

Benchmarking the 1999 EPAP recommendations with existing Fishery Ecosystem Plans

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Abstract: Ecosystem-based fisheries management (EBFM) is a holistic, multi-species (vs. single species) approach to fisheries management that recognizes the physical, biological, economic, and social complexities of managing living marine resources. In 1999 the Ecosystem Principles Advisory Panel published a report to Congress that outlined eight recommendations for creating Fishery Ecosystem Plans. We benchmarked those eight recommendations against ten existing Fishery Ecosystem Plans from four Regional Fishery Management Councils. We found that Councils addressed and applied most of the EPAP recommendations in their FEPs, and structured their FEPs differently depending on the specifics of their ecosystems, fisheries, and available information. We found that several recommendations were not addressed in FEPs because the recommendation was either too expansive to be applied with existing information or it was unclear how to apply the recommendation to an FEP. Through our review, we also identified three key concepts central to the development of FEPs that are not addressed directly in the EPAP recommendation, but that would further strengthen FEPs. These include the establishment of ecosystem goals and objectives, using ecosystem indicators to monitor progress or conservation and management needs, and the role of trade-off analysis in optimizing yield across an ecosystem. The wide range of approaches and use of the FEPs also shows that each Council has different needs and priorities for approaching EBFM. Future guidance on the development of FEPs should reflect the need for flexibility in fisheries management, while also promoting consistency in development, implementation and use of FEPs between regions.

1.0 Background

Ecosystem-based fisheries management (EBFM) is a holistic, multi-species (vs. single species) approach to fisheries management that recognizes the physical, biological, economic, and social complexities of managing living marine resources (Cicin-Sain and Knecht 1993; Grumbine 1994; Griffis and Kimball 1996, Patrick and Link 2015). NOAA Fisheries defines EBFM “as a systematic approach to fisheries management in a geographically specified area that ensures the resilience and sustainability of the ecosystem; recognizes the physical, biological, economic, and social interactions among the affected components of the ecosystem, including humans; and seeks to optimize benefits among a diverse set of societal goals.” (NMFS, 2015). NOAA Fisheries considers EBFM applicable to recreational and commercial fisheries, and recognizes that fishing for a single species is only one variable that affects the health and sustainability of a fish population. Interactions with other species, pollution, and environmental changes, such as climate also affect fish stocks and the communities that depend on them.

Federal agencies, including NOAA Fisheries, have promoted EBFM since at least the mid 1990’s. A 1994 U.S. Government Accountability Office report on ecosystem management identifies steps to more effectively implement ecosystem-based management across government agencies (GAO, 1994). In 1996, the Magnuson Steven’s Fishery Conservation and Management Act (MSA) was reauthorized and called for the creation of an Ecosystem Principles Advisory Panel (EPAP) to develop recommendations to expand the application of ecosystem principles in

fisheries management (16 U.S.C. § 1882). The 1996 MSA also authorized the Secretary of Commerce to support regional pilot programs with Fishery Management Councils (Council) to implement the EPAP recommendations. More recently, the U.S. Commission on Ocean Policy Report called for ecosystem-based management in 2004 (U.S. Commission on Ocean Policy, 2004).

In 1999, the EPAP published its report to Congress and identified fishery ecosystem plans (FEPs) as an important mechanism for implementing EBFM in U.S. fisheries (EPAP 1999). Using FEPs complements the existing fishery management framework required by the MSA, which requires that Regional Fishery Management Councils (Councils) develop Fishery Management Plans (FMPs) that contain conservation and management measures consistent with ten National Standards and other required provisions under section 303(a) of the MSA. The EPAP recommended that Councils should use existing FMPs for single species or species complexes but that they should be amended to reflect approaches consistent with a FEP. The EPAP further clarified that FEPs are useful mechanisms for incorporating core ecosystem principles, goals, and policies, and that they do not replace FMPs. To operationalize the use of FEPs, the EPAP laid out eight recommendations:

1. Delineate the geographic extent of the ecosystem(s) that occur within the Council's authority, including characterization of the biological, chemical, and physical dynamics of those ecosystems and "zone" the area for alternative uses.
2. Develop a conceptual model of the food web.
3. Describe the habitat needs of different life history stages for all plants and animals that represent the "significant food web" and how they are considered in conservation and management measures.
4. Calculate total removals, including incidental mortality. Show how they relate to standing biomass, production, optimum yields, natural mortality and trophic structure.
5. Assess how uncertainty is characterized and what kinds of buffers against uncertainty are included in conservation and management.
6. Develop indices of ecosystem health as targets for management.
7. Describe available long-term monitoring data and how they are used.
8. Assess the ecological, human, and institutional elements of the ecosystem which most significantly affects fisheries, and are outside the Council/Department of Commerce's authority. Included should be a strategy to address those influences in order to achieve both FMP and FEP objectives.

The 1999 EPAP report is the most comprehensive document detailing how to implement EBFM using FEPs, however there is no requirement that FEPs conform with the EPAP recommendations. Since then, several Fishery Management Councils have developed FEPs in the North Pacific, Pacific, Western Pacific, and South Atlantic, and others are currently planning to develop FEPs. In response to renewed interest nationally in ecosystem-based fisheries management (EBFM) and the use of FEPs in the fishery management process, NOAA Fisheries

Office of Sustainable Fisheries, reviewed the eight EPAP recommendations and benchmarked them against existing FEPs. The purpose of this review is to:

- Summarize how the Council’s implementation of FEPs compares with the 1999 EPAP recommendations.
- Characterize the diverse ecosystem planning needs and approaches across Councils.
- Better understand how Councils use their FEPs to meet their goals and objectives
- Develop suggestions to improve upon the existing EPAP recommendations to support the needs and approaches that Councils are using to advance EBFM.

