# Case Studies and Lessons Learned from Fishery Ecosystem Planning


**White Paper**

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# EXECUTIVE SUMMARY

The National Marine Fisheries Service (NMFS) has long recognized the need for an ecosystem-based approach to managing the nation's fisheries. NMFS policy has mandated Fishery Ecosystem Plans (FEPs) as the primary tool for Regional Fisheries Management Councils (RFMCs) to enact and incorporate Ecosystem Based Fisheries Management (EBFM). There is broad agreement on the value of this approach, but it has been complicated and challenging to implement. Most RFMCs have developed FEPs to varying degrees and with widely varying styles, though their utility has been limited by the general lack of actionable guidance.

The Gulf of Mexico Fishery Management Council (Gulf Council), presently has appointed the Ecosystem Technical Committee (ETC) as an advisory body to assist with the development of a FEP. In March 2020, the ETC proposed a mission statement for the FEP:

*"To provide a framework for integrating ecosystem science into the Council's decision making for long-term ecological and socioeconomic sustainability of Gulf of Mexico resources".*

The Gulf Council contracted LGL Ecological Research Associates, Inc. (LGL) to develop a framework and draft FEP in close coordination with the Gulf Council and NOAA Fisheries Southeast Fisheries Science Center (SEFSC). This document is meant to provide guidance to the Gulf Council based on FEP experiences from other U.S. RFMCs. The case studies are not exhaustive or comprehensive but are designed to capture lessons and actionable examples that could be adopted in the Gulf of Mexico Fishery Ecosystem Plan (Gulf FEP).

The document begins with an introduction to the challenges of FEP development and implementation followed by a brief history of the policy and legal basis for FEP development and guidance in the United States. Chapter 1 concludes with a brief comparison between the seven Fishery Management Regions to set the stage for Case Studies. Chapter 2 provides Case Studies of FEP development and implementation in each of seven Regions, each concluding with a summary of best practices and lessons learned. Chapter 3 provides specific recommendations for the Gulf Council, based on a synthesis of lessons learned and applicability to the Gulf.

LGL recommends that the Gulf FEP should provide a framework and guidance to achieve EBFM that should be accomplished through five priority actions:

1. Develop a common vision of EBFM in the Gulf
2. Use Fishery Ecosystem Issues to address specific priorities
3. Engage stakeholders fully and effectively
4. Build a Citizen Science and Cooperative Research Program
5. Address extra jurisdictional issues

Further details for each of these actions is outlined briefly herein and specific guidance, tools and mechanisms for implementation will be provided in a forthcoming draft FEP.

# ABBREVIATIONS USED IN THIS DOCUMENT

| | |
|---|---|
| ACL | allowable catch limit |
| CCCT | Climate and Communities Core Team |
| CCE | California Current Ecosystem |
| CCIEA | California Current Integrated Ecosystem Assessment |
| EAFM | Ecosystem Approach to Fisheries Management |
| EBFM | Ecosystem Based Fisheries Management |
| EEZ | Exclusive Economic Zone |
| eFEP | Example Fisheries Ecosystem Plan |
| EFH | Essential Fish Habitat |
| EFP | exempted fishing permit |
| EPA | Environmental Protection Agency |
| EPAP | Ecosystems Principles Advisory Panel |
| EPU | Ecological Production Unit |
| ETC | Ecosystem Technical Committee |
| FEP | Fishery Ecosystem Plan |
| FMP | Fishery Management Plan |
| FRA | Fish Replenishment Area |
| HAPC | Habitat Areas of Particular Concern |
| ICCAT | International Commission on the Conservation of Atlantic Tunas |
| IEA | Integrated Ecosystem Assessment |
| LGL | LGL Ecological Research Associates, Inc. |
| LME | Large Marine Ecosystem |
| MMA | Marine Managed Area |
| MPA | Marine Protected Area |
| MSA | Magnuson-Stevens Act |
| MSE | Management Strategy Evaluation |
| MSY | maximum sustainable yield |
| NEFSC | Northeast Fisheries Science Center |
| NEPA | National Environmental Policy Act |
| NGO | Non-Government Organization |
| NMFS | National Marine Fisheries Service |
| OY | optimum yield |
| RFMC | Regional Fishery Management Council |
| ROSA | Responsible Offshore Science Alliance |
| SAFE | stock assessment and fishery evaluation |
| SEFSC | Southeast Fisheries Science Center |
| SMZ | Special Management Zones |
| SSC | Science and Statistical Committee |

# GLOSSARY

Action Module: A management tool (used by the Pacific Council) describing a focused process whereby a task force focusses efforts on a specific fishery issue, defining objectives, and ultimately providing management advice.

Assessment Model: A statistical tool used to assess the status of a trophic guild, multispecies complex or stock. Assessments can range from an empirical indicator to more complex techniques such as an age-structured population model.

Conceptual Model: Descriptive mental concept of how a holistic fishery ecosystem functions, including the relationships among components.

Ecological Production Unit: A defined area containing all or the majority of an ecosystem where place-based management would be implemented. The EPU concept is used by the New England Council to ensure that the total removals from an ecosystem are directly linked to the productivity of that ecosystem.

Ecosystem: A geographic area or system that includes all of the biotic and abiotic system components and their interactions.

Ecosystem Based Fisheries Management: A systematic approach to fisheries management in a geographically specified area that contributes to the resilience and sustainability of the ecosystem; recognizes the physical, biological, economic, and social interactions among the affected fishery-related components of the ecosystem, including humans; and seeks to optimize benefits among a diverse set of societal goals. (NMFS 2016a)

Ecosystem Management: A holistic way of managing marine resources for system sustainability.

Ecosystem Indicators: Quantitative biological, chemical, physical, social, or economic measurements that serve as proxies of the conditions of attributes of natural and socio-economic systems.

Fishery: A fishery is a system that consists of linked biophysical and human subsystems with interacting ecological, economic, social, cultural and institutional elements (Essington et al. 2016).

Local Knowledge: Knowledge that people in a given community have developed over time, and continue to develop, based on experience, often tested over centuries of use, and adapted to the local culture and environment.

Management Objective: A clearly defined goal for the status of the ecosystem, or parts of it, and/or the status of the social/economic components for people relying on the ecosystem.

Maximum Sustainable Yield: The maximum level at which a fishery stock can be routinely exploited without long-term depletion.

Mental Model: An explanation of a thought process, representing the surrounding world and the relationships between its various parts.

Optimum Yield: The amount of fish that "will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems" (Sustainable Fisheries Act of 1997).

Resilience: The capacity of a system to return to a previous state following disturbances or perturbations.

Species Complex: A group of species that are caught together, share common life history characteristics, and play similar roles in the ecosystem with respect to energy transfer (e.g., eat similar food items).

Traditional Knowledge: Knowledge, skills and practices that are developed, sustained and passed on from generation to generation within a community, often forming part of its cultural or spiritual identity.

Triple Bottom Line: Ecosystem based fisheries management (EBFM) is often considered as managing towards a triple bottom line because it considers ecological, economic and social criteria.

Trophic Guilds: A group of species that utilize similar resources such as feeding on similar items or have similar dietary requirements and therefore can help define a Species Complex.

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# CHAPTER 1. INTRODUCTION

## 1.1 Introduction

The Gulf Council, along with all other Regional Fisheries Management Councils (RFMCs) were tasked with incorporating ecosystem-based fisheries management (EBFM) into management efforts with guidance from NOAA's EBFM Policy and EBFM Roadmap (NMFS 2016a; 2016b). These mandates follow from a long history of incremental policy and legislative steps, starting in 1871, with the establishment of the Fisheries Commission (see section 1.2). These policies are well grounded in numerous calls to implement EBFM (e.g., Pikitch et al. 2004, Fulton et al., 2014). Though a myriad of definitions of EBFM have emerged with subtle differences among them (Trochta et al., 2018), we herein adopt the definition of Fishery Ecosystem Planning from Link (2010). EBFM aims to manage fisheries as part of an integrated system (including physical, biological, economic, and social components) in order to optimize yields of all fisheries in an ecosystem. To do so requires evaluating cumulative impacts and tradeoffs from competing objectives and interests. Achieving EBFM will require that ecosystem considerations reach a level of management importance presently reserved only for managed species (Pikitch et al. 2004).

The Gulf Council endeavors to develop a Fisheries Ecosystem Plan (FEP) for the Gulf of Mexico (Gulf) that can be used to inform management decisions. To that end, the Gulf Council contracted LGL Ecological Research Associates, Inc. (LGL) to assist in that process. This document, one of the contract deliverables, is meant to provide guidance to the Gulf Council based on FEP experiences from other RFMCs. The case studies are not meant to be comprehensive, nor exhaustive, but rather selective based on the explicit request of the Gulf Council that any FEP guidance be "actionable". Herein we attempt to capture those lessons and tools that are most valuable and useful and could be adopted in the Gulf FEP.

The Mission statement proposed on 2 March 2020 by the Gulf Council Ecosystem Technical Committee (ETC) is:

> *"To provide a framework for integrating ecosystem science into the Council's decision making for long term ecological and socioeconomic sustainability of Gulf of Mexico resources".*

To inform FEP development for the Gulf, this document includes this introductory chapter which highlights some of the challenges to EBFM implementation followed by a brief history of the major steps the U.S. has taken to include ecosystem concerns in fisheries management. Chapter 2 offers brief case studies of the FEP development experiences from each of the nation's other RFMCs: North Pacific, Caribbean, South Atlantic, Pacific, New England, Mid-Atlantic, and Western Pacific. Chapter 3 provides a synthesis of lessons learned by theme and offers a set of recommendations for the Gulf Council. The overall intent of the document is help set the stage and guide development of an actionable FEP for the Gulf of Mexico.

## 1.2 Challenges of Implementation

The ETC categorized challenges to implementation (March 2020) to include:

- The complexity of fishery ecosystems
- Gulf Council burden to meet existing demands
- The assumption that fisheries should be managed to achieve Maximum Sustainable Yield (MSY) and the primary focus and use to guide existing management measures.
- Three major threats and impacts to Gulf fisheries are generated outside the jurisdiction of the Gulf Council (e.g., upland sources of nutrients and pollution, coastal development, and climate change)
- There are limitations on the utility of ecosystem models' utility to guide management.
- There is a need to involve stakeholders at all stages, but there are limitations on existing frameworks, process and resources to do so.
- The lack of a common vision.

These and other challenges are detailed below.

Fishery Ecosystem Complexity

An ecosystem is a geographic area or system that includes all of the biotic (organisms) and abiotic (physical environment) system components and their interactions. Attempts to understand the complexity of ecosystems requires consideration of at least three dimensions: (1) spatial heterogeneity, (2) organizational connectivity, and (3) temporal contingency (Cadenasso et al. 2006). Spatial heterogeneity considers the elements and components of the ecosystem and how they are arranged. Organizational connectivity considers the relationships and interactions of those pieces. Temporal contingency considers how those pieces change through time including slowly emerging indirect effects, lagged linkages, and historical processes. This complexity inherent to ecosystems results in self-organization, emergent properties, and non-linear behavior of its components (Cadenasso et al. 2006). Conceptually describing the complexity of ecosystems can be fairly intuitive, but taking it into account to make quantitative, or even qualitative, predictions presents a significant challenge. Progress on those fronts requires considerable attention to scale, sampling frames, life-histories of taxa, and metapopulation dynamics of species. Historically, efforts to understand ecosystems fall back on tracking energy or nutrient flows, rather than on specific system components (as would be useful for management decisions geared toward individual species or stocks) (Gates 1968). Ecosystem models provide a potential avenue for focusing on particular species of interest in the broader context but are not without significant complications and by the same token, simplifications (see below for further discussion) (Collie et al. 2016).

Further complicating matters, marine ecosystems tend to be more complex than terrestrial systems because of the highly dynamic (literally, fluid) nature of oceans (Carr et al. 2003; Putman 2018), and shift more rapidly in response to changing physical pressures (Burrows et al. 2011). The ecosystem science of marine fisheries itself pertains to the biophysical and behavioral intricacies of many linked species, but also the complex ocean systems that contain and condition such species and populations over time.

The equation is further complicated when human systems are introduced, as these are intimately part of a "Fishery Ecosystem". Humans both drive marine fisheries and affect the ocean environment directly and indirectly through the overarching relationships between ocean, earth, atmosphere, and human society. From the perspective of fishery management, adequate understanding of such systems is vital to decisions that have the potential to affect a wide diversity of stakeholders with differing perspectives and interests. Stakeholders include those involved with the harvest, distribution, and consumption of seafood. In addition, stakeholders include those in the tourism, agriculture, coastal development, and other industries, as well as regulatory agencies with often overlapping jurisdiction. All of these existing linkages are further confounded by the continually shifting socioeconomic, demographic, and environmental context.

Limitations on Bandwidth to Meet Existing Demands

Despite the national call for EBFM, RFMCs have an existing heavy burden to meet science and management needs that arise from the dominant single species stock management paradigm (Marshall et al., 2018).

Paradigm of Single Species Management

Fisheries management in the U.S. has almost exclusively been applied at the level of single species stocks.

A single species stock is a group of fish of the same species that live in the same geographic area and mix enough to breed with each other. The goals of single-species management are relatively straightforward and easily understood by the suite of stakeholders that interact with that species (Mace et al. 2004). Nonetheless, individual species do not operate in isolation. Integrating the considerations of the species and environment with which it interacts is necessary to manage even a focal species.

Managing Fisheries to Achieve MSY

Current efforts to manage single species stocks or multi-species stock complexes may complicate attempts to manage fisheries at an ecosystem level. When stocks become overfished, the National Marine Fisheries Service (NMFS) is obligated to develop rebuilding plans that will allow fishing to continue at a reduced level so the stock can rebuild to its target level and produce its MSY. MSY is the largest long-term average catch that can be taken from a stock under prevailing environmental and fishery conditions. In practice, catch limits are not to exceed Optimum Yield, (OY) the amount of fish (lower than MSY) that "will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems" (Sustainable Fisheries Act of 1997). Maintaining catch limits at or below OY is considered as a way to include ecosystem considerations in stock management.

In multi-species fisheries it may not be possible to harvest every species at levels that maximize yields or economic benefits without harming other components of the ecosystem. For instance, if multiple species are captured in a fishery with high discard mortality (e.g., trawl fisheries, or fisheries with severe barotrauma issues) there will often be a "choke" species (either targeted within the fishery, or caught as bycatch) whose allowable catch limit (ACL) is reached sooner than the other species captured in the same fishery. The remaining species cannot be harvested to

their full potential without harming the "choke" species stock. The transition to EBFM will require acceptance that some individual species will be harvested below traditional definitions of MSY/OY, or even that some species will be harvested above MSY/OY within a multi-species fishery. MSY calculations for assessed stocks may also be downward biased if early data from the fishery, when the stock was closer to an unfished state, is unavailable or not included (Pauly and Froese 2020). Additionally, MSY/OY calculations make the false assumption that stocks will experience ecosystem conditions in the future that are the same as present conditions. Effective EBFM needs to be able to adjust harvest expectations as ecosystems change.

Ecosystem Drivers Outside of Gulf Council Jurisdiction

Most RFMCs do not have management jurisdiction over some of the largest negative impacts to the fisheries they manage. The most pervasive impact is climate change. Other impacts include those generated from coastal development, and upland sources of pollution runoff, and increasing populations. Rapidly changing climate and associated increases in temperature, sea-level rise, ocean acidification, are impacting species distributions, migration patterns, phenology and thus changing the context and baseline from which fisheries are managed.

Limitations of Applying Ecosystem Models to Management

While ecosystem models may be successful in explaining how ecosystems function, the output must be translated into goals achievable through management actions. Stakeholder confidence in model output is diminished owing to their complexity, which makes them difficult to understand. Ironically, perhaps, the simplifying assumptions of ecosystem models may also reduce buy-in from stakeholders that are highly knowledgeable in a particular aspect of the ecosystem. Results not immediately intuitive may be met with skepticism (Ainsworth et al. 2018). Thus, ecosystem models run the risk of only being used to formalize existing viewpoints, rather than providing a novel understanding of linkages of ecosystem components and the ripple effects of perturbations (Rohal et al. 2020).

