Fishery Management Strategy.

Allocation issues of this type were an integral part of the Two-Tier management program implemented under ICNAF and ways of approaching this problem have already been developed, as was discussed in the section concerning Human Dimensions. Trade-offs in the catch allocation strategy will next need to be considered. For example, if species interact through predation or in other ways, we will need to decide how much of each can be harvested, accounting for overall sustainability requirements, and recognizing that management actions affecting one species will have indirect effects on interacting species. After identifying the implications of tradeoffs, the allocation strategy will need to be revisited and adjusted to reflect the tradeoffs. Finally, the mix of management tools to implement this management approach needs to be considered and the outcomes assessed against the EBFM objectives. Management tools might be largely drawn from the same toolkit used under the current management system but the relative importance of each and their use will depend on the EBFM objectives and the other considerations. EBFM also opens up the possibility for new governance tools such as the involvement of place-based fishing communities in particular fishing grounds, or other co-management processes. These would be more fully developed during the transition period. Assessment tools will be a combination of current ones as well as new ones referred to in the previous section on ecosystem assessment.

Fishery Production Potential

There are at least two principal approaches to defining the fishery production potential in an EPU. The first considers energy flow in the system and traces it through the food web. The second approaches the problem in ways that are similar to single species analysis using production models but instead tailors the approach to fish and shellfish communities as a whole. These models either directly or indirectly take ecological and fishery interactions into account and also account for environmental or climate related changes. Both approaches have been used in the Northeast region. Models of low to intermediate complexity are advocated as these have been shown to hold advantages over more complex models in developing predictions for management decisions. That said, during the transition period, developments and comparisons will be undertaken to evaluate model effectiveness and ensure a solid basis for decision - making. Also, configurations of these models will be explored to meet the needs of ABC – ACL determination. A sense of some this work is noted below.

The first approach to defining fishery production potential for a region involves the energy coming in at the base of the food web and the efficiency of transfer of energy through the web. Estimates of each of these quantities are available for this region (Fogarty et al. 2008) and have previously been reported to the Groundfish Assessment Review Meeting (GARM). Updates and refinements of these estimates are available. The amount of microscopic plant life (phytoplankton) that forms the base of the food web on the continental shelf can be determined from satellites and shipboard sampling. Primary production is essentially the turn-over rate of this plant life. A view of primary production in the Northeast region from space is provided in Figure 4. It can be seen that there are important regional differences in primary production with high levels in the coastal zone where runoff of nutrients fuels high production and in offshore areas such as Georges Bank where the topography and oceanography favor high levels of primary production. In contrast, primary production over the deep water basins of the Gulf of Maine is relatively low. It can be expected that fish and shellfish production which depends upon on this primary production will differ regionally according to spatial management unit.

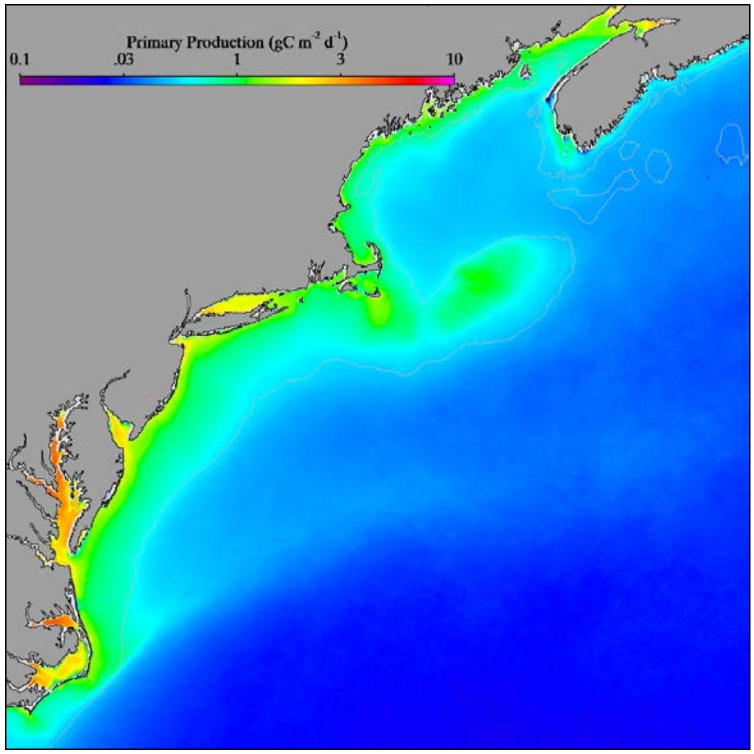

Figure 4. Estimates of the primary production on the Northeast Continental Shelf over an annual cycle based on satellite-derived estimates of chlorophyll and other factors; warmer colors indicate higher levels of primary production