2.0 Methods

The Office of Sustainable Fisheries reviewed ten existing FEPs against the eight EPAP recommendations described above: Aleutian Islands FEP, Pacific Coast FEP for the U.S. Portion of the California Current Large Marine Ecosystem, American Samoa FEP, Hawaii FEP, Marianas FEP, Pacific Remote Island Areas FEP, Pelagics FEP, South Atlantic FEP, Comprehensive Ecosystem-Based Amendment 1 (CEBA1), and Comprehensive Ecosystem-Based Amendment 2 (CEBA2). Our review focused on the FEP documents and the degree to which the FEP address the EPAP recommendations. Although we focused our analysis on the FEPs themselves, we also recognized that in many instances there were other supporting documents that also addressed some portion of an EPAP recommendation, and we have referenced them in the discussion. In addition to reviewing all FEPs, we spoke with Council and regional office staff about the approaches, priorities, and challenges of developing and using FEPs for their fisheries and associated ecosystems.

We based our review of each FEP and the degree to which it addresses each EPAP recommendation on the following qualitative criteria: incorporated in detail, partially incorporated, or minimally incorporated/not mentioned. Many of the EPAP recommendations were multi-part or multi-faceted recommendations. We considered a recommendation incorporated in detail if all or most facets of the recommendation were addressed and if the FEP also addressed the implications of that topic to the specific components of the ecosystem covered within the FEP. We considered a recommendation partially incorporated if only one facet of the recommendation was addressed and if the discussion in the FEP addressed only the general implications of that recommendation on the ecosystem. We considered a recommendation minimally incorporated if there was no mention of the topic or it was only broadly addressed in a way that was not specific to the ecosystem covered in the FEP. We applied these criteria to all 10 FEPs and have summarized the results into Table 1 that shows the degree to which each EPAP recommendation has been used across all FEPs.

3.0 Summary of Benchmark Review

3.1 North Pacific Fishery Management Council

For the North Pacific, we reviewed the “Aleutian Islands Fishery Ecosystem Plan” (AIFEP). The AIFEP, as published in 2007, is described as a living document to be updated annually and re-evaluated every 3-5 years. The goal of the plan is to serve as a reference document that provides scientific information and measureable indicators to evaluate and promote sustainable fisheries, ecosystem health and vibrant communities in the Aleutian Islands region. The plan was created as an informational document, and does not authorize management measures or changes to fishery regulations. Included is a statement that while the plan makes suggestions and ideas for change and improvement, any changes to management would need to be implemented through the FMP amendment process.

3.1.1 Delineate the geographic extent of the ecosystem(s)

The AIFEP delineates the geographic extent of the ecosystem and includes a description of the components of the ecosystem. Historical background information about the ecosystem including commercial exploitation of the area is described. Various animal populations that use the ecosystem are also described (marine mammals, sea birds, fish) and general habitat information is included. Physical dynamics of the ecosystem are divided into short sections about the benthic, pelagic and terrestrial habitat areas. Chemical relationships were not addressed and the area was not zoned for alternative uses.

3.1.2 Develop a conceptual model of the food web

The AIFEP describes a model of the food web that outlines and explains each of the major components of the ecosystem. Major energy flows are described in the model, as are relationships between lower and higher trophic levels. The food web model was also simplified to show the position of key species and the energy flows between them. The plan includes a description of the role of Atka mackerel, Pacific ocean perch, and myctophids in the ecosystem, and spatial relationships between food web components. For example, groundfish sometimes distribute themselves vertically along the shelf at different depths to maximize their access to prey.

3.1.3 Describe the habitat needs for all plants and animals included in the significant food web

The AIFEP does not include specific information about habitat needs for different life stages of plants and animals that are considered part of the ‘significant food web’. Some characteristics of habitat are described in detail, such as diet composition of Atka mackerel and pollock in a discussion of feeding habitat. Some habitat ranges are described for species in the Aleutian Islands, but the habitat needs, and needs of various life states, are not addressed. The plan does recognize that while the Council places boundaries on the ecosystem, the actual foraging and range distribution of the marine species (and humans) that use the ecosystem are not confined to

those boundaries. Additionally, in order to meet the requirements for essential fish habitat under section 303 (a) 7 of the Magnuson Stevens Act, Council FMPs already identify and describe essential fish habitat for the fishery.

3.1.4 Calculate total removals

The AIFEP does not include estimates of total removals or incidental mortality. Plan authors refer to a two million metric ton cap for the entire Bering Sea and Aleutian Islands management regions and across eighteen stock or stock complexes. However, only six of the eighteen managed species or species groups have total catch allocated separately for the Aleutian Islands and the Bering Sea. This total catch is one way of beginning to estimate total removal for the Aleutian Islands. The plan does not include a discussion about how total removals may relate to standing biomass, production, optimum yield, natural mortality or trophic structure.

3.1.5 Assess how uncertainty is characterized

Uncertainty is discussed throughout the AIFEP but there is not a discussion of the types of buffers against uncertainty that might be included in the conservation and management of the ecosystem.

3.1.6 Develop indices of ecosystem health as targets for management.

The AIFEP states that one of the goals of the document is to provide information on measurable indicators that evaluate and promote ecosystem health but the plan does not include such indices. The plan includes a statement that it would be easier to provide recommendations for maintaining a healthy ecosystem if ‘ecosystem health’ was defined, or if the Council defined “healthy ecosystem”. The Plan includes a statement indicating that further ways to develop the FEP would be to define ‘ecosystem health’ through a comprehensive ecosystem assessment.