Tradeoff Evaluations

Humans derive goods and services from their ecosystem, actions which necessarily alter the ecosystem, and thus the ability to continue to derive goods and services from it. The need to evaluate trade-offs is an essential component to any management decision, given that ecosystem components are not independent, but function within a complex suite of interactions, which lead to different environmental or socioeconomic outcomes related to different individuals or groups (Deng et al. 2016). However, managers evaluating trade-offs in marine systems rarely have evidence for direct or mechanistic impact pathways (Mach et al. 2015). Management efforts must occur within the existing regulatory framework.

The regulatory tools needed to manage fisheries at an ecosystem level may not yet exist. Also, management decisions do not occur in a vacuum, they have consequences for the individuals and communities who rely on the fisheries that these ecosystems support. It may be difficult to overhaul existing management systems without causing economic harm to those individuals who participate in fisheries under the current management regimes. What's more, though some tools exist to identify tradeoffs, deciding who will be "winners or losers" is, obviously contentious (Cord et al. 2017). Such obstacles may be overcome if different stakeholders share a common vision.

Lack of Common Vision

The management of marine fisheries requires a complex integration of ecological, economic, social, and institutional information with the values of diverse stakeholders. Groups that interact with fish in different ways (e.g., directed fisheries versus bycatch) or for different reasons (e.g., livelihood versus leisure) often diverge in philosophies and perceptions (Johnson and Griffith 2010). As such, conflicts in shared fishery resources are common. Shared values and vision among stakeholders are a critical aspect of effective management but can be challenging to identify. An often-touted unifying value is that of ‘‘sustainability’’, described as a fishing level that can be maintained in perpetuity without major negative impacts on the fished population or the ecosystem (Pauly et al. 2002; Hilborn et al. 2003). Quantifying what is sustainable is its own scientific challenge and even if solved, “better science” does not resolve many of the most pressing management complications; notably, determining the allocation of sustainable harvest to different groups (Gallaway et al. 2020).

## 1.3 History of EBFM Development in the U.S.

The U.S. has been fortunate to be surrounded by rich and productive marine waters that have provided food security and subsistence use, commercial sale, and sport fishing starting prior to the Nation’s founding in 1776. In spite of the enormous productivity, harvesters and policy makers eventually acknowledged that the resources were finite. Starting at the end of World War II, the U.S. enacted policies to protect assets from foreign fishing fleets.

**1871:** The U.S. Commission of Fish and Fisheries was established by Congress. The Fish Commission (as it became known) had the mandate to determine if there had been diminution in the Nation’s food-fishes and if so, to determine the causes and evaluate the need for protective or precautionary measures. The same year, The Fish Commission established what became known as the Northeast Fisheries Science Center (NEFSC), primarily to examine the problem and causes of declining fish stocks in the North Atlantic. Marine ecosystem research has expanded and evolved over the next 100 years.

**1969:** The National Environmental Policy Act (NEPA) was enacted and became particularly important in providing regulatory teeth for the inclusion of ecosystem considerations in all development activities (including roads, bridges, buildings, oil and gas development, etc.) and new regulations. Indeed, NEPA requires that all federal agencies use “a systematic, interdisciplinary approach that will ensure the integrated use of the natural and social sciences in any planning and decision making which may have an impact on the human environment”. NEPA is intended to “encourage productive and enjoyable harmony between (hu)man(s) and environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of (hu)man(s); to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality.” NEPA laws are still highly applicable to fishery management and RFMCs must follow them closely in their decision-making. NEPA was developed to promote public input on decisions that have a range of regulatory options.

**1970:** The Environmental Protection Agency (EPA) was established by Congress. The EPA and the regulations it was designed to enforce have also played an important role in the gradual institutional development supporting ecosystem management.

**1972:** The Coastal Zone Management Act, Marine Mammal Protection Act, and Clean Water Acts were all passed by Congress.

**1976:** The Magnuson-Stevens Fishery Conservation and Management Act (MSA) was enacted and, provided the modern framework for marine fisheries management in the U.S. The MSA extended the nation's offshore jurisdiction to 200 nautical miles, called for an end to overfishing, and established eight RFMCs (designed roughly to correspond with the boundaries of Large Marine Ecosystems (LMEs). The RFMCs were directed to rebuild and manage each region's marine fisheries such that stocks produce MSY defined as the largest long-term average catch that can be taken from a stock under prevailing environmental and fishery conditions.

**1987:** The NMFS Program Development Plan for Ecosystems Monitoring and Fisheries Management was released by the NMFS. The plan directed RFMCs to maintain capacity to meet the demands of existing management processes but also to recognize the inherent complexities of ecosystem-based management. The RFMCs were directed to develop ecosystem models that include physical, ecological, and human systems to provide context for fisheries and protected species management. The plan stated that the models should be used to expand and direct existing research and data collection efforts to generate a more holistic understanding of the complexity surrounding the Nation's fisheries. To this end, the plan called for better integration of fisheries research and data collection efforts among the NOAA components, other Federal and state agencies, and academia.

**1996:** The Sustainable Fisheries Act was passed as an amendment to the MSA. The amended Act brought heightened attention to ecosystem-based fishery research and management. The Act introduced the need to define and conserve essential fish habitat. The Act also redefined OY as the amount of fish which: "will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems". The Ecosystems Principles Advisory Panel (EPAP) was established through the Act and was tasked with developing recommendations for applying ecosystem principles into fishery management, including habitat concerns. The EPAP determined that EBFM should be implemented by gradually replacing existing Fishery Management Plans (FMPs) with FEPs.

**2001:** An Ecosystem Approach Task Force was established by NOAA. The Task Force identified five core actions deemed essential for developing useful FEPs, including, (1) enhanced communication and cooperation within and across federal and state fishery management agencies; (2) delineation of geographic and other key parameters of marine ecosystems; (3) preparation of goals and objectives for managing living marine resources under the ecosystem paradigm; (4) formulation and application of indicators for gauging the status of marine ecosystems; and (5) examination and selection of socioeconomic data suitable for evaluating management tradeoffs.

**2004:** An Ocean Blueprint for the 21st Century (U.S. Commission on Ocean Policy 2004) was released by the Bush administration. The Blueprint identified the natural role of the RFMCs in administering the ecosystem approach: "The fishery regions were originally defined roughly along the lines of LMEs and thus have the geographic reach necessary to encompass ecosystem concerns. In addition, all RFMCs have multispecies management plans that force the RFMCs to look broadly at the ecosystem they manage." The Blueprint also provided guidance for FEPs: "Despite these positive efforts, most RFMC multispecies fishery management plans now focus only on species assemblages that are commercially important, or those taken by particular types of gear. Little attention is given to species that, while commercially insignificant, are still important to the functioning of an ecosystem.". The Blueprint suggested that FEPs should consider ecosystem components and their interrelationships including human dimensions, coastal and marine habitats, protected species, species assemblages that were not exploited (e.g., forage fish) and external environmental influences, such as pollution.

**2005:** An *ad hoc* ecosystem working group was convened by scientists and managers at NOAA fisheries. The group objective was to formulate guidance to RFMCs for incorporating ecosystem concepts and principles into the fishery management process, specifically through FEPs.

**2007:** The Magnuson-Stevens Fishery Conservation and Management Reauthorization Act was enacted by Congress. The Act acknowledged that several RFMCs had demonstrated significant progress in integrating ecosystem considerations into fisheries management using existing legislation. The Act also called for a study that addressed "the state of the science for advancing the concepts and integration of ecosystem considerations in regional fishery management", and provided ten national standard guidelines for RFMCs to advance EBFM in management.

**2010:** The Integrated Ecosystem Assessment (IEA) program was launched by NOAA to augment scientific understanding of marine ecosystems and the potential application of such understanding to fishery management issues around the nation. Subsequent to its inception, the program has undertaken work in five regions as it plays a key role in refining and implementing federal ecosystem-based fishery management policy.

**2016:** An EBFM Policy and EBFM Roadmap were released by NOAA to help the RFMCs further incorporate EBFM into their management efforts (NMFS 2016a; 2016b) and selected Fishery Ecosystem Planning (FEP) as the primary tool to implement EBFM. According to this guidance, the plans are based on the following six actions or guiding principles: (1) implementation of regional ecosystem-level planning, (2) advancement of understanding regarding ecosystem processes, (3) prioritization of vulnerabilities and risks among the nation's marine ecosystems, (4) the exploration and addressing of management trade-offs with respect to a given ecosystem, (5) incorporation of ecosystem considerations into management advice, and (6) the maintenance of resilient marine ecosystems around the nation.

**2017- present:** RFMCs have developed FEPs and other ecosystem management measures, detailed within case studies in Chapter 2.

# CHAPTER 2. REGIONAL FISHERY MANAGEMENT COUNCILS' EFFORTS AND EXPERIENCES

In this section we provide brief case studies of the Fishery Ecosystem Planning (FEP) experiences of seven Regional Fishery Management Council (RFMCs) Each of the RFMC regions has a unique diversity of fisheries, cultures, environments, and socio-economic settings, which have spurred innovations and a corresponding diversity of approaches to Fishery Ecosystem Planning. Along with diversity there are also convergences, suggesting broad utility of some approaches. This chapter highlights best practices and lessons learned from each Regional Case Study, to identify the best and most relevant examples, and tools that could be emulated or incorporated into the Gulf FEP.

The offshore waters under U.S. federal jurisdiction are managed through eight RFMCs (Figure 2.1) that vary in widely in their size, landings and revenue. Link and Marshak (2019) provide a comprehensive, comparative analysis of the regions' fishery ecosystems with an aim to identify the determinants of success in moving to EBFM. It serves as an excellent, companion resource for readers of this document.

Pointing to a few broad comparisons, we note that the Western Pacific region contains over 50% of the U.S. EEZ, but the lowest annual landings (35 million lbs.) and revenue ($118 million) from reported landings (Table 2.1). The North Pacific region contains 25% of the nation's coastlines and some of the world's most productive fisheries – resulting in the highest annual landings by weight (5,631 million lbs.) and highest annual revenue ($1.6 billion) of any other region (Table 2.1 A and B). The Caribbean Region, by contrast, has negligible landings compared to other regions and has only limited capacity and infrastructure to accurately report landings. The New England Region has the smallest area under jurisdiction (Link and Marshak 2019) but some of the nations' most lucrative fisheries (including scallops and lobsters) that contribute to the region's relatively high annual revenue ($550 million). There is a range in species targeted, volumes and revenue of landings, and sport fishing effort (Table 2.1), fishing gears and techniques, governance capacity and management tools and approaches.

The Gulf of Mexico is the nation's second most productive fishery measured by weight of landings (1.74 billion lbs.) and revenue ($1.33 billion; Table 2.1 A and B). The Gulf also boasts the most annual recreational fishing trips of any other RFMC (19.5 million) or roughly a third of all recreational trips taken in the nation (Table 2.1 C). The FEP needs of the Gulf are unique in the nation, though many valuable lessons and examples are identified herein. It would be impossible to capture all of the great work that has been done to develop EBFM throughout the nation.

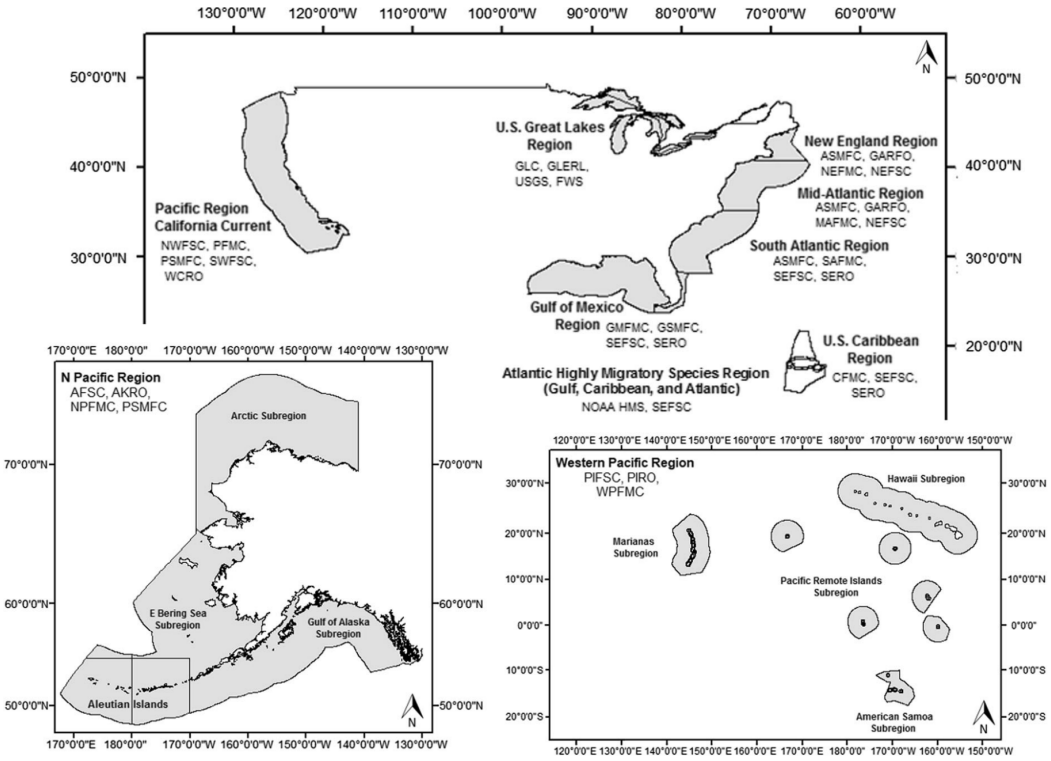


**Figure 2.1.** Regional Fisheries Management Council jurisdictions and associated management and scientific institutions (Link and Marshak, 2019)

**Table 2.1.** Comparisons between Regions: A) Commercial landings (millions of lbs.), B) Commercial Landings Revenue ($ millions) and C) Recreational Fishing Trips (millions) (NMFS, 2018).

A)

| Region | Landings |
|---|---|
| U.S | 9,602.00 |
| North Pacific | 5,630.99 |
| Gulf of Mexico | 1,744.50 |
| Pacific | 937.80 |
| Mid-Atlantic | 597.50 |
| New England | 595.00 |
| South Atlantic | 106.30 |
| Western Pacific | 35.10 |

B)

| Region | Revenue |
|---|---|
| U.S | $5,337.10 |
| North Pacific | $1,609.60 |
| Gulf of Mexico | $1,325.90 |
| Pacific | $912.10 |
| Mid-Atlantic | $688.90 |
| New England | $550.30 |
| South Atlantic | $190.90 |
| Western Pacific | $118.10 |

C)

| Region | Trips |
|---|---|
| U.S Total | 63.3 |
| Gulf of Mexico | 19.5 |
| South Atlantic | 16.8 |
| Mid- Atlantic | 14.0 |
| New England | 6.1 |
| Pacific | 5.2 |
| Hawai`i | 1.0 |

## 2.1 North Pacific

### 2.1.1 North Pacific Fishery Ecosystem Description

The North Pacific Fishery Management Council (North Pacific Council) has jurisdiction over all of the U.S. federal waters surrounding Alaska, and has divided the area into four subregions for management purposes, i.e. Bering Sea, Gulf of Alaska, Aleutian Islands and Arctic (Figure 2.2). The North Pacific Council chose to initiate Fishery Ecosystem Planning in the Bering Sea Subregion so the remainder of this section focusses only on the Bering Sea.