The second approach is based on multispecies production models and includes methods that combine species into aggregate groups, as in the development of the Two-Tier quota management system mentioned earlier. Overholtz et al. (2008) reported on aggregate-species production models to the GARM. Models can also be developed that directly estimate predator-prey and other interactions among species (e.g. Worm et al. 2009). Gamble and Link (2009) describe an important simulation tool incorporating ecological interactions in a multispecies model that will be valuable in this work.

Ecosystem Reference Points

Target and limit ecosystem exploitation rates (or in the case of the aggregate production model analyses, a measure of ecological exploitation rate) need to be defined. These are analogues to single species reference points necessary to guide management decisions in an ecosystem context. The choice of the underlying model and system components dictates to a large degree the issues surrounding the selection of target exploitation rates.

For the energetics approach described above, the overall production of exploited species is a function of the amount of new annual primary production in the ecosystem. This new production is principally related to the amount of nutrients replenished each year through oceanographic processes. The fraction of new production in the system (the ratio of new to total primary production) is called the *f-ratio*. One potential candidate exploitation rate under this modeling approach is to specify that the *f-ratio* sets the upper limit to exploitation that would then be used to select a lower target level. This is predicated on the understanding that it is the new production only that would be continuously available to support the production of exploited species. An alternative is to use target exploitation rates developed using other models (see below) and apply them to the energetically-based estimate of fishery production potential.

The aggregate production model provides a direct estimate of the limiting level of fishing mortality in the same way that F_{MSY} is estimated in a single-species assessment (see Overholtz et al. 2008). For more detailed multispecies models, the consequences of applying ecosystem reference points on the individual species in the system can be explored. For example, Worm et al. (2009) used a size structured multispecies model to consider target exploitation rates that not only considered sustainable yield but the effects on species composition and depletion of individual species within the assemblage. This model was applied to a complex of 21 species on Georges Bank.

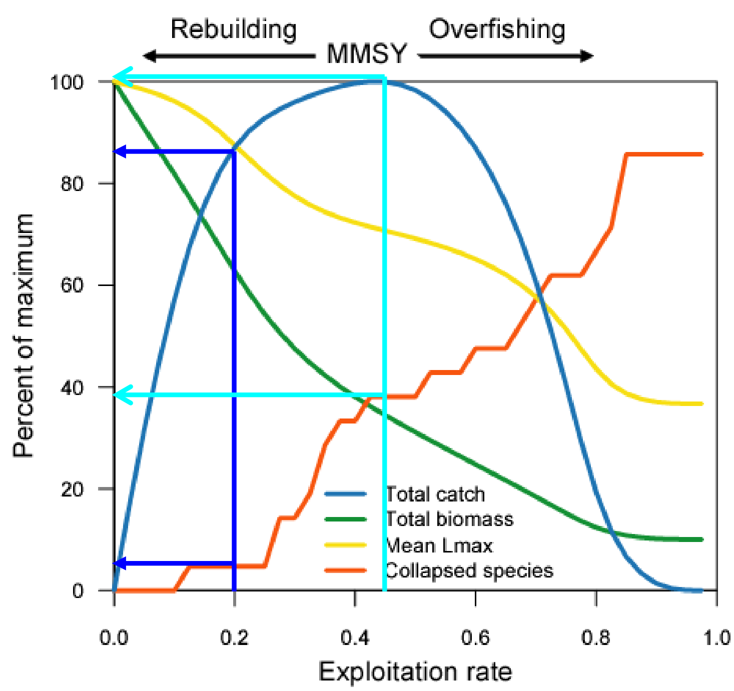

Figure 5. Multispecies production model showing total catch (all species), total biomass, average maximum size (mean Lmax) and the proportion of collapsed species for a 21 species system on Georges Bank (adapted from Worm et al 2009); all quantities expressed as percent of maximum value to simplify presentation

The maximum sustainable yield for this complex was achieved at a community exploitation rate of 0.45 (Figure 5 adapted from Worm et al. 2009). However, consideration of the proportion of species that would be driven to less than 10% of their maximum biomass levels as exploitation rates increased demonstrated that substantial benefits could be achieved by reducing exploitation rates to lower levels with little loss in yield. Specifically, reducing the community exploitation rate to 0.2 would maintain nearly 90% of the projected yield while the number of species classified as depleted (< 10% of maximum) would decrease from nearly 40% at E_{MSY} to less than 10%.