3.1.7 Describe available long-term monitoring data and how they are used.

The AIFEP describes existing long-term monitoring programs (groundfish self-reporting and observer programs, monitoring of incidental take of marine mammals). To track critical ecosystem interactions a list of indicators were put into one of three categories: available via Stock Assessment and Fishery Evaluation (SAFE) reports; based on data that is not monitored by the Council; and those for which data is not available. Although the framework of indicators has been identified, mechanisms, time frames, and process for monitoring the indicators have not been established. Additionally, there is little physical oceanographic data for the Aleutian Islands that could describe the current state of physical forcing in the ecosystem or that could be used to monitor changing conditions for an ecosystem indicator. The plan identifies several research and monitoring priorities for oceanographic information (including long-term temperature monitoring) that over time may strengthen the use of indicators for EBFM planning.

3.1.8 Assess the ecological, human, and institutional elements of the ecosystem.

The AIFEP includes a summary of risk assessments for fisheries, regulatory issues, climate change, socio-economic topics, and predator prey interactions. The plan also identifies which risk factors may be outside Council control (e.g. water temperatures, ocean acidification, weather patterns). The plan does not include a strategy to address non-fishing risk factors that could affect attainment of fishery ecosystem objectives. It lays out possible actions for the Council to take if they are not already addressing a particular risk factor.

3.1.9 Summary

Overall the North Pacific Council's AIFEP incorporated parts of most of the eight EPAP recommendations. The document has not been updated since its publication in 2007, but contains relevant and useful information about the Aleutian Islands ecosystem and the fisheries in the region. The Council uses the plan primarily as an informational reference. Combined with the regularly updated ecosystem chapter of the SAFE reports, the Council has ready access to comprehensive and recent available information about the Aleutian Island Fishery Ecosystem.

3.2 Pacific Fishery Management Council

For the Pacific, we reviewed the "Pacific Coast Fishery Ecosystem Plan for the U.S. Portion of the California Current Large Marine Ecosystem" (PCFEP). The plan, published in 2013, supports the Council's fishery stock-specific management with ecosystem science, ecosystem considerations, and management policies and helps the Council coordinate management across its individual FMPs and the California Current Ecosystem. FMPs for the West Coast include goals and objectives related to avoiding overfishing, minimizing bycatch, maintaining sustainability in landings, minimizing impacts to habitats, and accommodating existing fishing sectors. The plan aims to build on those FMP goals and objectives and includes three main fishery ecosystem objectives: improve and integrate ecosystem information used in Council decision-making; build toward fuller stock assessments that can inform more developed descriptions of the greatest long-term benefits from the conservation and management of marine fisheries, optimum yield and tradeoffs; and provide administrative structure and procedures for coordinating conservation and management measures across the Council's jurisdiction. The plan does not directly change existing fishery management strategies or policies contained in FMPs, and was designed as a guidance document to inform future conservation and management measures in FMPs. The plan includes an Ecosystem Initiatives Appendix that describes ten "Initiatives" around topics such as forage fish, age and size distribution in managed stocks, biogeographic region identification, and bycatch and catch monitoring policies. These initiatives are meant to provide concrete steps for implementing measures that address ecosystem goals and objectives contained in the plan. The Pacific Fishery Management Council decided to implement the first initiative addressing forage fish in 2014. The Council continues to regularly revisit the other initiatives as they incrementally build their ecosystem-based approach to fisheries management.

3.2.1 Delineate the geographic extent of the ecosystem(s)

The PCFEP delineates the geographic extent of the ecosystem as the entire U.S. West Coast Exclusive Economic Zone (EEZ). This area includes parts of the California current ecosystem (CCE) within the EEZ. While the geographic extent of the Pacific Coast ecosystem excludes freshwater and estuarine ecosystems of the CCE, the Council does recognize the importance of these habitats, and is considering expanding the plan to include such habitats in the future. The plan does not zone any of the area for alternative uses.

3.2.2 Develop a conceptual model of the food web

The PCFEP includes a model of the food web that outlines and explains each of the major components at each trophic level: high trophic non-fish species, mid to high trophic fish and invertebrates, and low trophic fish and plankton. Marine mammals, seabirds, and sea turtles of the CCE are the primary components of the non-fish mid to higher trophic level, and most are protected species. Fishes at the higher trophic level tend to be highly valued target species. The plan also includes examples of species interactions from the CCE.

3.2.3 Describe the habitat needs for all plants and animals included in the significant food web

The PCFEP does not include specific information about habitat needs for different life stages of plants and animals that are considered part of the ‘significant food web’. While essential fish habitat for managed fish is identified and described in amendments to the Council’s FMPs for groundfish, salmon, highly migratory species and coastal pelagic species, the plan does not describe all life stages of plants and animals in the ‘significant food web’. Within the plan some characteristics of habitat are described in detail, such as abiotic, geological, and water column properties, and there is some discussion of the major habitat types and their importance, including microbial algal blooms, kelp beds and structure forming invertebrates. The plan mentions activities that are likely to affect habitat including both fishing and non-fishing related, but the plan does not include discussion about specific habitat needs for the ‘significant food web’ and how they would be considered in conservation and management.

3.2.4 Calculate total removals

The PCFEP includes commercial landings data for all stocks from 2001 to 2011, which ranged from a high of 546,000 metric tons to a low of 403,000 metric tons. However, total removals, including incidental mortality or discards, are not part of that estimate. The plan also does not calculate or recommend a total removal amount across managed stocks. The plan does not include a discussion about how total removals may relate to standing biomass, production, optimum yield, natural mortality or trophic structure.

3.2.5 Assess how uncertainty is characterized

The PCFEP touches on how uncertainty may be characterized in each of the individual FMPs for the West Coast. However, the plan does not address uncertainty, or how uncertainty across ecosystems may be characterized. There is not a discussion of the types of buffers against uncertainty that might be included in the conservation and management of the ecosystem or individual fisheries.