The Bering Sea includes a deep central basin surrounded by continental shelves and some of the world's most productive fisheries. The eastern Bering Sea shelf is one of the most studied LMEs in the world and encompasses 525,099 square miles. Since the eastern Bering Sea LME exhibits substantial connectivity with adjacent subregions, the Bering Sea FEP boundaries are treated as flexible when considering ecosystem issues with varying spatial scales. The waters of the Bering Sea form part of the North Pacific sub-Arctic gyre, the counterclockwise circulation which is fed from the Gulf of Alaska via channels in the Aleutian Islands. Currents exit via the Kamchatka Strait and further north through the Bering Strait to the Arctic Ocean. At the interface between competing Arctic and sub-Arctic weather systems, the physical conditions of the Bering Sea vary according to the relative intensities of these systems and their effects on sea ice, water temperature and mixing. Winter sea-ice is a major driver of the ecosystem dynamics in the Bering Sea which shows extreme seasonal and interannual variability.


**Figure 2.2.** North Pacific Fishery Management Area.

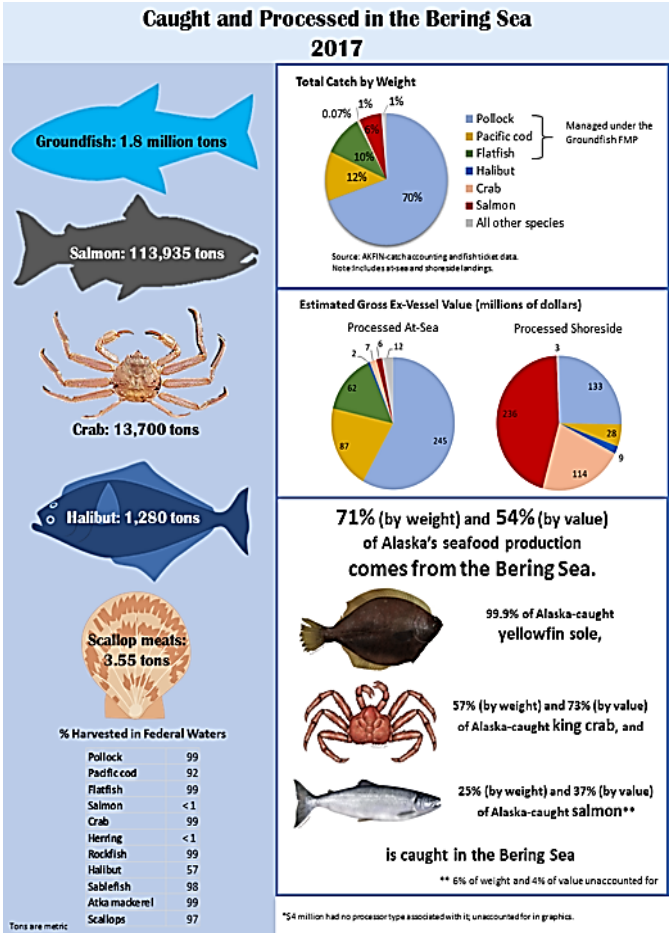


**Figure 2.3.** Commercial production in the Bering Sea (from NPFMC 2020).

The ecological biomes of the Bering Sea are highly complex, productive, and interlinked. For conceptual understanding and planning, the Bering Sea FEP classifies non-human species into nine groupings (or guilds). The guilds include: Primary Production; Zooplankton; Benthic Community; Forage Species; Groundfish; Commercial Crabs; Salmon; Birds; and Marine Mammals. The FEP further distinguishes fishery groupings as: Groundfish (Pollock, Cod, Halibut, Sablefish, rockfish, Arrowtooth Flounder, Greenland Turbot, skates, small flatfish); King crabs, and salmon (Sockeye, Chum, Coho, Pink, Chinook) (Figure 2.3). Primary economic activities include commercial fishing, recreational fishing, marine transportation, and subsistence fishing.

There are over 60 coastal communities in the Bering Sea region, and nearly all are engaged in, and dependent on, federally managed fisheries of the Bering Sea. Many of the communities are considered wholly indigenous Alaska Native while others are considered, "non-native" heterogenous communities, yet often including some indigenous community members. Community members maintain traditional knowledge of the ecosystems, considered important for inclusion in management. The productive waters of the Bering Sea also attract fishermen from vessels that hail from homeports and communities upriver and from other areas of the Pacific Northwest. Many of these fishers have exploited the region for generations and maintain local knowledge that could also be incorporated in management considerations.

In 2016, commercial fishermen in the North Pacific Region landed over 5.6 billion pounds of finfish and shellfish with an Ex-vessel value (calculated as the price per pound at first purchase multiplied by total pounds landed) totaling $1.6 billion. The economic impacts from recreational fishing activities in Alaska in 2016 generated 4,865 jobs, $539.4 million in sales, $195.1 million in income, and $315.5 million in value-added impacts (NMFS 2018).

### 2.1.2 Fishery Ecosystem Plan Development

The North Pacific Council has practiced an ecosystem approach to fishery management starting with the groundfish fishery in 1981. The North Pacific Council attempts to abide regulations for ecosystem based management based on MSA National Standards 1, 8, and 9 by setting an OY which includes minimizing adverse effects to fisheries, marine ecosystems, and essential fish habitat (EFH); considers the social and economic impacts of conservation and management measures on fishing communities; and reduces bycatch (NMFS 2007). In addition, specific ecosystem-based management measures have been directly incorporated in primary FMPs for the Bering Sea (Crab, Scallop, Salmon, Groundfish) and are considered in decisions on annual catch limits. In an effort to be immediately reactive, the Ecosystem Status Report (NPFMC 2020) states: "one current best practice is to present contextual ecosystem information from the ESRs immediately preceding the review of species-specific harvest recommendations. This allows for general discussion of ecosystem status and observations that are outside the scope of individual stock assessments yet may have impacts to the considerations of harvests."

The Bering Sea FEP has benefited from a long history of ecosystem level research through extensive research partnerships and leveraged funding. North Pacific Council ecosystem research partners include the Alaska Fisheries Science Center, the Pacific Marine Environmental

Laboratory of NOAA's Office of Oceanic and Atmospheric Research, the North Pacific Research Board, the North Pacific Anadromous Fish Commission's Bering Aleutian Salmon International Survey, the Bering Sea Fisherman's Association, and the Alaska Sustainable Salmon Fund. The FEP is supported by intensive interdisciplinary data and active FEP teams focused on the various FEPs for subregions (Bering Sea, Gulf of Alaska, Aleutian Islands and Arctic) (Figure 2.2). The Bering Sea FEP is the most advanced and serves as a model and template for other FEPs under development.

Formal FEP planning began with the IEA Program, completed in 2012 and updated in 2015 and 2018, and achieved acceptance of the final Bering Sea FEP core document in 2018 (Figure 2.4). The Bering Sea FEP is designed to serve as a tool to guide the North Pacific Council in achieving its ecosystem management goals and considers the regional ecosystem as a synthesis of its components. Focus on each component is organized around specific Action Modules which together build to the holistic Bering Sea FEP. Each Action Module is designed to address and implement key ecosystem objectives of the FEP and can be created and added to an official list by the FEP Team, the North Pacific Council and its panels, or the public. Modules from the list are initiated according to North Pacific Council priorities and available funding, upon which they are assigned their own focal team, scope, objectives, timeline and expected outcomes. Each module is designed to be integrated into the North Pacific Council process and trigger specific North Pacific Council actions. The North Pacific Council selected 5 priority Action Modules and initiated two of them: 1) evaluate short- and long-term effects of climate change on fisheries, and develop management considerations, 2) develop protocols for using local knowledge and traditional knowledge in management and understanding the impacts of North Pacific Council decisions on subsistence use.

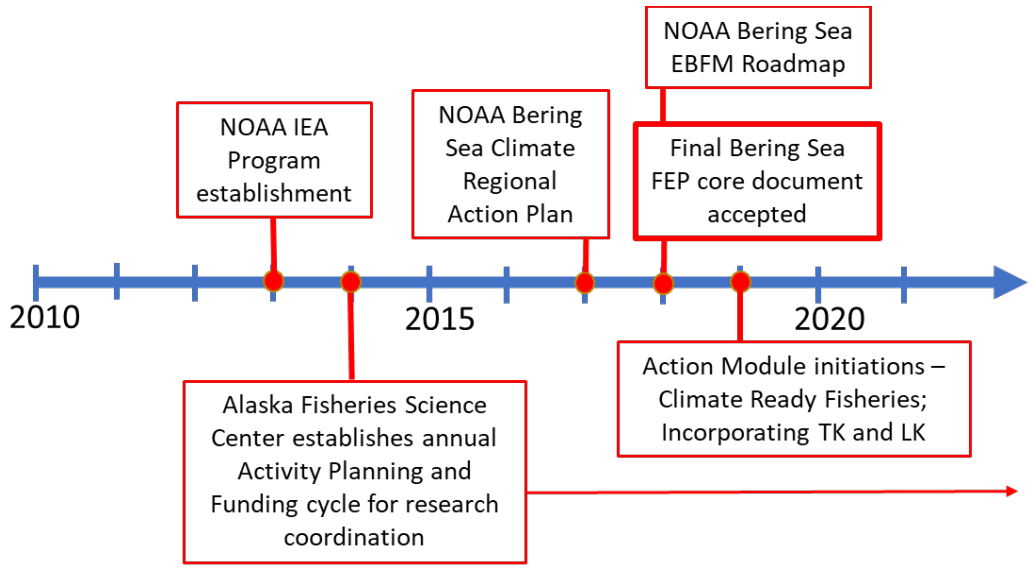


**Figure 2.4.** Timeline of Bering Sea FEP development.

The Bering Sea FEP recognizes that mechanistic models of ecosystem function are desirable but rarely (if ever) attainable. Therefore, the Bering Sea FEP relies on qualitative conceptual models of ecosystem components, species groupings, human impacts, and the linkages among these.

The Bering Sea FEP has made it a priority to diagram ecosystem conceptual models, but as of 2019 has classified this as an Action Module that has not yet been initiated. Nonetheless, the North Pacific Council has chosen a suite of indicators selected for their utility in succinctly capturing the most important processes that effect biological and physical ecosystem status. These include the North Pacific Index, sea ice extent, motile epifauna, benthic and pelagic foragers, fish apex predators, a sea bird index, and others. The North Pacific Council has provided annually updated Ecosystem Status Reports between 1995 and 2021 (NPFMC 2020) based on monitoring and analysis of indicator data. The same data are used to produce user driven data visualization dashboards, and graphical posters (Figure 2.5) designed for the public.

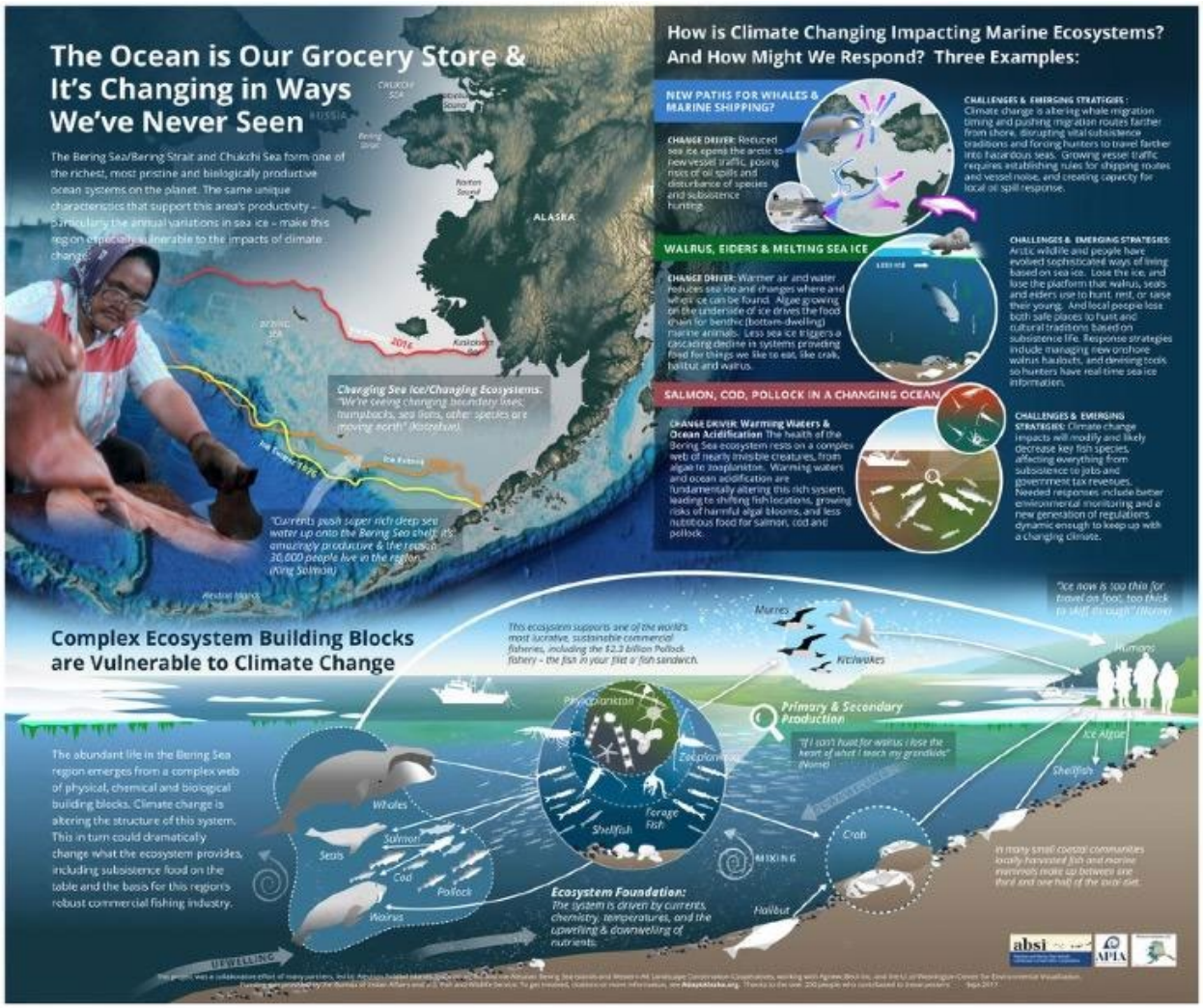


**Figure 2.5.** Ecosystem conceptual model of the Bering Sea ecosystem and the effects of climate change on ecosystem components. This depiction is "accessible" i.e. easily understood, by a broad and diverse group of stakeholders and thus serves as a good example for depicting conceptual ecosystem models in other regions.

### 2.1.3 Resulting Management Actions

Marine Protected Areas (MPAs)

The North Pacific Council has used MPAs extensively as an EBFM tool (Figure 2.6). Fishing for Pollock and Pacific Cod is prohibited within 20 nm of all five Steller Sea Lion rookeries in the Bering Sea. To protect Pacific Walrus, the North Pacific Council enacted spatial and seasonal groundfish fishing closure areas. Note that habitat protection was considered to protect deep sea corals but based on best available science, the North Pacific Council did not create new closed areas. The North Pacific Council designated large areas around the Pribilof Islands, Bristol Bay and the Bering Sea Red King Crab Closure Area as Habitat Areas of Particular Concern (HAPC) and prohibited scallop fishing and bottom trawling to protect crabs and sensitive habitats. The North Pacific Council also closed areas within ten miles of St. Lawrence, King, and Little Diomede Islands to commercial King and Tanner Crab fishing to protect local subsistence crab fisheries.