Species Catch Allocation

Should an approach involving system-wide energetics or aggregate-species production levels be selected for further exploration, it will still be necessary to consider catch allocation strategies for individual species. Not all species hold equivalent value in the market place and differential exploitation and selection patterns must be anticipated. There is a a critical and ongoing role of the results from individual species assessment and management in shaping a strategy for dealing with this issue. It is suggested that an overall ceiling or cap be established for total catches set by an estimate of system-wide production and a corresponding target ecosystem or community-level exploitation be specified.

Lower biomass limits (floors) for individual species will need to be developed that are based on estimates of the limiting level of biomass (B_{LIM}) inferred from single species stock assessments. In this process, it may be desirable to work from estimates of the limiting level of fishing mortality and translate these into estimates to B_{LIM}. For species that are not assessed or are only taken incidentally in fisheries, it may be possible to derive estimates of limiting exploitation levels based on life history characteristics affecting their intrinsic rate of increase. Future work may lead to a different set of lower limits based on other ecological considerations. However, under current guidelines, it will be necessary to incorporate considerations such as B_{LIM} to set safeguards under an EBFM.

CONSEQUENCES FOR COUNCIL INSTITUTIONS

Council institutions (i.e., processes and procedures) need to be designed to address the implications of cumulative ecosystem impacts of fishing. Institutional changes required by EBFM depend on the form of EBFM the Council decides to implement. If the Council adopts the transition strategy, current FMPs with omnibus amendments (e.g., habitat, forage, environment) and possibly the addition of Fishery Ecosystem Plans may meet target species and bycatch species objectives. However, a plan-specific approach will likely not resolve many of the challenges of mixed-stock fishery management, and thus not meet newly developed ecosystem objectives. If the Council decides to proceed to a full EBFM strategy, additional institutional changes will be required.

The Council is not alone in its experience with EBFM implementation. Most if not all the other regional fisheries management councils are in different stages of experimentation with EBFM. Additionally, terrestrial areas have worked through these conceptual shifts and may provide valuable insights particularly in terms of process. It is instructive to keep informed of these efforts as the Council can learn from them.

Implementation of EBFM in the northeast region presents unique challenges and opportunities, some of which are highlighted below. It is necessary to be aware of these when considering revisions to Council institutions required by EBFM. A sense of some of these changes is provided below, recognizing that these will evolve during the implementation of EBFM.

Experience of Other Regional Fishery Councils

Other councils have made varying amounts of progress in developing fishery ecosystem plans or incorporating ecosystems based fisheries management into existing FMPs and likewise, have adopted a variety of institutional arrangements in dealing with ecosystems issues. Below is an outline that briefly summarizes the councils' progress and what type of council committee or groups have specific responsibility for developing fisheries ecosystem plans or dealing with ecosystems issues.

South Atlantic

The South Atlantic Council has developed a fishery ecosystem plan (FEP) that evolved from the Council's Habitat Plan and is comprised of six volumes (South Atlantic FEP Overview). The FEP explains that *"The Council has implemented ecosystem-based principles through existing fishery management actions*." The Council recently developed an amendment to the FEP that will protect specific areas of sensitive habitat, deemed Coral Habitat Areas of Particular Concern which is under review.

The SAFMC established an EBFM Committee consisting of Council members to develop and update the FEP. The committee consists of Council members and scientists. Although it does not have a technical committee or an advisory panel specifically assigned to the FEP process, it does have a large Habitat and Environmental Protection Advisory Panel.

Gulf of Mexico

The Gulf Council is in the initial phase of developing a fishery ecosystems plan.

The Council has recently established an Ecosystems SSC, which has a different membership than its 'regular' SSC, to advise on the development of EBFM. No other Council committee or technical committee has been assigned to this effort.