3.2.6 Develop indices of ecosystem health as targets for management.

The PCFEP does not include targets for ecosystem health or management. However the plan appendix includes examples of how the Council could address issues that affect two or more Council FMPs, or coordinate major Council policies across all FMPs to address needs at the plan level. The Council, in support of its ecosystem-based managed process, has requested that NMFS, in coordination with other interested agencies, develop a concise annual state-of-the-ecosystem report that reflects best available science. The plan also notes that the concept of a healthy ecosystem is subjective and has yet to be defined in objectively quantifiable terms. A fished and 'healthy' ecosystem is very different from an ecosystem that has never been fished, and there is not a comprehensive understanding of possible long-term consequences of fishing activities on ecosystems.

3.2.7 Describe available long-term monitoring data and how they are used.

One of the objectives of the PCFEP is to inform FMP fisheries management actions with ecosystem information generated through the implementation of the plan, including information about the cumulative ecological effects of management actions taken for FMP species and fisheries. This ecosystem information is generated in part from the results of existing monitoring programs used for managing coastal pelagic, groundfish and highly migratory fisheries. The plan describes the role of observers, how monitoring contributes to effective enforcement, and the importance of monitoring for bycatch in single stock fisheries management. The plan also describes monitoring programs that are part of the West Coast Governors Alliance on Ocean health, which is a partnership to manage coastal and ocean resources and the economies they support along the west coast. This partnership also seeks to expand ocean and coastal scientific information, research and monitoring. The plan does not describe approaches for using existing monitoring data to either develop indicators or evaluate progress in ecosystem-based fishery management or identify new data collection priorities.

3.2.8 Assess the ecological, human, and institutional elements of the ecosystem.

The PCFEP discusses five broad categories of ecological and human elements of the ecosystem. These five categories include: fish abundance within the CCE; the abundance of nonfish organisms within the CCE; changes in biophysical habitat; changes in fishing community involvement in fisheries and dependence on fishery resources; and aspects of climate change

expected to affect living marine resource populations within the CCE. The Ecosystem Initiatives appendix to the plan addresses more institutional elements of the ecosystem such as how the Council could address issues that affect two or more Council FMPs or coordinate major Council policies across the FMPs to fulfill identified FEP needs. Initiatives discussed in the appendix included protection for unfished forage fish, long-term effects of harvest policies on age and size distribution in managed stocks, bio-geographic region identification, cross FMP bycatch and catch monitoring, cross FMP essential fish habitat, safety, human recruitment to the fisheries, and socio-economic effects of fisheries management, and effects of climate shifts.

3.2.9 Summary

Overall the PCFEP incorporated parts of most of the eight EPAP recommendations. The document has not been updated since its publication in 2013, but contains relevant and useful information about the California Current Ecosystem and the fisheries in the region. The Council also continues to review and revisit the initiatives described in the plan's appendix.

3.3 Western Pacific Fishery Management Council

The Western Pacific Fishery Ecosystem Plans (WPFEPs), as published in 2009, reorganized the Western Pacific FMPs geographically. Each of the five FEPs from the Western Pacific contain fishery conservation and management measures according to the required provisions of FMPs as stipulated in 303(a) of the MSA. These FEPs are unique from those created by other Councils because they are also full FMPs. Each of the five WPFEPs include a goal statement to establish a framework under which the Council will manage fishery resources, improve its abilities to realize the goals of the MSA through incorporating ecosystem science and principles, and begin the integration and implementation of ecosystem approaches to management. The plans also identify topics under ecosystem approaches to management and outline 10 objectives to help the Council implement ecosystem approaches to fisheries management. These objectives are: to maintain biologically diverse and productive marine ecosystems that foster the long-term sustainable use of marine resources; provide flexible and adaptive management systems; improve public and government awareness and understanding of the marine environment; encourage and provide for the sustained and substantive participation of local communities; minimize bycatch; manage and co-manage protected species, protected habitats and protected areas; promote the safety of human life at sea; encourage and support compliance and enforcement with all local and federal fishery regulations; increase collaborating with domestic and foreign fishery management organizations (both governmental and non-governmental) to successfully manage marine ecosystems; and improve the quantity and quality of available information to support marine ecosystem management. The Council recently conducted an external review of their plans and is working on reviewing and updating their plans.

3.3.1 Delineate the geographic extent of the ecosystem(s)

Each of the WPFEPs delineates the geographic extent of the ecosystems. While each of the plans is different in terms of extent and area each covers, descriptions of the physical and biological environments are included. The plans also indicated where the geographic extent of one FEP overlaps with another. None of the plans zone the areas for alternative uses.

3.3.2 Develop a conceptual model of the food web

The WPFEPs mention food webs and describes why food webs are important for understanding ecological relationships. All five plans contain the same example of a Central Pacific pelagic food web to illustrate these ecological principles, but food web models for each of the five ecosystems are not presented.

3.3.3 Describe the habitat needs for all plants and animals included in the significant food web

The WPFEPs comply with the requirement to identify and describe essential fish habitat according to the Section 303(a)7 requirements in the MSA and include some specific essential fish habitat information for some life stages of animals that are considered part of the ‘significant food web’. Some of the plans describe various habitat types but do not include discussions about different life stages and habitat needs of important species. Some of the plans identify which species found in the ecosystems are commercially important. None of the plans include discussion about how those plants and animals that are part of the ‘significant food web’ are considered in conservation and management for the fishery. There is some discussion about protected species (turtles, whales, birds) that are found in each of the defined ecosystems. Habitat has been identified as an important item for the Council moving forward, and they plan to address this with the review and update of the FEPs currently underway.