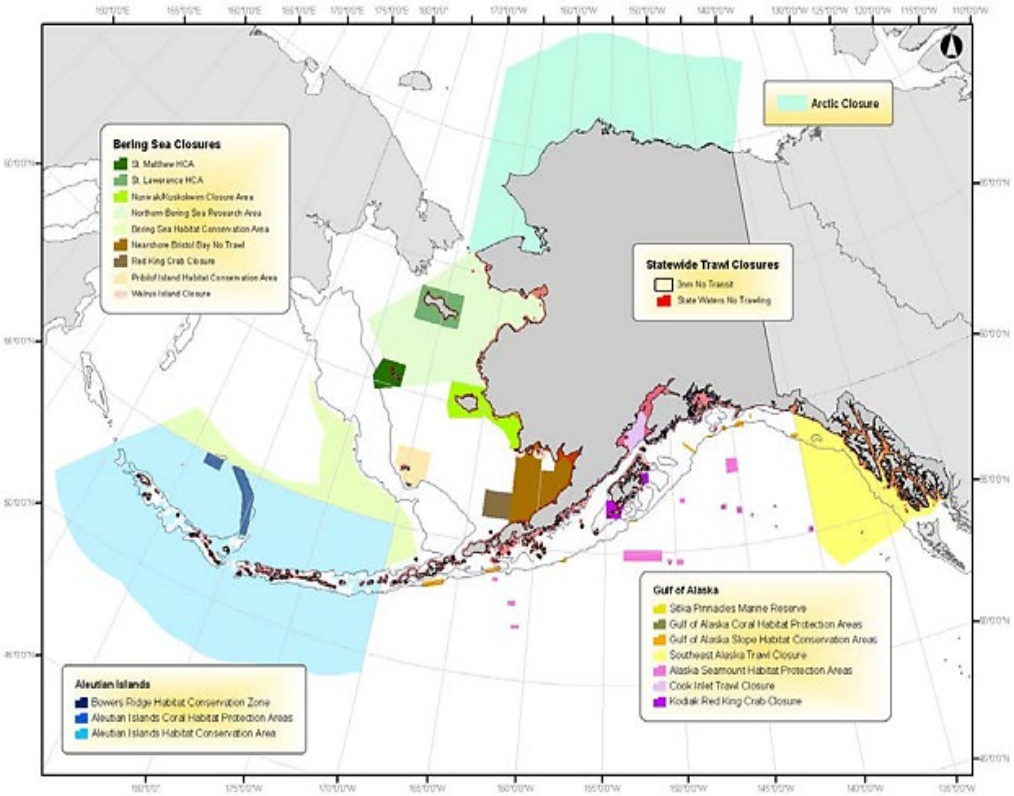


**Figure 2.6.** Protected areas in the Bering Sea (from NPFMC 2020).

In June 2007, the North Pacific Council adopted, what they described as precautionary measures to conserve benthic fish habitat in the Bering Sea by "freezing the footprint" of bottom trawling. This was done by limiting trawl effort only to those areas that have been recently trawled. Implemented in 2008, the new measures prohibit bottom trawling in a deep slope and basin area (62,000 square miles), and three habitat conservation areas around St. Matthew Island, St. Lawrence Island, and an area encompassing Nunivak Island, Etolin Strait, and Kuskokwim Bay.

The North Pacific Council also established the Northern Bering Sea Research Area (112,500 square miles) to study the impacts of bottom trawling on benthic habitat before any commercial trawling was authorized.

Monitoring Ecosystem Health

As stated above, the Bering Sea has benefitted from decades of multi-institutional collaborative research and monitoring, supported by large-scale, long-term and diversified funding sources. Additionally, the North Pacific Council has selected a suite of indicators and uses monitoring data to provide annual Ecosystem Status Reports (NPFMC 2020). Alaska Ecosystem Status Reports provide stronger links between Alaska ecosystem research and fishery management, and spur new understanding of the connections between ecosystem components by bringing together the results of diverse research efforts.

Developing Climate Ready Fisheries

The seasonal progression and retreat of sea ice over the shelf is the defining variable for Bering Sea ecosystem dynamics. Late arrival of sea ice is more common over the past 40 years (NPFMC 2020). The southeastern and northern Bering Sea are experiencing a persistent warm stanza (consecutive years of above average ocean temperatures), greater in both magnitude and duration than that of the early 2000s.

An Action Module has been included in the FEP and a Taskforce has been empaneled to evaluate the vulnerability of key species and fisheries to climate change and to strengthen resilience in regional fisheries management. Ecosystem and stock assessment scientists worked together to account for the influence of exceptional environmental conditions in the Bering Sea on commercially important fish stocks. They considered ecosystem information in 21 full assessments for eastern Bering Sea and Aleutian Islands stocks. The scientists concluded that two stocks' catch limits should be reduced to address uncertainty about ecosystem concerns, but precautionary measures were considered sufficient for the remaining 19 stocks.

Incorporating Traditional Knowledge and Local Knowledge

Traditional knowledge and local knowledge are both experiential in nature, stemming from time spent in close interaction with fisheries and the marine ecosystem over years of an individual and often through generations and through history embedded in indigenous culture. The individuals possessing this knowledge may be able to offer perspective on ecosystem components and their linkages, as well as the changes that have occurred through time.

An Action Module to incorporate this pool of knowledge was prioritized by the North Pacific Council when the final FEP was accepted in 2018, and an Action Module Workplan was drafted by the FEP team to develop protocols to make this knowledge actionable within the North Pacific Council process. A dedicated Taskforce was formed in 2019 to carry out the Workplan. Workplan objectives are to identify sources of Traditional Knowledge, Local Knowledge, and subsistence use knowledge and to provide recommendations on analysis and incorporation into management practices. Several work products (e.g., written protocols, guidelines and final report) to help meet these objectives are specified within the Workplan. Mechanisms to maximize inclusion of knowledgeable individuals and groups are also specified, which include holding Taskforce meetings in rural areas as possible and allowing remote participation in

Taskforce discussions through teleconferencing. Regular and transparent communication amongst the FEP Team, the Taskforce, and stakeholder groups is established as a critical component to the entire process and for this Action Module (Local knowledge, traditional knowledge, and subsistence workplan: https://www.npfmc.org/wp-content/PDFdocuments/membership/LKTKS/LKTKSworkplan.pdf).

### 2.1.4 Summary of Best Practices and Lessons Learned

Best Practices

- Subregional areas are the focal scale for management.
- MSA National Standards 1, 8, and 9 are explicitly considered in all FMPs.
- MPAs have been used extensively as an Ecosystem Management Tool
- Stock assessment scientists and ecosystem scientists convene to consider Ecosystem Status effects and incorporate up-to-date ecosystem information into annual Total Allowable Catchs.
- Long-term, well-funded cooperative research and monitoring allow detailed and comprehensive indicator tracking that can be visualized in time series.
- Annual Ecosystem Status Reports (and briefs) provide managers with useable and understandable formats.
- Action Modules are used to address specific ecosystem issues (including climate impacts) using dedicated taskforce, a workplan with a timeline of deliverables. Modules are solution oriented.

Lessons Learned

- Action Modules provide an excellent, replicable example of a formal framework and guidelines to address ecosystem issues.
- MPAs are used extensively for EBFM, protected species management, managing gear conflicts, and research.
- Climate mitigation measures can be developed through an Action Module process.
- Local Knowledge can be gathered and incorporated in ecosystem conceptual models.
- Purposeful stakeholder engagement can build stakeholder support for EBFM.
- Conceptual models provide stakeholder driven issue identification.

## 2.2 Caribbean

### 2.2.1 Caribbean Fishery Ecosystem Description

The Caribbean Fisheries Management Council (Caribbean Council) has jurisdiction over the federal waters surrounding the three U.S. Virgin Islands (St. Croix, St. Thomas, and St. John) and Puerto Rico, encompassing an Exclusive Economic Zone (EEZ) area of 75,687 square miles. These islands are part of the Greater and Lesser Antilles island chains, separating the Caribbean Sea from the greater western Atlantic Ocean. The islands are located on a shelf platform surrounded by deep canyons and natural banks (CFMC 2019; Figure 2.7). Major currents

surrounding the islands entail the Antilles Current to the north and the Caribbean Current to the south, both of which flow westward after splitting from the North Equatorial Current at the Lesser Antilles chain. Extensive coral reefs and hard bottoms are found in the area, as well as mangroves, seagrass beds, algal plains, soft bottoms, and estuaries, much of which is designated as EFH and HAPC (https://www.caribbeanfmc.com/fishery-management/2-uncategorised/173-feis-to-the-efh). These habitats support productive tropical fish populations, including snappers, groupers, parrotfishes, grunts, jacks, and pelagics and highly migratory species (e.g., sharks, tuna, mackerel, billfish), as well as important invertebrate fisheries for lobster, shellfish, and cephalopods. Many species of protected megafauna also inhabit the region, including sea turtles, whales, and manatees.

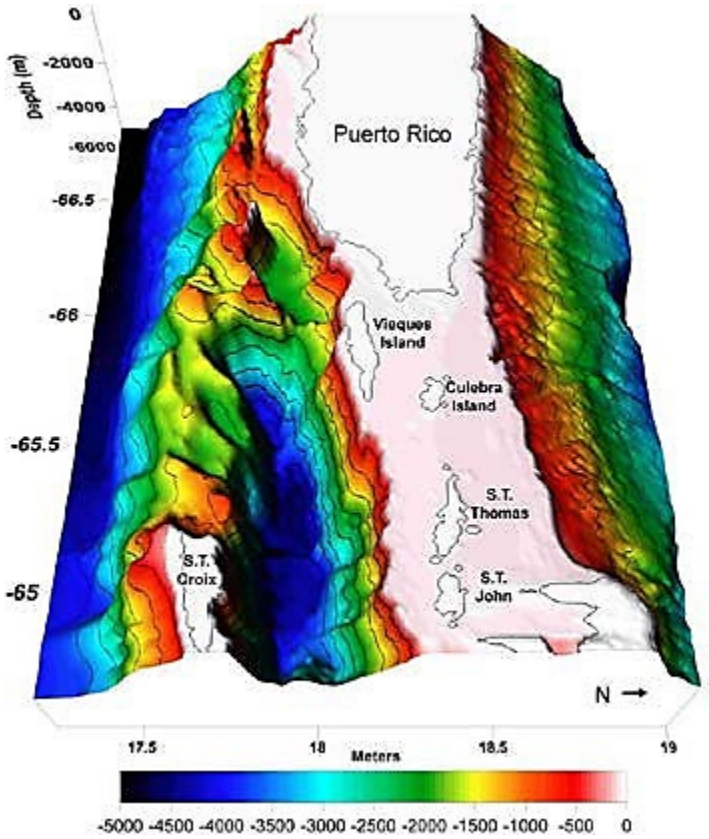


**Figure 2.7.** The Caribbean Fisheries Management Council (Caribbean Council) has jurisdiction over the federal waters surrounding the three U.S. Virgin Islands (St. Croix, St. Thomas, and St. John) and Puerto Rico, encompassing an EEZ area of 75,687 $mi^2$. The islands are located on a shelf platform surrounded by deep canyons and natural banks (García-Sais et al. 2005).

The economic and social value of Caribbean Fisheries was not reported in Fishery Economics of the United States (NMFS 2018) along with other regions, in part because it is difficult to quantify using existing data. Nonetheless, the region's fisheries are intimately tied with local cultural identity, fishing and tourism economies, subsistence, livelihoods, and the overall social and economic well-being of the region. They are primarily artisanal and coral reef based, targeting a variety of species using multiple gear types (e.g., line, trap, net).

### 2.2.2 Fishery Ecosystem Plan Development

The Caribbean Region has always been considered "data limited", which has necessitated an ecosystem-based approach from its inception (Cummings et al. 2014). The Reef Fish FMP, developed in 1985, addressed management of at least 30 species from various families including groupers, snappers, grunts, jacks, parrotfish, triggerfish and others. However, the FMP acknowledged that stocks could not be defined and almost no data existed regarding harvest levels and stock status. Management actions included the establishment of MPAs, and FMPs were developed for queen conch and spiny lobster. However, data to support these plans were severely limited, and the regulations did not well address ecosystem-based management. Following the reauthorization of the MSA and its requirement to end overfishing, the Caribbean Council was required to conduct region-wide Stock Assessments, and establish annual catch limits and rebuilding plans for fisheries that were considered overfished. The data with which to conduct assessments (using tools that were common in other regions) were severely limited, which in turn limited their applicability to management. Further confounding applicability, the Caribbean Council recognized the vast differences between the ecosystems, fisheries, and socioeconomics of each island and thus decided to refocus using an island-based management system, creating distinct FMPs for Puerto Rico, St. Croix, and St. Thomas/St. John.

In 2017, the Caribbean Council began FEP development following guidance from a report of the Lenfest Fishery Ecosystem Task Force, *Building Effective Fishery Ecosystem Plans* (Essington et al. 2016), widely considered as best guidance for development of "Next-Gen FEPs". Initial funding for FEP development was provided by the Lenfest Ocean Program and the Caribbean Council. Additional financial and technical support from the Pew Charitable Trust and the Lenfest Ocean Program have created additional bandwidth for the Caribbean Council be able to invest in FEP, in addition to their existing priorities. Initial planned steps included outreach and interaction with stakeholders, visioning, data mining, conceptual (mental) modeling, indicator selection, and threat inventories. The current target completion date for the Caribbean FEP is 2023 (Figure 2.8).

The region as a whole is considered "data poor", and FEP developers recognized that expert opinion and stakeholder perceptions were the primary qualitative data source with which to initially proceed in the form of conceptual ecosystem models, which are to be subsequently incorporated into quantitative models. In order to synthesize ecosystem conceptual models from the perspective of stakeholders, the University of Puerto Rico and Lenfest jointly planned and conducted conceptual modeling workshops with specific stakeholder groups, e.g., coastal businesses, environmental non-government organizations (NGOs), fishing communities, and scientists with the Science and Statistical Committee (SSC). A cognitive mapping approach was used in which stakeholders identified primary ecosystem components, their connections, and natural and anthropogenic factors affecting them. Resulting mental models addressed all possible fishery ecosystem components and habitats, without explicit focus on fisheries management.

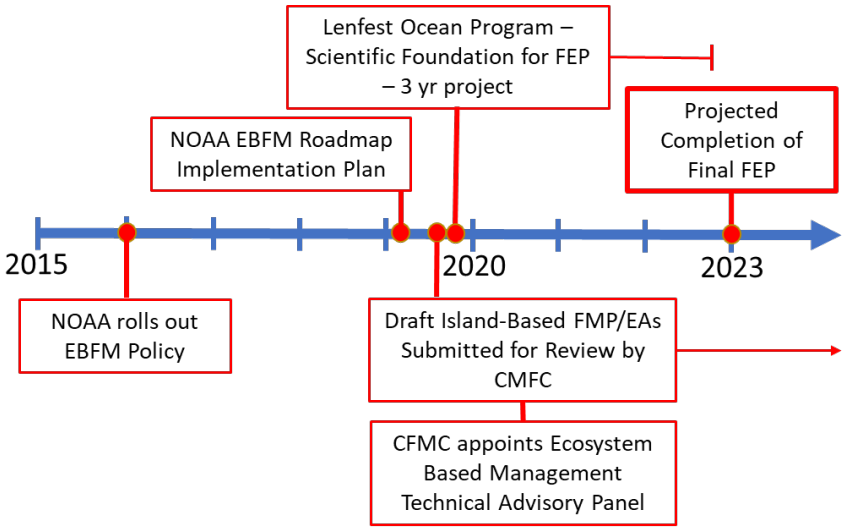


**Figure 2.8.** Timeline of significant events in Caribbean FEP Development.

Concepts, their linkages, and the direction and strength of their interactions were depicted with mental models using Mental Modeler software (Figure 2.9), though these may be difficult for stakeholders to interpret in this format. The FEP development team plans to use the conceptual models to assess gaps, select indicators, and help develop hypotheses to be tested within qualitative and quantitative ecosystem models, ideally providing a basis for ecosystem assessment and management within the FEP.