Caribbean

The Caribbean Council currently is not developing a fishery ecosystem plan or an EBFM plan and has not formed any EBFM – associated institutions.

Mid-Atlantic

The Mid-Atlantic Council currently is not currently developing a fishery ecosystem plan or an ecosystems based fisheries management plan. It addresses ecosystem-related issues on a case by case basis through its Ecosystems/Ocean Planning Committee.

Western Pacific

The Western Pacific has developed separate fishery ecosystems plans (FEP) for the Hawaii (Hawaii FEP), American Samoa, Mariana Archipelagos, the U.S. Pacific Remote Islands and a Pacific Pelagic Fishery Ecosystems Plan.

The FEPs are developed by regional ecosystem advisory committees from the American Samoa, Hawaii and Mariana Archipelagos. Each advisory committee includes Council members and representatives from federal, state and local government agencies, businesses and non-governmental organizations. Technical analyses may be provided either by the Council staff or plan teams.

North Pacific

The North Pacific Council has a fishery ecosystem plan for the Aleutian Islands (AIFEP Overview) which is a policy and planning document to guide the Council in its management actions relating to the Aleutian Islands. The Council also participates with 10 Federal agencies and four State agencies in the Alaska Marine Ecosystem Forum.

The Council has established an Ecosystem Committee to discuss current ecosystem-related initiatives and positions relative to: (1) defining ecosystem-based management; (2) structure and Council role in potential regional ecosystem councils; (3) implications of the NOAA strategic plan; (4) draft guidelines for ecosystem-based approaches to management; (5) draft MSA provisions or requirements relative to ecosystem-based management; and (6) generally coordinating with NOAA and other initiatives regarding ecosystem-based management.

The Council also has a technical Aleutian Islands Ecosystem Team to assist Council staff in updating the FEP. The team is a multi-disciplinary group of mainly federal and state scientists

Pacific

The Pacific Council is just beginning a process to develop recommendations on for an ecosystem-based management plan envisioned to complement, but not replace the Council's four existing FMPs.

The Council has established an Ecosystem Plan Development Team and an Ecosystem Advisory Subpanel. It also has hired a contractor to help facilitate the effort and assigned a Council staff member to support it. The Ecosystem Advisory Subpanel is an 11-member multi-disciplinary group representing industry, policy, and conservation interests from the states and tribes. The Council has four advisory subpanels, one for each FMP being developed or monitored. The Ecosystem Plan Development Team is a 13-member group of state, federal, and tribal scientists and policy analysts whose primary responsibility will be to provide analyses and recommendation to the Council on the latest science in support of ecosystem-based fishery management principles and to develop goals, objectives, and policy alternatives for Council consideration as the Ecosystems FMP takes shape over the next few years.

EBFM Challenges and Opportunities

Currently, FMPs are defined by species and stocks rather than geographical, biological or socio-cultural definitions of ecosystems. The EPU approach advocated under the full EBFM strategy would require alignment of these stocks with the four EPUs described earlier. There will be cases where current stock definitions cross EPU boundaries and decisions will have to be made on how best to resolve these on a case by case basis.

One of the EPUs (Middle Atlantic Bight) is within the jurisdiction of the Mid-Atlantic Fisheries Management Council. As well, changes to Council institutions may require dialogue with State agencies to ensure that its EBFM efforts are complementary to those in State waters.

EBFM may require the Council to consider activities that it does not directly regulate and to broaden public input into its EBFM process. Alos, single species management has led to the establishment of constituents with historical interests in particular fisheries, which will heighten the difficulties and the potential disagreements that may arise in setting objectives and making trade-offs. To accommodate either different roles or to expand public input, the Council may have to change some of its consultative processes, as well as build on creating a participatory and transparent governance process.

Over the past few years, major shifts in management approaches (including the implementation of a number of catch share programs) have required significant changes in the way fishermen and fishing communities operate and relate with the marine environment and with each other. These changes have relied on public participation and involvement. While this creates opportunities (stakeholders are arguably better organized than they have been in the past), managers need to be sensitive to the fact that stakeholders may suffer from participation fatigue and concern that once again external shifts in management approaches will transform their lives. Given this, transparency and early public involvement will be key.

Additionally, the current Council plan development process may be too cumbersome for developing EBFM Plans, making it difficult to include the full range of expertise needed. Further, the institutional requirements for developing and implementing EBFM are likely to change over time. Recognizing this at the outset of the process should make it easier to implement needed institutional changes in the future.