3.3.4 Calculate total removals

The WPFEPs include historical commercial landings for some fisheries, but total removals including any incidental mortality is not calculated in any of the plans. Discussion of how removals relate to standing biomass production, optimum yield, or trophic structure is also not included. Information on total removals for each fishery is found in SAFE or other Council reports.

3.3.5 Assess how uncertainty is characterized

The WPFEPs mention uncertainty and how uncertainty relates to some life history characteristics, stock assessments, and bycatch estimates. However none of the plans include descriptions of how uncertainty is characterized. There is not a discussion of the types of buffers against uncertainty that might be included in the conservation and management of the ecosystem or individual fisheries.

3.3.6 Develop indices of ecosystem health as targets for management.

The WPFEPs include discussion of the need for developing indicators to answer questions about the status and trends in the ecosystem. Some of the plans identify the development of indicators as a future research need which would benefit from collaboration among scientists, fishery managers and communities in some of the Pacific Island regions. Some of the FEPs suggest that identifying and using indicator species for rapid assessment of ecosystem health would further their ongoing ecosystem approach. The Council is currently developing more specific and measurable management objectives related to ecosystem status than are in current FEPs to collect, synthesize, and report on data necessary to evaluate progress in meeting those objectives.

3.3.7 Describe available long-term monitoring data and how they are used.

The WPFEPs contain descriptions of types of ecosystem monitoring but does not describe the kind of programs that are already in place and/or how that data may be used. Descriptions of monitoring and monitoring-like programs will be updated in the revised FEPs, and data from those programs will be found in Council reports.

3.3.8 Assess the ecological, human, and institutional elements of the ecosystem.

The WPFEPs include the identification and description of essential fish habitat and conservation and management measures to minimize the impacts of fishing according to Section 303(a)7 of the MSA. This includes discussion of activities that affect essential fish habitat such as habitat loss and degradation, pollution and contamination, dredging, marine mining, water intake structures, aquaculture and introduction of exotic species. Each plan also addresses some possible mitigating effects for non-fishing activities on essential fish habitat, and some possible conservation measures. The Council is working on developing specific and measurable ecosystem management objectives that speak to various ecosystem status elements.

3.3.9 Summary

Overall, the WPFEPs incorporated parts of some of the eight EPAP recommendations. The plans have been updated and amended since their original publication in 2009, and contain relevant and useful information about the ecosystems in the Western Pacific. These FEPs are considerably different from those created by other Councils as they are documents that contain all of the required conservation and management measures required by Section 303(a) of the MSA, and serve as the region's FMPs.

3.4 South Atlantic Fishery Management Council

For the South Atlantic, we reviewed the South Atlantic FEP as well as Comprehensive Ecosystem Amendments 1 and 2. The South Atlantic FEP is a large compilation of information (6 volumes), and was designed as a source document. The Council adopted broad goals for ecosystem-based management that include: maintaining or improving ecosystem structure and

function, maintain or improving economic, social and cultural benefits from resources, and maintaining or improving biological, economic and cultural diversity. The FEP serves as a source document and presents more complete and detailed information describing the South Atlantic ecosystem and the impact of the fisheries on the environment. The South Atlantic Fishery Management Council has also published two comprehensive ecosystem-based FMP amendments (CEBA1 in 2009 and CEBA2 in 2011), which implement specific conservation and management measures. The FEP is referenced throughout those amendments. A third CEBA, related to bycatch, is under development. Management actions in CEBA1 included establishment of deepwater Coral Habitat Areas of Particular Concern (HAPCs) and prohibiting the use of bottom damaging fishing gear to protect a large contiguous distribution of deepwater coral ecosystems in the South Atlantic. CEBA1 also allows for the creation of fishing zones within HAPCs in historical fishing grounds for golden crab and deepwater shrimp fisheries. CEBA2 amended the FMPs to respond to ecosystem issues that go across multiple fisheries as opposed to single species management for those issues. Actions under CEBA2 included modifying management of octocorals in the South Atlantic through the establishment of an annual catch limit, modifying how special management zones off South Carolina are managed, revising sea turtle release and smalltooth sawfish gear requirements for the snapper grouper fishery, and designating EFH and EFH-HAPCs in the South Atlantic. The actions in CEBA2 were needed to remain in compliance with the MSA and address concerns from fishermen.

3.4.1 Delineate the geographic extent of the ecosystem(s)

The SAFEP describes the extent of the ecosystem as the region under the jurisdiction of the Council inland through the region's coastal watersheds. The South Atlantic ecosystem area intersects two Large Marine Ecosystems and interacts with the Gulf of Mexico and Mid-Atlantic Regions and the Bahamas and Sargasso Sea. The plan includes descriptions of some of the many types of ecosystems found in the area under Council control including freshwater, estuarine, marine and offshore systems. Habitat is discussed in great detail throughout the plan. Each of the CEBA amendments also describes the particular attributes of the ecosystems affected by the management actions in the amendment. Appendix B Volume of the SAFEP presents area associated with all Council managed areas including, Special Management Zones, Deepwater Coral HAPCs, and gear and species year round closures. The biological, chemical and physical dynamics of the ecosystem are discussed in Volumes 1-3 and the oceanographic characterization or monthly climate variability is presented in Appendix A Volume 1. The FEP does not identify zones within the South Atlantic Ecosystem for alternative uses.

3.4.2 Develop a conceptual model of the food web

The SAFEP includes descriptions of species and habitats that make up the food web in chapter 2 of the FEP. The FEP highlights that the Council worked cooperatively with the University of British Columbia and the Sea Around Us project to develop a straw-man and preliminary food

web models (Ecopath with Ecosim) to characterize the ecological relationships of South Atlantic species, including those managed by the Council.