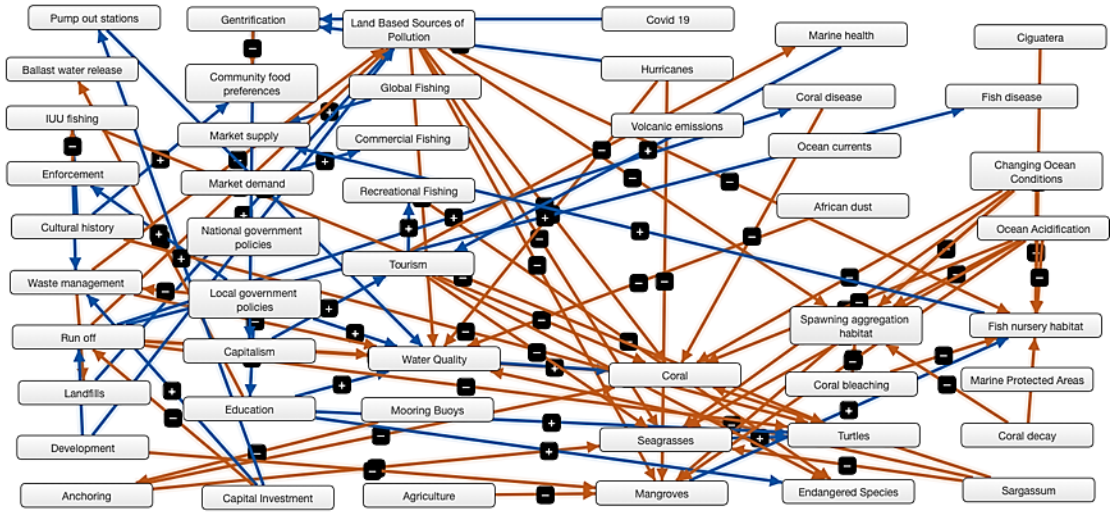


**Figure 2.9.** NGO conceptual model of Caribbean ecosystem components and their interactions developed using interviews and "Mental Modeler". Though the diagram captures many of the conceptual linkages in stakeholders' understanding, this, and other similar models, maybe difficult to interpret without further explanation.

### 2.2.3 Resulting Management Actions

The Caribbean Council has initiated an ambitious FEP process but it is still too early in the process to expect resulting management outcomes. Nonetheless, the Caribbean Council is proposing to transition management of federal fisheries in the U.S. Caribbean from the current species-based FMPs to island-based FMPs. Currently, FMPs in the U.S. Caribbean are structured by species (i.e. Spiny Lobster, Queen Conch) or species groups (i.e. Reef Fish and Coral). The proposed transition will allow managers to apply management measures at sub-regions (i.e. Puerto Rico, St. Croix, and St. Thomas/St. John) and thus better consider the differences in culture, markets, gears, and seafood preferences among the U.S. Caribbean islands. Draft Island-based FMPs have outlined goals and objectives to use ecosystem-based management principles to ensure long-term sustainable use of fisheries resources, providing a basis for FEP protocols and implementation.

### 2.2.4 Summary of Best Practices and Lessons Learned

Best practices

- The Caribbean Council is promoting Island-based FMPs, that allows for regional differences in ecosystems, cultures, economies and resulting management.
- Stakeholder engagement with conceptual modeling has helped illustrate the regional (island) differences in management needs and priorities.
- The Caribbean Council has received financial and science support and partnership with external agencies, Universities, including the Lenfest Ocean Program that have helped advance FEP development.

Lessons learned

- FEP development is a long, complex evolutionary process.
- Subregional management planning allows for tailored, placed-based EBFM solutions.
- Severe data limitations can be overcome through conceptual modeling with intensive stakeholder engagement, and willingness to take bold precautionary management actions.
- RFMCs can partner with external agencies and institutions that can provide valuable financial and technical support to FEP efforts.

## 2.3 South Atlantic

### 2.3.1 South Atlantic Fishery Ecosystem Description

The South Atlantic Fishery Management Council (South Atlantic Council) has management jurisdiction over fisheries within federal waters between Key West, FL and Cape Hatteras, NC, encompassing about 38,000 square miles. Diverse recreational and commercial fisheries occur in the region. In 2016, commercial fishermen landed 70.8 million pounds of shellfish, primarily shrimp and blue crab in the South Atlantic. Total annual landings, including finfish (flounders, snappers, groupers, king mackerel, swordfish and tuna) and other species came to 106.3 million pounds, creating revenue of $191 million (NMFS 2018). In 2016, 2.3 million recreational

anglers took 16.8 million trips in the region and expended $5.4 billion, of which $9.81 million was expended on trips alone.

The South Atlantic marine ecosystem is largely governed by interaction between the temperate continental shelf region and the strong, northward flowing Gulf Stream current. The Gulf Stream is fed by the Loop Current in the Gulf as it is forced through the narrow Florida Straits. The Gulf Stream carries warm (sometimes tropical) waters northeasterly along the region's coast until it is forced offshore at Cape Hatteras, forming the natural northern boundary to the region. There is a strong latitudinal habitat gradient in the South Atlantic starting in the southwest with tropical reef ecosystems in the Florida Keys. Meeting cooler waters off SE Florida, the continental shelf edge comes closest to the coast (10 km) and then gradually transitions to the broad (120 km) continental shelf off Georgia and more temperate waters off the Carolinas.

The distribution of benthic fishes and invertebrates in the region follow a north south gradient. Coastal migratory pelagics (e.g., dolphin, wahoo, king mackerel) move freely through the area, sometimes with seasonal migrations that transcend the jurisdiction of the South Atlantic Council. Marine fauna are further influenced by dynamic variations in the speed, location, and contents of the Gulf Stream. For example, there are areas of "tropical bottom" that occur on hard substrates as far north as the Carolinas that are colonized from pulses of the larvae and juveniles of species that have centers of distribution in tropical waters but occasionally become entrained in the Gulf Stream System. The latitudinal gradient in habitat and the associated increasing northward seasonality also controls fishing effort, especially in the recreational sector. Cold winters prohibit access in the north while the southern part of the region is accessed year-round. To account for these variations, the South Atlantic Council has developed sub-regional regulations for stocks that transcend the region, e.g., Cobia and King Mackerel.

### 2.3.2 Fishery Ecosystem Plan Development

The South Atlantic Council was an early adopter of the FEP concept and completed a FEP in 2009 (SAFMC 2009). The document includes five main sections and totals 2,185 pages plus 303 pages of appendices. The FEP provides a comprehensive description of habitats and species, human and institutional ecosystems, threats and recommendations, research and data needs. More recently, the South Atlantic Council began work on FEP II, described as a mechanism to incorporate the evaluation and consideration of ecosystem principles, goals, and policies into fishery management in the region (SAFMC 2018). The South Atlantic Council has not found the FEP implementable given the lack of specificity in its recommendations.

In addition to the FEP, the South Atlantic Council has invested in other actions and activities that are leading to achieving EBFM. The rest of this section will focus on these additional experiences, which offer valuable and replicable techniques and approaches. Primary ecosystem-based approaches to management in the Southeast include visioning exercises, an extensive system of MPAs, and a well-developed Citizen Science Program.

While some conceptual modeling has been done for the SA region as a whole, using trophic simulation models, perhaps the most recent and promising examples emanate from conceptual models developed by stakeholders. The recent efforts to manage Dolphin and Wahoo resources,

based on information generated in participatory workshops, provides an excellent example. Dolphin and Wahoo, behave like Highly Migratory Species, transcending the South Atlantic Council jurisdiction. The South Atlantic Council is the primary RFMC in charge of managing the Dolphin Wahoo fishery along the entire Atlantic Coast from Maine to Key West, in cooperation with the Mid-Atlantic and New England Councils.

Stakeholders voiced growing concerns over Dolphin and Wahoo management during public comment at South Atlantic Council meetings. Conflicts emerged based on subregional perspectives about the status of and use of the stock. There was an urgent need to guide management and a paucity of existing information to do so. Natural and social scientists with the Southeast Fisheries Science Center (SEFSC) partnered with practitioners from the South Atlantic Council's Citizen Science Program to rapidly develop and implement a results-driven, participatory process designed to provide management guidance from the perspective of stakeholders. The team used a participatory conceptual modeling approach to develop conceptual models of the Dolphin and Wahoo fishery in its ecosystem context, based on the perceptions of fishermen themselves. Workshops were conducted in the NC/VA area as well as the in the FL Keys. Scientists and managers were invited to these workshops, but only as observers. Techniques included participatory graphing of the factors (socio-economic, physical, biological) and trends in the fishery by time and location, i.e., seasonal variations in landings and longer-term trends in abundance over time (Figure 2.10). The workshops produced conceptual hypotheses about how changes in the ecosystem affect the fishery, businesses and communities. The Southeast Fisheries Science Center used existing data to evaluate the conceptual hypotheses and documented major regional differences in both environmental drivers and regional values (i.e. role of the species in the larger complex).

Though no formal stock assessment had been completed for either species, and both are considered data-limited, the South Atlantic Council developed draft Amendment 10 to the FMP to consider management changes for these stocks. Amendment 10 to the FMP addresses possible changes in ACLs, ACL allocation between commercial and recreational sectors, changes in retention and size limits that could differ between for-hire and private recreational sectors, as well as possible changes to regulations over the commercial longline fishery. Finally, the Amendment considered sub-regional ACLs. In sum, the participatory workshop process helped managers and scientists work together to produce new conceptual models of the fishery ecosystem, validate these models with existing data, and offered subtle changes to Amendment 10 to Dolphin Wahoo FMP, that accounted for regional differences in ecological drivers and stakeholder values.

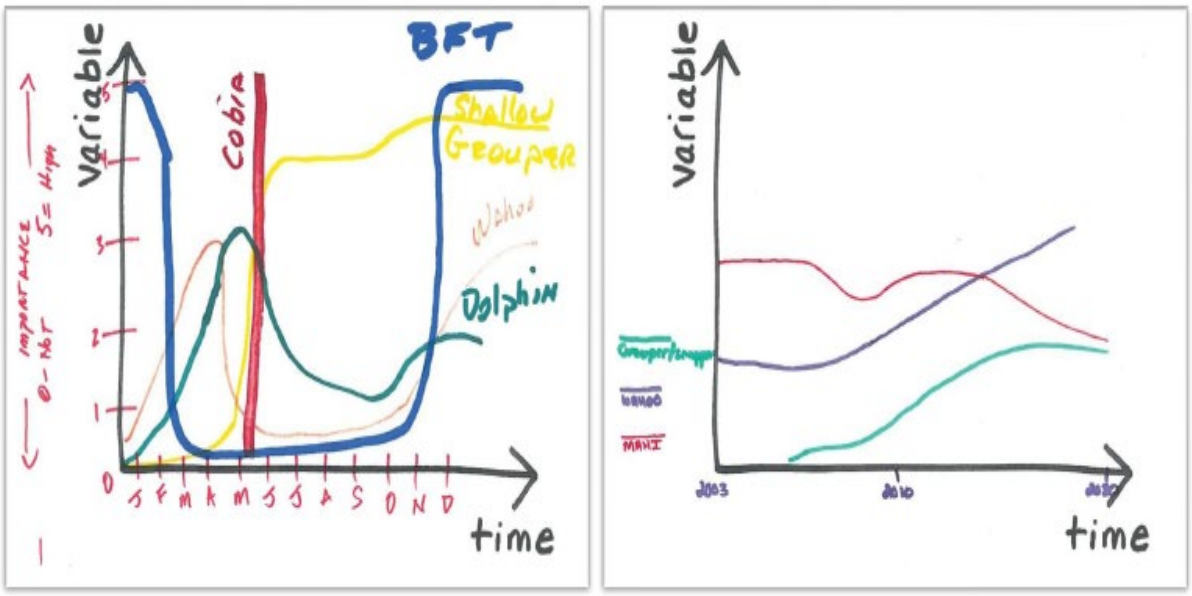


**Figure 2.10.** Results from participatory workshops on Dolphin Wahoo in North Carolina and Virginia. Participant fishermen plotted the seasonal pattern of effort directed towards various species, including Dolphin, Wahoo, Cobia, Shallow water grouper, and Bluefin Tuna (BFT, left). Note that these fisheries are concentrated on stocks as they migrate through the region. Cobia are targeted during their peak spawning season. Fishermen also plotted their perceptions of the historical changes in stock catchability over time.

### 2.3.3 Resulting Management Actions

The South Atlantic Council has not found the FEP implementable given the lack of specificity in its recommendations. Nonetheless, progress towards EBFM has advanced rapidly in the region following different pathways.

Marine Protected Areas

The South Atlantic Council has consistently used habitat protection and management as an EBFM tool. Amendment 10 established EFH and HAPC for the snapper grouper complex in the South Atlantic region (SAFMC 1998). Deepwater MPAs protect sensitive habitats in Special Management Zones (SMZ), (SAFMC 2016). The Comprehensive Ecosystem-Based Amendment (CE-BA 1) was implemented in 2010, and protects specific areas of sensitive habitat, deemed Coral Habitat Areas of Particular Concern (Coral HAPCs). These Coral HAPCs house Deepwater coral species living in waters ranging from 400 meters (1200 ft.) to 700 meters (2300 ft.).


**Figure 2.11.** Photo from 1954 submitted to the FISHStory program (*https://safmc.net/safmc-fishstory/*).

To address declines in reef fish, particularly Warsaw Grouper and Speckled Hind, the South Atlantic Council convened expert workshops to guide management responses. The workshops brought together experts on spawning aggregations that included both highly knowledgeable fishermen and scientists that focus on spawning aggregations. The workshops produced detailed maps and suggested boundaries for new (and in some cased revised) MPAs, designed specifically to protect spawning reef fish (Farmer et al. 2017). All these protected areas were designed with intensive stakeholder input, and all serve as multi-species reserves.

Citizen Science Program

The South Atlantic Council has grappled with the challenge of ensuring adequate and timely science to support management despite limited resources, a multitude of species to manage, and a complex and highly diverse ecosystem. Discussions of data shortcomings and the resulting scientific uncertainties often lead to offers from fishermen to provide their vessels as research platforms, collect samples and record their own observations to help increase scientific knowledge and "fill the gaps" (Bonney et al. 2021). The South Atlantic Council designed and built the Fishery Citizen Science program and accompanying sampling protocols to ensure that information collected through such efforts is useful. To meet this growing need, the South Atlantic Council developed a comprehensive Fishery Citizen Science Program. The Participatory Dolphin Wahoo workshops (described above), and FISHStory (described below) are a collaborative project of the Citizen Science Program.

FISHStory, another project, used crowd-sourced historical photos, taken from charter fish and headboat docks, to document species and size composition of for-hire landings prior to 1970s when fishery dependent data began to be collected in the SA region (Figure 2.11). In partnership with Zooniverse, citizen scientists globally help to classify the species and calculate lengths from the photos. The data are in turn being used to explore changes over time and to help understand the status of present fishery stocks in a historical ecosystem context. Though results are still being analyzed, over 3,000 historical photographs have been analyzed by volunteer citizen scientists.

### 2.3.4 Summary of Best Practices and Lessons Learned

Best Practices

- Visioning for the Snapper Grouper Fishery helped bring all stakeholders together in a common vision for research, management, governance
- Comprehensive MPA system, designed with stakeholder input and focused on spawning protection, deep water corals, and reef fish
- Citizen Science Program has increased stakeholder support for management action
- Participatory workshops with fishermen used to create conceptual models of fishery ecosystem issues and to guide research and management advice.
- FISHStory uses crowd-sourced historical photos to document landings prior to the 1970s before quantitative, systematic data collection began.
- Several stocks are managed using subregional regulations to account for within-region ecosystem variations.