Finally, under current national guidelines, reference points such as minimum stock size and maximum fishing mortality thresholds must be defined for each stock to the extent possible, and each stock must be managed to achieve these reference points within fixed time periods. It will be necessary to configure ecosystem reference points consistent with these guidelines.

Institutional Change in support of EBFM

Current Institutions

Before considering changes to Council structures, it is useful to briefly recap the current institutions. The current Council Committee process consists of five different groups that help develop FMPs for Council consideration:

- Fishery Oversight Committee (more commonly referred to as the species committee)
- Advisory panel
- PDT
- SSC
- SAW or other assessment group

Typically, an issue or problem is dealt with in a sequential, iterative manner by the Committee, the PDT and at least one other of these of these groups. Additionally public input is provided at different levels and at different points in the process.

Scientific input from outside the PDT is generally limited to stock assessment advice from the SAW and/or SSC. This typically includes information on stock status, and may include estimation of biological reference points and projections based upon these. The SSC may provide the Council with advice on a wide range of issues including stock – specific ABCs, biological and management reference points, peer reviewed biological, economic or social impact analyses and so on. PDTs may work on all aspects of FMP development with the exception of providing stock assessments and ABC recommendations, except perhaps as alternatives for SSC consideration.

Currently, PDTs necessarily have a number of members whose expertise is in meeting the procedural requirements and providing analyses under the MSA, NEPA and other statutes. PDTs may also do limited amounts of scientific work such as providing stock projections particularly under different management alternatives, analyzing alternative measures in terms of how they might change fishing mortality, analysis of economic and social impacts and summarizing management impacts on other species, including protected species, and habitat.

It should be noted that currently, the Habitat Committee has been tasked by the Council to undertake EBFM - related tasks.

Institutions under EBFM

During the transition to EBFM, the structures required for its effective implementation will be designed and the task of modifying current institutions undertaken. Having said this, a sense of what some of these changes may be is presented below. It is emphasized that these are provided for discussion purposes.

Under full EBFM, the focus of planning will become the EPUs, of which there are two under Council jurisdiction (GOM and GB). The development of EBFM plans for each of these will likely require the dedicated efforts of a PDT for each. During the transition, this may be a task that could be undertaken by an existing Council committee or newly formed one. Also, it will be necessary to cross-walk the activities of the current PDTs with the new EPU-based PDTs. This process will largely dictate the final form of the EBFM planning structures.

No changes are seen required of the SSC as its mandate currently addresses the full suite of biological, social and economic issues confronting the Council. On the other hand, there may be more need for the SSC to consider the socio-economic consequences of EBFM plans than has been the case with single species plans.

Outside the Council, changes to the SAW process may be required. While peer-reviewed stock assessments will continue to be required, there will also be a need for peer-reviewed analyses on the overall state and productivity of the EPUs. Dialogue with NMFS will be required on how best to provide these.

NEXT STEPS

This White Paper is intended as a vision for the implementation of EBFM in the Council's mandate area. If the Council adopts this vision, a more detailed implementation plan will be developed by the SSC which outlines activities during a transition period towards full EBFM, most of which are outlined in this White Paper including:

- EBFM Functions
    - Define Ecosystem Production Units (EPU)
    - Identify issues and ecosystem services associated with each EPU that require attention under EBFM
    - Define EBFM objectives to be achieved for each EPU and identify the risks of not achieving these
    - Develop management strategies to achieve the EBFM objectives
    - Define EPU status and design productivity reporting requirements and the associated assessment tools required to monitor progress towards EBFM objectives
- EBFM Structures
    - Issues at Council level
        - Design consultative processes to facilitate greater participation and transparency
        - Dialogue with MAFMC and New England states on harmonization of EBFM efforts
    - Issues at PDT level
        - Outline EBFM plan requirements
        - Design PDT structures for each EPU and dialogue with current PDTs to develop transition
    - Issues at SSC level
        - Dialogue with NMFS and Council staff on stock assessment, EPU assessment needs, and socio-cultural and economic assessment needs
        - Prepare white paper outlining socio-economic analyses required by EBFM

If the Council pursues EBFM as a top priority, it is expected that a detailed implementation plan could be developed over the next one – two years.

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