3.4.3 Describe the habitat needs for all plants and animals included in the significant food web

The SAFEP provides details on all managed species (SAFMC, South Atlantic States, ASMFC, and NOAA Fisheries Highly Migratory Species and Protected Species), including their biology, ecology, and food web dynamics. Volume 2 of the plan contains detailed information on various habitats within the ecosystem. Also included are descriptions of species under Council management including information on reproduction, growth and movement, ecological relationships, distribution, habitat, abundance and stock status. The habitat information provided in the plan and CEBA amendments (1 and 2) is extensive, and includes available information about habitat needs for different life stages for Council managed species but not for all plants and animals that are considered part of the ‘significant food web’. The focus of CEBA1 is to protect a large deepwater coral ecosystem. Regulatory actions under CEBA1 establish deepwater coral HAPCs, and prohibit the use of bottom fishing gear, and allow for fishing zones within coral HAPCs in historical fishing grounds for golden crab and deepwater shrimp. CEBA1 also updates EFH descriptions. CEBA2 also addresses endangered species. Species of concern are identified and descriptions provided, but neither amendment describes how habitat needs should be considered in conservation and management measures.

3.4.4 Calculate total removals

The FEP presents information on all managed fisheries their status and removals. In addition, Appendix B Volume III includes spatial presentations of all commercial catch from the Atlantic Coastal Cooperative Statistics Program (ACCSP) averaged 1990-2006. CEBA1 and CEBA2 include some historical information on the number of vessels landing, and total landings for related fisheries. Managed species and associated bycatch are addressed in both amendments and the issue of total removals is investigated. The broader discussion of how total removals relate to biomass, production, optimum yield, natural mortality, or trophic structure is limited.

3.4.5 Assess how uncertainty is characterized

The SAFEP, CEBA1 and CEBA2 include discussions of applying buffers for stock conservation and management. They also highlight the Council’s approach for protecting sensitive essential habitat from fishing impacts to mitigate some uncertainty in stock conservation and management.

3.4.6 Develop indices of ecosystem health as targets for management.

The SAFEP includes a chapter on threats to the South Atlantic ecosystem and recommendations but specific indices of ecosystem health, as targets for management are not included. CEBA1

and CEBA2 do not include any discussion surrounding development of indices of ecosystem health as targets for management.

3.4.7 Describe available long-term monitoring data and how they are used.

The FEP summarizes existing research programs and identifies biological, social, and economic research needed to fully address EBFM in the region. The SAFEP also includes a description of the South Atlantic's monitoring priorities since 2008. Actions for 2008-2012 included collecting basic data elements by fishery, collecting biological and survey information to support stock assessments, and collection of information to support evaluation and refinement of management programs and actions. Outlined in the plan are also long-term research needs. CEBA1 does not describe available monitoring data but there is some discussion about the Council's intent to investigate monitoring and enforcement tools for future use in some fisheries. CEBA2 discusses coral, coral reefs and coral community habitat status as it relates to monitoring efforts that originated as impact and mitigation studies from adverse environmental impacts to specific sites. CEBA2 does mention that modifying the annual catch limit for octocorals would require monitoring and documentation to track the annual catch limit, and that this would result in additional cost and personnel resources unless this monitoring mechanism is already in place.

3.4.8 Assess the ecological, human, and institutional elements of the ecosystem.

The SAFEP discussed the ecological elements of the ecosystem in volumes 1-5 of the document. The plan discusses the ecological, human, and institution elements of the ecosystem through a discussion of the threats to the South Atlantic ecosystem from sources that are generally landward of the shoreline (e.g., agriculture, aquaculture, urban development) or those that occur oceanward of the shoreline (e.g., navigation, dumping, marine debris). Most threats to the South Atlantic ecosystem are discussed in relation to how EFH may be affected. CEBA1 and CEBA2 focus on impacts of the proposed actions within the amendments on the ecosystem, and less on anticipating how ecosystem drivers outside Council authority may affect fisheries. CEBA1 includes a discussion of actions affecting the resources in the ecosystem, including human impacts and the activities that may have negative effects. However, those topics discussed are not necessarily outside Council authority and there is not a strategy to address those influences. CEBA2 discusses biological, social, economic and administrative effects of each of the alternative amendments for the proposed actions but does not go into detail or assess the ecological, human and institutional elements of the system that are outside Council/Department of Commerce authority. The plan does not include a strategy for how to address influences included in the plan.

3.4.9 Summary

Overall the South Atlantic Council's FEP and CEBA1 and CEBA2 incorporated parts of the eight EPAP recommendations. The overarching FEP document is largely centered on habitat, and the amendments are slightly different from FEPs and initiatives created by other Councils as

they direct specific management actions within regions of the South Atlantic. The documents discussed here contain relevant and useful information about the South Atlantic ecosystem and the fisheries in the region.

4.0 Discussion

4.1 Discussion of the EPAP recommendations

The purpose of the eight EPAP recommendations was to advance EBFM through the development of FEPs that guide the incorporation of ecosystem-based conservation and management measures in FMPs. This benchmarking review of the EPAP recommendations with existing FEPs revealed the relative importance of some EPAP recommendations over others in developing FEPs that advance ecosystem-based approaches to fisheries management. This benchmarking review also provides a snapshot of the varying approaches Councils have used to develop FEPs and the different goals they have for using FEPs.