Lessons Learned

- Effective EBFM actions can be accomplished outside Fishery Ecosystem Planning, using processes and labels that stakeholders understand and embrace (e.g., participatory workshops and citizen science)
- FEPs must provide actionable guidance.
- Subregional regulations may help address within-region fishery ecosystem diversity.
- A well-developed Citizen Science program can address issues of data deficiency, and build stakeholder participation and confidence in the science-based management process.
- Participatory workshops can support conceptual modeling from fishers, gathering fisher-developed management solutions, addressing data-deficiencies, and building stakeholder support for EBFM through participation and inclusion.

## 2.4 Pacific

### 2.4.1 Pacific Fishery Ecosystem Description

The jurisdiction of the Pacific Fishery Management Council (Pacific Council) encompasses the 317,690 square mile EEZ of the entire Pacific coast of the continental U.S. from 3 to 200 nm offshore. In the Pacific region, commercial landings in 2016 totaled 938 million pounds for a revenue of $912 million. (NMFS 2018). The California Current Ecosystem (CCE) supports economic and social dynamics of at least 125 communities along the coastline of California, Oregon, and Washington, including major fishing ports like San Francisco and Los Angeles, as well as tribal communities that have treaty-protected fishing rights, co-management roles with state and federal fisheries, and designated representation and voting rights on the Pacific Council.

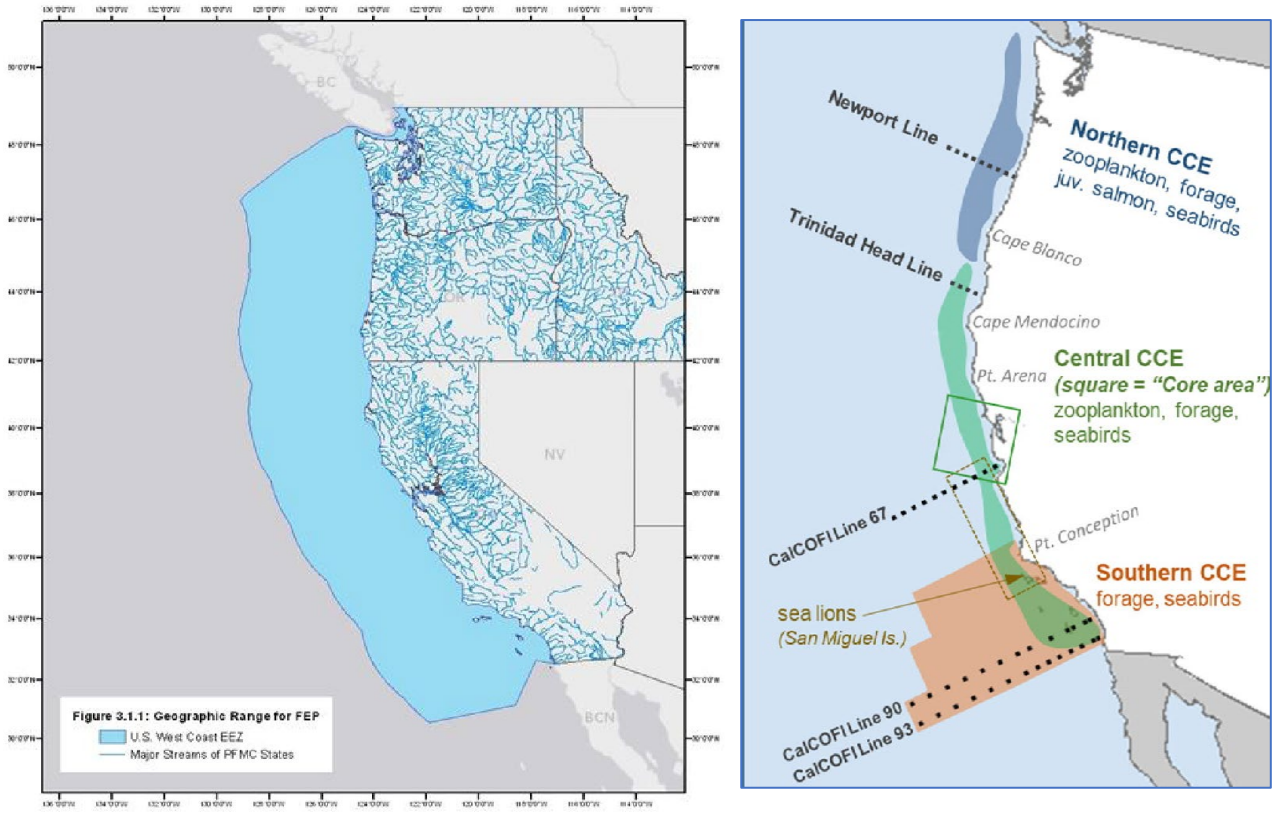


**Figure 2.12.** Left: Pacific region FEP geographic range (PFMC 2013). Right: Subregions within the CCE used for sampling and monitoring indicators and other management practices (Harvey et al. 2021).

The California Current flows south from Vancouver Island where the North Pacific Current meets land, driving coastal upwelling and short-term and long-term variability in other abiotic environmental conditions and productivity. Extensive estuarine and freshwater river systems are part of the region, influencing abiotic factors such as freshwater inputs, and important biotic factors such as anadromous fish species. The region is largely divided into three subregions for management purposes, but this framework flexes depending on the spatial scale of the species and management issue being considered (Figure 2.12).

Productive fisheries with complex management issues exist in the region, with four FMPs enacted by the Pacific Council: Coastal Pelagic Species (CPS), Highly Migratory Species (HMS), Groundfish, and Salmon. Coastal Pelagic Species, including anchovy, squid, sardine, and mackerels, dominate lower trophic levels, and vary on decadal boom-bust cycles with some species requiring "actively managed" intense harvest practices and annual adjustments in quotas. Highly Migratory Species, such as tuna, billfish, seabasses, and a variety of sharks, are valuable upper trophic level species, targeted by fisheries in multiple jurisdictions, which requires collaboration amongst nations and regulating agencies. Over a hundred species of groundfish, including rockfish, flatfish, sharks, and skates, are managed across many fishery sectors, gear

types, and jurisdictional boundaries using various management strategies, such as individual fishing quotas and electronic monitoring. Salmon, primarily chinook and coho and secondarily pink, are targeted by valuable commercial, recreational, and tribal ceremonial and subsistence fisheries, and present many challenges in management due to their long migrations in both marine and freshwater ecosystems. In addition to productive fisheries, the CCE also supports many resident and migratory upper trophic level groups, including sea lions, seals, whales, sea turtles, and sea birds.

### 2.4.2 Fisheries Ecosystem Plan Development

As EBFM concepts and implementation advanced in fisheries science and management, the Pacific Council appointed two advisory bodies to develop an FEP in coordination with the Pacific Council, the Ecosystem Plan Development Team and an Ecosystem Advisory Subpanel comprised of a variety of stakeholders to guide development. A final version of the FEP was accepted in April 2013 (Figure 2.13), designed with the following objectives: 1) Improve informational integration within decision-making in existing FMPs, by using descriptions of environmental components, indicators and trends, by identifying knowledge gaps on long-term effects, and by allowing for a science/management framework for spatially appropriate assessment of fish stocks. 2) Improve assessments of the benefits of conservation and management actions through time, of MSYs, and the intersection and tradeoffs between the two, by assessing trophic flows, socioeconomic effects of ecological interactions, and how the state of the ecosystem through time may impact fisheries. 3) Develop a framework and protocols for coordination of conservation and management actions on an ecosystem level, by conveying annual status reports to the Pacific Council, by providing a meeting point for all external ecosystem-based management activities at all relevant spatial scales to inform and communicate possible impacts on fisheries, and by supporting cross-FMP efforts through increasing understanding and conservation of ecological connections and trophic flows involving non-target species.

To help achieve these goals, the Pacific Council requested an annual “state-of-the-ecosystem” report starting in 2014 from the California Current Integrated Ecosystem Assessment (CCIEA) team made up of NOAA scientists and other agencies to summarize trends in ecosystem indicators, resultant effects on ecosystem components, and possible implications of management actions. The CCIEA is a primary partner and scientific source for the Pacific Council.

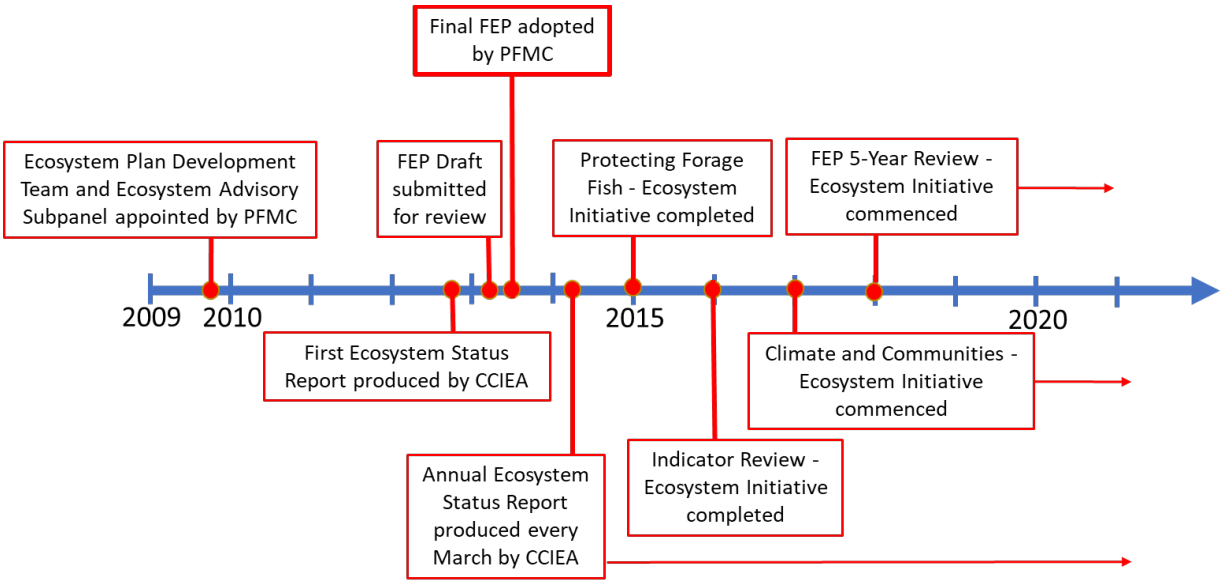


**Figure 2.13.** Timeline of key events in FEP development and implementation by the Pacific Fishery Management Council.

Implementation of EBFM measures is achieved through the selection and undertaking of specified Ecosystem Initiatives, which address fisheries issues that cross regulatory authority of multiple FMPs. These ecosystem level topics may be heavily science-based or policy-based and require collaboration and information external to a single FMP. The Pacific Council has institutionalized the process and timing for Ecosystem Initiative selection and review. During their March meeting each year, the Pacific Council reviews progress of any ongoing Ecosystem Initiatives and has the opportunity to select a new Ecosystem Initiative on which to focus in the coming year. New initiatives based on the FEP Purpose and Need Statement, FEP Objectives, and MSA requirements may be added to the appendix by the Pacific Council every two years. These can lead to enforceable amendments to FMPs.

It is also suggested that ecosystem information may also be incorporated into fisheries management through the expanded contextualization of stock assessments, achieved through collaboration between NMFS and the Pacific Council SSC. More thorough ecosystem science could be utilized both within stock assessment models and within stock assessment documents and references for the SSC when management decisions are considered and executed.

Marine area management is also used as a tool in achieving EBFM. Large areas of EFH and HAPC, established within each FMP, are managed by the Pacific Council using recommendations from the Habitat Committee in conjunction with other advisory bodies, and include kelp forests, seagrass, rocky reefs, estuaries, deep-water benthic habitats, and others.

A conceptual model of the biophysical and human dimensions of the CCE, though not included in the Pacific FEP, has been succinctly visualized by the CCIEA team in a system model diagram (Figure 2.14). Ecological factors include the major tiers of Ecological Integrity, Habitat, and Climate and Ocean Drivers, analogous to the human factors of Human Wellbeing, Local

Social Systems, and Social Drivers. Human Activities fall at the center of the circle, indicating the bridge at which ecological and human interactions primarily take place.

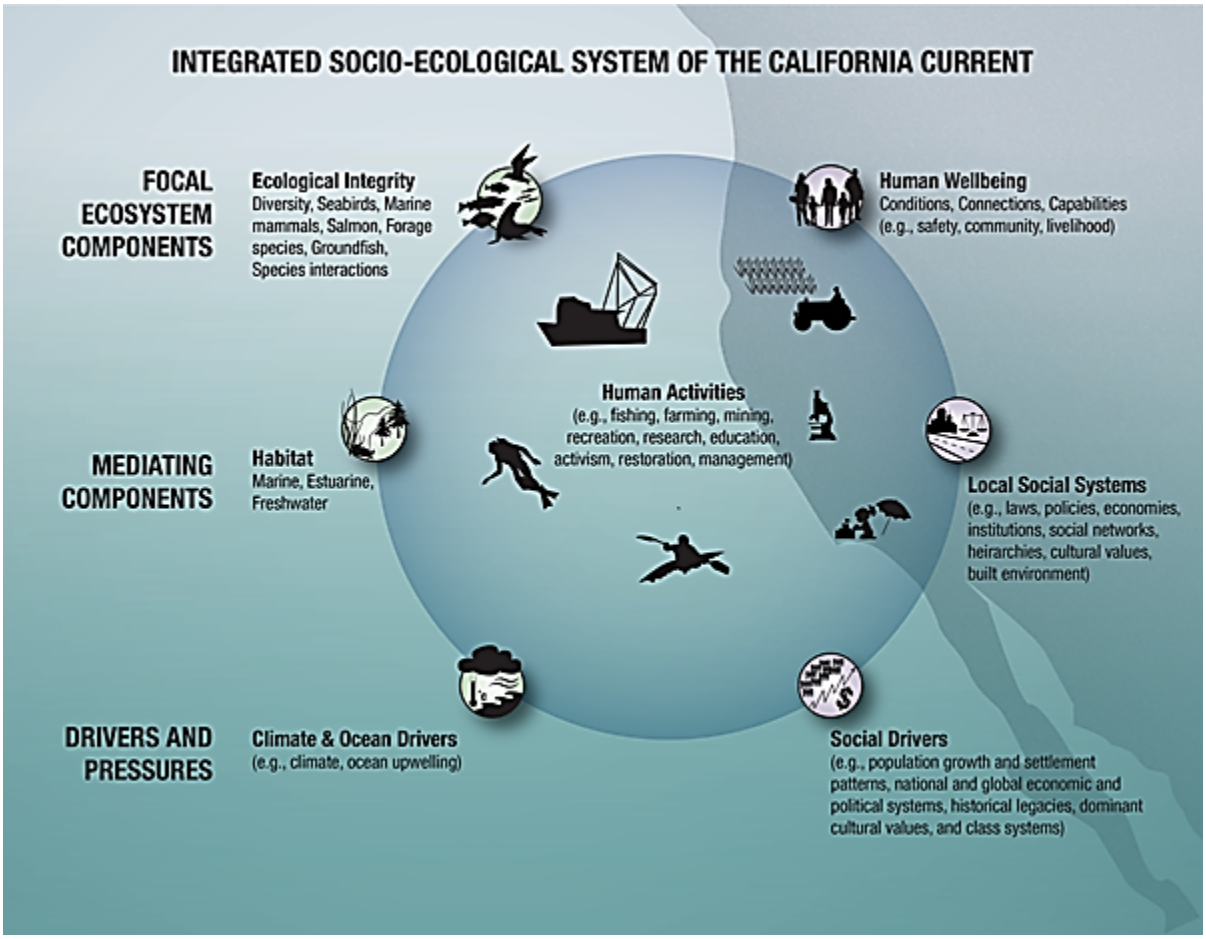


**Figure 2.14.** Socio-Ecological Model of the California Current by the CCIEA (https://www.integratedecosystemassessment.noaa.gov/regions/california-current/social-ecological-model). This conceptual model includes most of the identified ecosystem components and drivers but may not be "accessible" i.e. easily understood by a broad and diverse group of stakeholders.