Overall, ten different FEPs were prepared by four different Councils. All covered similar ideas and principles, with each FEP varying depending on the needs of a specific Council and the fisheries and ecosystems under their jurisdiction. For example, the Pacific Fishery Management Council has set up their FEP to create a framework for setting policies and priorities to be implemented through FMP amendments and for tracking progress through a set of indicators. In some cases, the FEPs developed were compilations of ecosystem information with a strong focus on habitat that supported implementation of MSA essential fish habitat. Others, such as the Aleutian Island FEP, were primarily reference documents of ecosystem information to facilitate efficient implementation through FMPs. The Western Pacific FEPs contain conservation and management measures and meet the requirements of FMPs, but reflect groupings of managed stocks around geographically defined island/archipelago areas and are called FEPs.

Each FEP reflected some, but not all of the EPAP recommendations, and some recommendations were used more extensively than others. We have summarized the percent of FEPs that incorporated recommendations in 3 categories: incorporated in detail; partially incorporated; or minimally incorporated (Table 1). Some of the FEPs did not fully incorporate recommendations because they were addressed in other documents (such as ecosystem chapters of SAFE reports, stock assessments, and FMP amendments). Using alternative documents has made it easier for some of the Councils to update crucial ecosystem related information without having to update an entire FEP. For example, the North Pacific supplements information in their FEP with ecosystem chapters of SAFE reports that are regularly updated. Additionally, to meet the requirements for essential fish habitat under section 303(a)7 of the Magnuson Stevens Act, Council FMPs already identify, and describe EFH, which was helpful in meeting aspects of the third EPAP recommendation.

Table 1: % of FEPs reviewed that incorporated in detail, partially incorporated, or minimally/did not incorporate each EPAP recommendation				
EPAP Recommendations	Incorporated in detail	Partially Incorporated	Minimally/not Incorporated	Notes about recommendation
1. Delineate the geographic extent of the ecosystem(s) that occur(s) within Council authority, including characterization of the biological, chemical and physical dynamics of those ecosystems, and "zone" the area for alternative uses.	70%	20%	10%	While most FEPs did define the area the FEP covered, they did not zone their area for alternative uses.
2. Develop a conceptual model of the food web	20%	0%	80%	Councils found this recommendation not as useful for informing conservation and management measures in FMPs.
3. Describe the habitat needs of different life history stages for all plants and animals that represent the "significant food web" and how they are considered in conservation and management measures.	0%	100%	0%	Councils found this recommendation to not be as useful as others for informing conservation and management measures because Councils already must meet requirements for EFH.
4. A. Calculate total removals-including incidental mortality	0%	20%	80%	Because most of this information could be found in other Council documents this recommendation was not typically incorporated.
4. B. show how total removals relate to standing biomass, production, optimum yields, natural mortality and trophic structure.	0%	0%	100%	Because most of this information could be found in other Council documents this part of the fourth EPAP recommendation was not incorporated
5. A. Assess how uncertainty is characterized	0%	20%	80%	Councils generally address uncertainty during the process of establishing annual catch limits, which is a management approach that was developed after the EPAP recommendations were released.
5. B. What kind of buffers against uncertainty are included in conservation and management	0%	0%	100%	The EPAP report does not elaborate on additional elements of uncertainty that should be addressed in responding to this recommendation.
6. Develop indices of ecosystem health as targets for management.	0%	80%	20%	There are several steps between developing ecosystem indicators and using them in the context of management targets that are not clearly articulated in the EPAP report, which contributed to the lack of information on this topic in all the FEPs
7. Describe available long-term monitoring data and how they are used.	20%	20%	60%	Use of this recommendation was mixed, and in many cases information was available in other documents or at least mentioned within the FEP.
8.A. Assess the ecological, human, and institutional elements of the ecosystem which most significantly affect fisheries, and are outside Council/Department of Commerce (DOC) authority.	0%	40%	60%	Absent more specific direction about how to do such an assessment to inform actionable FEPs, this recommendation was largely viewed as too substantial an undertaking by Councils.
8. B. Included should be a strategy to address those influences in order to achieve both FMP and FEP objectives	0%	20%	80%	Absent more specific direction about how to do such an assessment to inform actionable FEPs, this recommendation was largely viewed as too substantial an undertaking by Councils.

Other FEPs did not contain material related to one or more EPAP recommendations, because the recommendation was seen as unclear or required analysis of information that didn't exist. For example, the recommendation to delineate the geographic extent of the ecosystem was largely addressed in all FEPs (recommendation #1). However, the second part of that recommendation to zone areas for alternate uses was not addressed in any of the FEPs. Many Councils viewed that part of the recommendation as beyond the scope of their authority. Similarly, the recommendation (#2) to develop a conceptual model of the food web and describe all life stages of animals considered part of the significant food web (recommendation #3) were not as useful for informing conservation and management measures in FMPs, and only a few Councils fully addressed those EPAP recommendations in their FEPs. An estimate of total removals (recommendation #4) helps fishery managers understand harvest impacts and manage across multiple fisheries. While many FEPs did not include these estimates, several Councils did use supporting information about total removals such as SAFE reports, or FMP amendments. For example, in order to meet the requirements of EFH, councils updated FMPs to identify and describe essential fish habitat for fisheries. And some Councils, including the North Pacific and Western Pacific, use SAFE reports to present information on total removals, stock assessments, and regularly updated ecosystem information. Finally, while the AIFEP doesn't include estimates of total removals, discussion of total catch allocated is included.

Most of the FEPs did not include assessments of uncertainty as called for in recommendation #5. Councils generally address uncertainty during the process of establishing annual catch limits, which is a management approach that was developed after the EPAP recommendations were released. The EPAP report does not elaborate on additional elements of uncertainty that should be addressed in responding to recommendation #5. This lack of clarity on approaches and options for addressing uncertainty with existing and available information was an impediment to address this recommendation more fully. Many FEPs included varying degrees of discussion about ecosystem indicators (recommendation # 6), but the second part of the recommendation to link the use of those indicators as targets for management was largely unaddressed. There are several steps between developing ecosystem indicators and using them in the context of management targets that are not clearly articulated in the EPAP report, which contributed to the lack of information on this topic in all the FEPs. Most FEPs did address in part recommendation #8 to fully assess ecological, human, and institutional elements of the system that affect fisheries. However, absent more specific direction about how to do such an assessment to inform actionable FEPs, this recommendation was largely viewed as too substantial an undertaking. This lack of clarity explains why most FEPs also didn't include specific strategies to address the influence of those elements on FEP and FMP goals and objectives. Another challenge with this recommendation is that it assumes that the FEP contains goals and objectives which the EPAP recommendations don't explicitly call for.

4.2 Discussion of key elements of FEPs not contained in the EPAP recommendations

Through our review, we also identified three key concepts central to the development of FEPs that are not addressed directly in the EPAP recommendation, but that would further strengthen FEPs. These include the establishment of ecosystem goals and objectives, using ecosystem indicators to monitor progress or conservation and management needs, and the role of trade-off analysis in optimizing yield across an ecosystem. The EPAP recommendations that address the concepts of total removals and monitoring progress, presume that goals and objectives have been established, that indices for monitoring progress in achieving those goals have been developed and that approaches are in place for evaluating tradeoffs to maximize progress towards achieving those goals. However the EPAP does not explicitly address these three concepts. We suggest that further clarifying these three concepts would enhance the ability of Councils to respond to the original EPAP recommendations and further strengthen FEPs.

4.2.1 Goals and objectives

Defining clear, attainable management goals for an ecosystem is one of the most challenging aspects of EBFM (Link, 2005). Each of the FEPs examined in this review included statements about why the document was created and how it was to be used. However, missing from each of the FEPs were clear goals and objectives for the ecosystem itself from a fisheries perspective. There are many different approaches identified in the literature for framing and developing ecosystem goals and objectives that could inform future FEP development (Rosenberg and McLeod 2005, Levin and Lubchenco 2008, Palumbi et al. 2008, Hilborn 2007).

Defining goals and objectives was not an explicit recommendation in the EPAP report; however it was implied in the recommendations to monitor, develop indicators, and assessing uncertainty. Ecosystem goals and objectives are important for operationalizing the FEP through FMPs as called for in EPAP, because they will establish the ecosystem priorities for the Councils and can serve as the basis for assessing tradeoffs in selecting conserving and management measures through FMPs. Achieving agreement on the goals of an FEP will ultimately aid in achieving those goals (Ruckelshaus 2008).

4.2.2 Tradeoffs

Trade-off analyses play a critical role in optimizing yield across fisheries within an ecosystem and transitioning to EBFM. It is the process by which different management options are evaluated to help understand and balance impacts across competing goals and objectives (Patrick and Link, 2015). Goals and objectives should be presented in a way that allows for fisheries managers to prioritize among a range of tradeoffs.

While the EPAP recommendations call for FEPs to address issues such as total removals and uncertainty which implies doing a trade-off analysis, the EPAP recommendations do not

explicitly call for a trade-off analysis or how to do that analysis. Since the publication of the EPAP recommendation, several articles that address the importance of and approaches for conducting trade-off analysis have been published (Sainsbury et al., 2000; Levin et al., 2009; Link, 2010). For example, one way to approach trade-off analysis could be through the management strategy evaluation (MSE) process (Link, 2010) across a range of objectives (Smith, 1994), for both target species and the larger ecosystem (Sainsbury et al., 2000). Such an approach depends on well-defined fisheries ecosystem objectives, performance measures for each objective, alternative management strategies, and an evaluation process for each strategy (Link, 2010, Sainsbury et al., 2000, Punt et al. In press).

4.2.3 Indicators

The use of indicators or decision criteria is needed to evaluate and assess what steps are needed to achieve one's goals (Link, 2005). While the 6th EPAP recommendation speaks to using indicators in management and some of the FEP documents we reviewed did include ecosystem indicators, there was no clear indication of how, or if, those indicators were incorporated into management decisions or related to the stated goals of the FEP or fisheries in general. Having an effective FEP will require indicators to follow and identify any changes in status to any or all parts of the ecosystem (Samhuri et al. 2010).

Ecosystem indicators are necessary in order for Councils to be able to address how all activities and ecosystem components may be affecting a fishery (Link, 2010). To be most effective, indicators need to identify major processes within the ecosystem, and lead to stated objectives. And, if indicators are accepted or vetted by the larger stakeholder community, they're more likely to be accepted in the management context (Smith et al., 2008, Link, 2010). Indicators may be biological in nature, but will also need to incorporate topics beyond achieving optimum biological yield and include other ecosystem goals like conservation, and social and economic considerations (Kellner et al. 2011). Indicators that facilitate EBFM fall into 3 broad groups: biological (size, production etc.), physical (habitat) and socioeconomic (Rice and Rochert 2005, Link 2010).

5.0 Conclusions

We found a range of variability in how FEP documents were created, used, and structured. The 1999 EPAP recommendations provide a starting point for many of the Councils that developed FEPs. However, it is also clear that some of those recommendations would be more effective with additional guidance on how to implement them and some recommendations were not relevant given available information or other ongoing processes and analyses in FMP-related documents. As we continue to develop and refine FEPs, it will be important to consider goals and objectives, tradeoffs, and indicators. Due to the wide range of approaches and use of the FEPs, it is clear that each Council has different needs and priorities and no single template would work for all. Future recommendations for FEPs should maintain the need for flexibility in

fisheries management, while also promoting consistency in creation, implementation and use of FEPs between regions.

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7.0 References

16 U.S.C. §1882.

16 U.S.C. §1853(a)

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