Ecosystem indicators in the CCE are monitored and reported by the CCIEA and were primarily selected using thorough screening procedures developed by Kershner et al. (2011). Annual Ecosystem Status Reports, produced by the CCIEA and communicated to the Pacific Council, capture changes in all identified ecosystem indicators at all spatial scales relevant to the CCE, presenting trends through time, exceeded thresholds, and what each indicator trend may suggest about corresponding trends in fisheries. The CCIEA conducts interpretation of indicators through tools and modeling to help predict influences on the ecosystem from changing environmental drivers, human activities, and management actions (https://www.integratedecosystemassessment.noaa.gov/regions/california-current/cc-about). An overall synthesis of trends is also provided in the report, stating large-scale general trends in

environmental changes and productivity in the CCE for the year, as well as significant positive or negative events within ecological and social spheres, thereby providing a general ecosystem backdrop for all fisheries decisions. Status reports are requested by the Pacific Council to be approximately 20 pages in length, and indicator trends are graphically represented to be easily digestible within the decision-making context. Relevant indicators and their implications are utilized within Ecosystem Initiatives, allowing environmental variability to inform management and alternative actions.

### 2.4.3 Resulting Management Actions

The Pacific Council has completed two Ecosystem Initiatives to date and has two more currently in progress, with each resulting in enforceable amendments to FMPs, dissemination of information on ecosystem issues and management, and/or improvements to the FEP document and process.

Protecting Unfished and Unmanaged Forage Fish Species
This initiative, completed in 2015, led to the designation of selected forage fish species as "ecosystem components" across all four FMPs. This led to amendments in each FMP, and resulted in the prohibition of development of any commercial fishery targeting these shared "ecosystem components." Ongoing incidental catch in existing fisheries was not regulated.

Coordinated Ecosystem Indicator Review
The goal of this initiative, was refinement of the suite of ecosystem indicators identified by the Annual CCE Status Report in order to better integrate them into the decision-making process. The review was conducted by the Ecosystem Working Group in conjunction with the CCIEA team and the SSC Ecosystem Subcommittee. The reviewed indicators were then assimilated by the CCIEA team into the 2017 Annual Ecosystem Status Report. The Pacific Council also created a webinar series to easily convey these updates to internal advisory bodies for incorporation into decisions. Indicators undergo continuing review by the SSC as better science becomes available.

FEP 5-year review
The FEP document was opened to review in 2018 with this initiative, with final action being taken in 2020 to revise Chapters 1 and 2 based on review by the public and other advisory bodies in the Pacific Council. Chapter 3 and 4 revisions have been proposed in 2021, as well as an additional stand-alone document entitled "Guidance Document on Offshore Non-Fishing Activities," based on Chapter 5 of the FEP to be produced by the Ecosystem Working Group.

Climate and Communities Initiative
Commenced in 2017, this initiative aims to better understand the effects of short-term and long-term changes in climate on fish, fisheries, and fishing communities, and to integrate this understanding into management decisions. Climate change effects on individual species will still be captured by individual FMPs, whereas this initiative intends to assess cumulative multi-species impacts. The Ecosystem Working Group, coordinating with NMFS Northwest and Southwest Fisheries Science Centers, organized a webinar series to inform Pacific Council advisory bodies and the public on relevant research on and potential fisheries effects of climate

change in the future. This was supported by The Nature Conservancy's concordant Climate and Communities Initiative Workshop and resultant report in 2018, in which all interested stakeholders could offer pertinent input to the Pacific Council on these issues.

Preliminary investigations and workshops within this initiative led to Pacific Council work on a "climate change scenario planning process," to prepare for possible future alternative climate scenarios. In March 2019, the Pacific Council formed the Climate and Communities Core Team (CCCT) to lead planning exercises for specific scenarios (e.g., shifting stock availabilities as the initial topic) and develop tools and products to help respond to those scenarios, all within a 20-year timeframe (2040 end date). A workshop with The Nature Conservancy was held in 2020 to develop new scenarios, which were then expanded on by the CCCT, including species-specific examples within and across the four FMPs. Four climate change scenarios, once detailed by the CCCT, were translated to potential Pacific Council, management, and stakeholder actions through online "implications" workshops conducted in four regions, which focused on idea generation (e.g., of likely outcomes, beneficial responses, how to increase resiliency) by diverse groups of 20 to 30 stakeholders recruited to participate. Workshops were led by an external contractor. Results synthesized from the four scenarios were conveyed to the Pacific Council in March 2021, resulting in identification of "priority action areas" that would benefit management no matter which scenario took place. Three example areas established were: 1) management flexibility, to bend regulations as circumstances demand; 2) marketing, outreach and education, to cope with shifting supply and demand; 3) council efficiency, to rethink and streamline council processes as environmental complications increase. The next step looking forward is for the Pacific Council is to "reflect on the issues raised" and decide if and how to take further action as the Pacific Council and/or how to foster stakeholder action.

### 2.4.4 Summary of Best Practices and Lessons Learned

Best Practices

- "Ecosystem Initiatives" a formal process and framework, are used to address specific ecosystem issues (e.g., climate resilience and forage fish management)
- Increasing stakeholder engagement through purposeful recruitment for regional workshops during Ecosystem Initiatives
- Annual Ecosystem Status Reports are concise, and graphic to allow managers to digest their contents and implications of indicators and support the decision-making purposes.
- Partnering with other agencies, tasks forces and NGOs on issues of mutual concern.

Lessons Learned

- "Ecosystem Initiatives" are effective mechanisms to address ecosystem concerns and have led to enforceable amendments to FMPs (e.g., for forage fish).
- Climate impacts can be addressed through scenario planning and implications workshops in which stakeholders examine possible future scenarios, likely outcomes and beneficial responses, and priority actions to build resilience to changing conditions.
- Partnerships with NGOs and other organizations can help address ecosystem issues.

## 2.5 New England

### 2.5.1 New England Fishery Ecosystem Description

Commercial fishermen in New England landed over of 595 million pounds of finfish and shellfish with revenue totaling almost $550 million for 2016 (NMFS 2018). The region encompasses the marine waters from Maine to the southern coast of Cape Cod, Massachusetts. The New England Fishery Management Council (New England Council) has jurisdiction over the region but works closely with the Mid-Atlantic Fishery Management Council (Mid-Atlantic Council) the Greater Atlantic Regional Fisheries Office, the Atlantic States Marine Fisheries Commission and with support from NOAA's NEFSC. Fisheries resources in this region are also tracked by the Transboundary Resource Assessment Committee (TRAC), with representatives from the United States and Canada.

The New England Council created regional subdivisions called Ecological Production Units (EPUs), as defined by their unique biogeophysical characteristics within the Northeast Continental Shelf including the Gulf of Maine, and Georges Bank (Figure 2.15). These areas are highly productive fishing grounds, starting with the submarine plateau, Georges Bank. North of Georges Bank lies the Gulf of Maine Basin, and the offshore banks of the Scotian Shelf. Georges Bank is a distinct and highly productive submarine plateau off the New England coast delimited by deep water channels on the southwest and northeast edges of the bank. It is positioned on the continental shelf between the deep-water basin of the Gulf of Maine to the west and the deep-water abyssal basin of the Atlantic Ocean to the east.

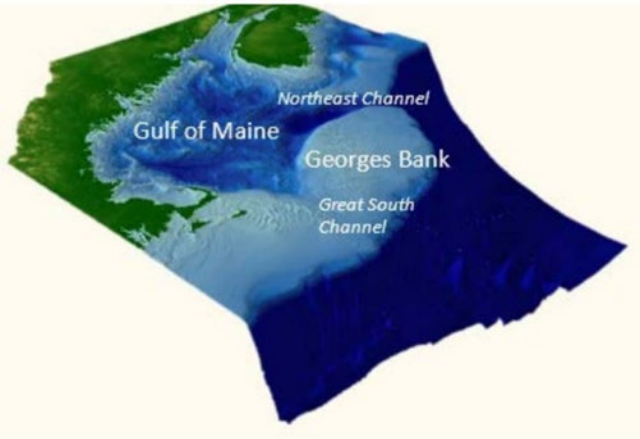


**Figure 2.15.** New England Regional EPUs (from NEFMC 2019).

In support of data collection for management, the NEFSC's Fisheries Monitoring and Research Division has an entire branch dedicated to Cooperative Research. The Cooperative Research Branch employs various tools and initiatives including the Gulf of Maine Bottom Longline Survey and a "Study Fleet" of over 50 active commercial vessels that actively participate in fisheries dependent (fine scale catch, effort, discard and location) and fisheries independent and environmental sampling. The NEFSC has also developed a Regional Cooperative Research Strategy, along with other cooperative research entities throughout the region.

### 2.5.2 Fishery Ecosystem Plan Development

An example Fisheries Ecosystem Plan (eFEP) for Georges Bank by the New England Council was drafted in 2019 (NEFMC 2019). The plan for Georges Bank proposes seven species complex categories for management (NEFMC 2019). These categories include: Benthos,

Benthivores, Mesoplanktivores, Macroplanktivores, Macrozoo-piscivores, Piscivores, and Apex Predators. Within these complexes, 82 species have been identified within the Georges Bank EPU. These include of Cod, Haddock, Pollock, Hake, Monkfish, Flounder, Skate, Dogfish, Lobster, Crabs, and Scallops.

The draft eFEP proposes a framework in which total removals from fishing should not exceed a threshold percent of total productivity of the EPU (i.e. a ceiling over removals). This constraint would reserve a proportion of the system productivity for other purposes within the ecosystem, such as supporting populations of higher trophic level species that are not captured by fishing (e.g., marine mammals, turtles, seabirds, etc.). Management measures are being considered that could allow adaptation to the rapid changes occurring in the ecosystem and to achieve a broad range of objectives that include OY harvest of multiple species and complexes, but also the sustainable maintenance of ecosystem services. The draft eFEP also includes mechanisms to assess trade-offs between generating a high flow of benefits and the ability to ensure that the benefit flow is stable and sustainable.

To evaluate the outcomes of possible EBFM actions, the NEFSC is comparing outputs from four candidate ecosystem models, Ecopath, Hydra, Kraken and Atlantis. Atlantis is a biogeochemical model for the Northeast United States that incorporates physical processes, biological processes, and human dimensions. The NEFSC is comparing outputs and probable outcomes from the various models and alternative management procedures and actions using a Management Strategy Evaluation (MSE) process.

### 2.5.1 Resulting Management Actions

The FEP for the Georges Bank EPU is under review. While members are relatively supportive of the concept, the group recognizes the inherent complexity of the ecology, contrasting ecosystem model outputs, competing management interests and the inertia from existing management. Existing IFQ holders, permit holders, and participants in the highly valuable scallop fisheries are skeptical; the proposed plans could jeopardize their existing access and have been resistant to participating in the cooperative FEP process. No management actions have resulted from the current process as it is still in the framework development stage.

State of the Ecosystem Reports have been provided by NOAA annually since 2017 for both the New England and Mid-Atlantic Councils. These provide insights about social, ecological, and economic components of the ecosystem, including fishing engagement, and oceanographic and climate conditions. Characterizing the structure and function of the ecosystem is achieved with three overall concepts for reporting: Multiple system drivers, Regime shifts, and Ecosystem reorganization (NOAA Fisheries 2021). Data from these reports allow for current performance to be measured against ecosystem level management objectives and for assessment of potential risks to meeting fishery management objectives.

Like many of the other management regions, the New England Council has enacted some ecosystem level management actions within the existing regulatory framework. This includes multispecies FMPs, such as the Northeast Multispecies FMP which covers thirteen co-occurring species of groundfish. The New England Council, in partnership with adjacent RFMCs also uses

marine managed areas (MMAs) to address scallop and groundfish fisheries management (Figure 2.16). For example, areas in the Gulf of Maine have been assigned seasonal closures to help protect Atlantic Cod spawning aggregations (Zemeckis et al. 2014).

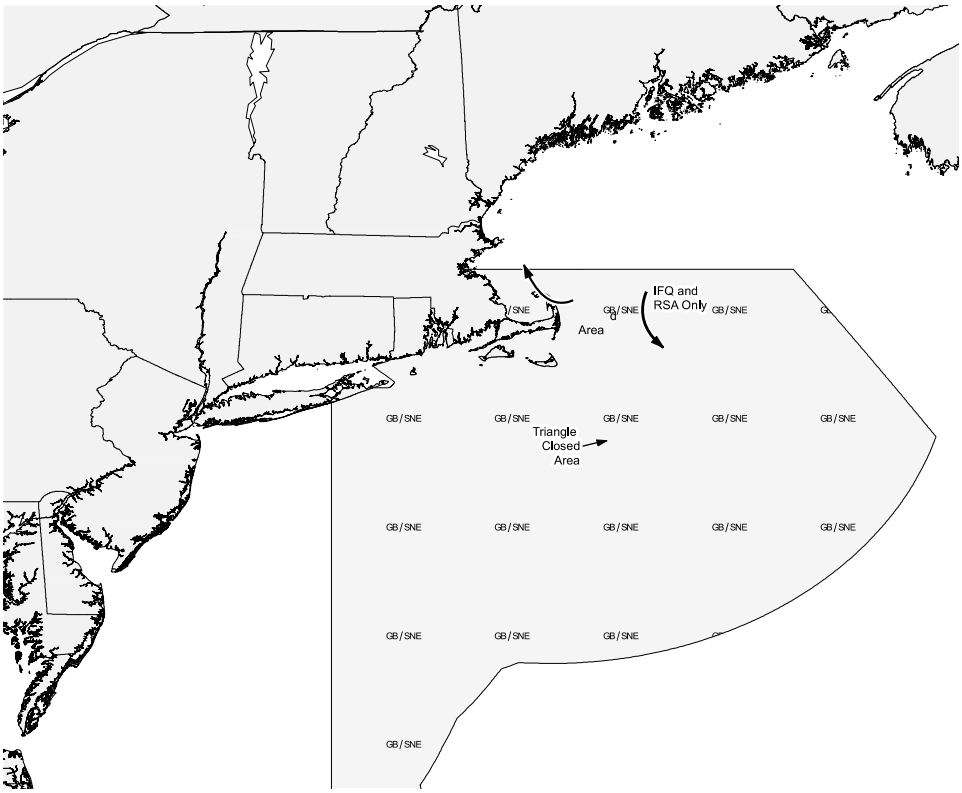


**Figure 2.16.** MMAs in the Northeast Atlantic, including seasonal and permanent fishing closures for scallops and groundfish, research only areas, and seasonal closures to protect spawning Atlantic Cod (NEFMC, 2019).

### 2.5.2 Summary of Best Practices and Lessons Learned

Best Practices

- Inter-agency and international collaboration on transboundary management of most of the region's fishery resources.
- An entire branch of the NEFSC's Fisheries Monitoring and Research Division is dedicated to Cooperative Research between scientists and fishermen. The division works with a "Study Fleet" of over 50 commercial vessels to collect fisheries data to support assessments and for ecosystem monitoring.
- Seasonal and area closures to manage groundfish and scallops and to protect spawning Cod.

Lessons Learned

- Management of the transboundary resources can be addressed through collaboration with many agencies and institutions, including Canada.
- "Study Fleets" used for cooperative research and monitoring are valuable for gathering needed data and building stakeholder confidence in science-based management.
- The Georges Bank eFEP aims to replace the existing management structure for Georges Bank based on a holistic EBFM perspective. This can be considered a "revolutionary" approach rather than an "incremental" one. It is also very difficult to attain.
- It is an enormous challenge to create and use ecosystem models to effectively capture the fishery ecosystem complexity, impacts from the long history of exploitation, rapid and recent changes in the ecosystem, and to assesses tradeoffs between short term productivity and long term sustainable and stable energy flow and also account for the concerns of existing permit and IFQ shareholders.

## 2.6 Mid-Atlantic

### 2.6.1 Mid-Atlantic Fishery Ecosystem description

The mid-Atlantic ecosystem stretches from the Gulf of Maine in the north to Cape Hatteras, North Carolina in the south, and the jurisdictional boundaries of the Mid-Atlantic Fishery Management Council (Mid-Atlantic Council) extend from New York to the North Carolina-Virginia border (Figure 2.17). The Mid-Atlantic Council manages 64 species with seven FMPs. Fourteen species are directly managed with specific FMPs. These include spiny dogfish and monkfish, which are managed jointly with the New England Council. The Mid-Atlantic Counsel also coordinates the management of summer flounder, scup, black sea bass, bluefish, and spiny dogfish jointly with the Atlantic States Marine Fisheries Commission. In addition, the Mid-Atlantic Council manages more than 50 forage species as "ecosystem components" in all seven FMPs. Commercial landings in the region totaled 597 million pounds, generating $689 million in revenue (NMFS 2018).

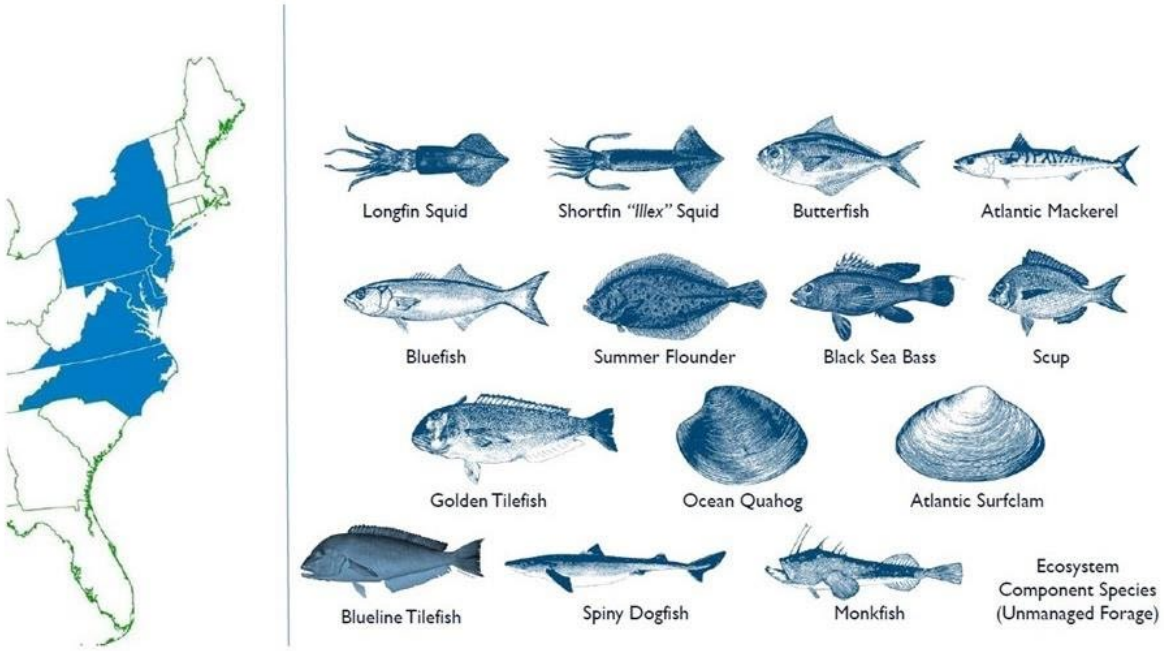


**Figure 2.17.** States and species within the Mid-Atlantic Council's jurisdiction (https://gulfcouncil.org/technical/archive/).

### 2.6.2 Fishery Ecosystem Plan Development

The Mid-Atlantic Council began considering ways to introduce ecosystem considerations into the fishery management process in the late 1990s, and published a document titled "Evolution Towards an Ecosystem Approach to Fisheries" in 2006 (MAFMC 2006; Figure 2.18). The Mid-Atlantic Council took several steps towards EBFM in 2011, including participating in a national SSC workshop to discuss incorporation of ecosystem considerations in federal fisheries management, and a Visioning Project to guide the future of marine fisheries management in the Mid-Atlantic based on extensive stakeholder input. These efforts lead to the development of the Mid-Atlantic Council's 2014-2018 Strategic Plan (http://www.mafmc.org/strategic-plan), which established the goal of maintaining sustainable fisheries, ecosystems, and habitats in the Mid-Atlantic through the development of management approaches that minimize adverse ecosystem impacts. The Mid-Atlantic Council decided to focus on the following major ecosystem-related issues: 1. Forage/low trophic level species considerations; 2. Incorporation of ecosystem-level habitat conservation and management objectives in the current management process; 3. Effects of systematic changes in oceanographic conditions on abundance and distribution of fish stocks and ramifications for existing management approaches/programs; and 4. Interactions (species, fleet, habitat, and climate) and their effects on sustainable harvest policy and achievement of OY. The Mid-Atlantic Council organized a series of four workshops between 2013 and 2015 to discuss the four topics and later developed white papers which provide detailed information on each of these topics. Finally, the Mid-Atlantic Council released its Ecosystem Approach to Fisheries Management Guidance Document in 2016, and revised the document in 2019.

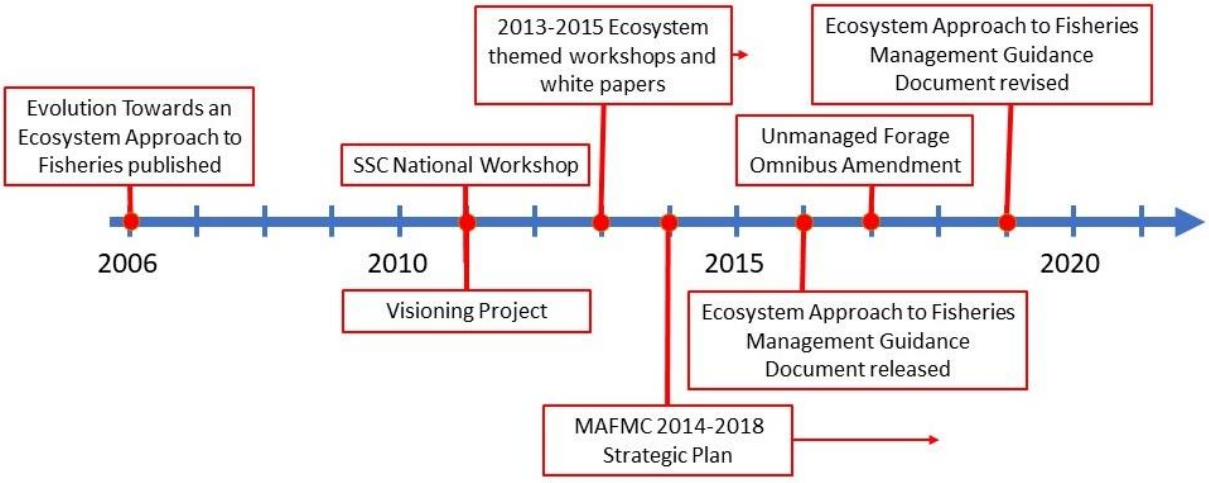


**Figure 2.18.** Timeline of ecosystem management in the Mid-Atlantic Region.

### 2.6.3 Resulting Management Actions

The Mid-Atlantic Council decided to take an approach to incorporating ecosystem considerations into fishery management that was "evolutionary, not revolutionary", labeling their work as an ecosystem approach to fisheries management (EAFM) rather than EBFM. The Mid-Atlantic Council defined EAFM is "An ecosystem approach to fishery management that recognizes the biological, economic, social, and physical interactions among the components of ecosystems and attempts to manage fisheries to achieve OY taking those interactions into account." In addition, the Mid-Atlantic Council developed the following EAFM goal: To manage for ecologically sustainable utilization of living marine resources while maintaining ecosystem productivity, structure, and function. The EAFM strategy allows for transition from single-species to ecosystem level management, movement towards a definition of OY which takes into account interactions at multiple dimensions of the ecosystem, and recognizes that humans are inextricably a major component of marine ecosystems.

The Ecosystem Approach to Fisheries Management Guidance Document (MAFMC 2019) describes a number of policies adopted by the Mid-Atlantic Council. These include strengthening EFH designations and considering habitat essential from a multispecies/ecosystem perspective emphasizing the connectivity between species, life history stages, and inshore and offshore habitats, and identifying new species likely to become established in the Mid-Atlantic (from the South Atlantic), and species likely to expand or shift distribution into waters under the jurisdiction of New England and Canada. The document also acknowledges that single species stock assessments already incorporate environmental, species, and fleet interactions. For example, by changing weight-at-age data over time which incorporates the effects of a changing environment and ecology on fish growth, or by changing natural mortality rates over time which can represent changing species interactions (such as predation), but could also represent habitat or other environmentally mediated changes. The document also encouraged the use of conceptual models similar to those developed for the California Current IEA as a useful tool for

the Mid-Atlantic Council to address species and fleet interactions, and as a communication tool between the Mid-Atlantic Council, other scientists, and the public.

The Mid-Atlantic Council set a policy to support the maintenance of an adequate forage base in the Mid-Atlantic to ensure ecosystem productivity, structure and function, and to support sustainable fishing communities. Steps were taken to enact this policy when the Unmanaged Forage Omnibus Amendment was implemented in 2017. The Amendment prohibits the development of new, and expansion of existing, directed commercial fisheries on 50 unmanaged forage species until the Mid-Atlantic Council has had an opportunity to assess the available scientific information for these species and consider the potential impacts to existing fisheries, fishing communities, and the marine ecosystem. The amendment also established an incidental possession limit of 1,700 pounds for all of these species combined. The amendment requires use of exempted fishing permits (EFPs) prior to allowing any new fisheries or expansion of existing fisheries for unmanaged forage species and establishes a new policy for Mid-Atlantic Council review of EFP applications (MAFMC 2019).

Like other regions, there are many extra jurisdictional issues that affect the fisheries within the Mid-Atlantic region. A cross-sectoral partnership for the New England and Mid-Atlantic Regions, known as the Responsible Offshore Science Alliance (ROSA), was formed to address issues surrounding new offshore wind energy developments being installed on the Atlantic coast (Perry and Heyman 2020). ROSA was formed by fishers and wind developers in collaboration with federal and state agencies, academic and nongovernmental institutions, and resource managers. ROSA's mission is to enhance the scientific understanding necessary to support the coexistence of wind energy development and sustainable fisheries. The organization seeks to accomplish this by convening the scientific community, fishers, wind developers, and relevant management agencies to identify and prioritize research and monitoring needs, coordinate entities, administer research funding, oversee programs, and facilitate dissemination of findings and access to data. RFMC participation in partnerships such as ROSA will facilitate their ability to address issues that beyond their jurisdiction.

### 2.6.4 Summary of Best Practices and Lessons Learned

Best Practices

- Visioning exercises built stakeholder support for an incremental rather than revolutionary approach to incorporate ecosystem considerations in management, labelling the process EAFM. Yet, their process is nearly identical to what other RFMCs call EBFM. They have received less resistance than other regions.
- Prohibiting new fisheries targeting unexploited forage species is an easy first step for forage fish protection, but also a good tool for precautionary management.
- EFH designations were strengthened to support connectivity between habitats required for multi-species life cycle support.

Lessons Learned

- RFMCs should proactively plan for species range shifts caused by climate change.
- Conceptual models are useful as a communication tool.

- Marketing, labelling, and branding can be important in gaining stakeholder support for EBFM

## 2.7 Western Pacific

### 2.7.1 Western Pacific Fishery Ecosystem Description

The Western Pacific Regional Fishery Management Council (Western Pacific Council) has jurisdiction over three U.S. territory archipelagos and eight remote islands, encompassing an area of more than 1.7 million square miles (Figure 2.19). The Western Pacific Council has chosen the Hawaiian Archipelago as the first subregion for Fishery Ecosystem Planning (Figure 2.20).

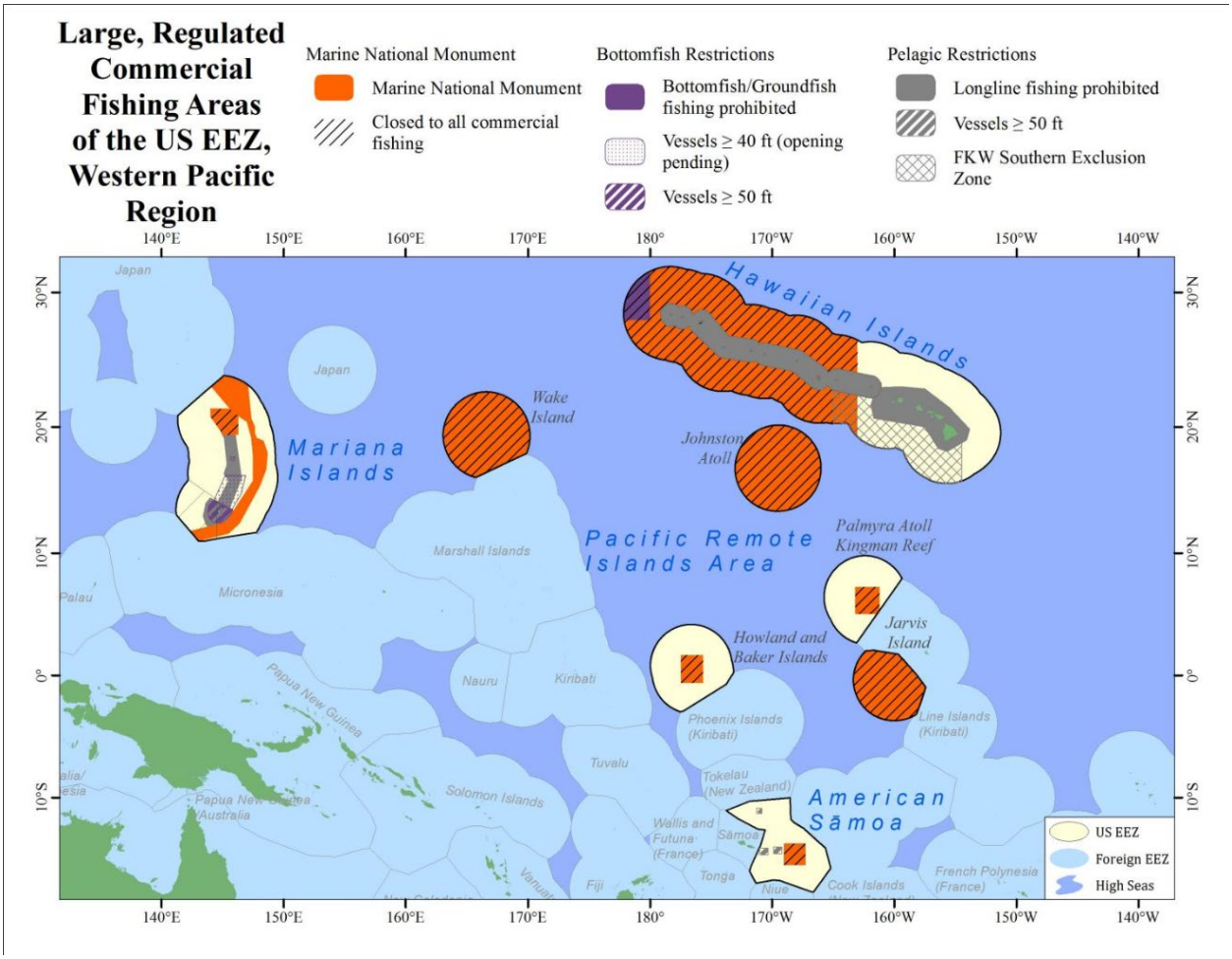


**Figure 2.19.** West Pacific region jurisdiction and management areas. Source: WPRFMC, 2018.

Ocean surface currents around the Hawaiian Archipelago are dominated by the North Equatorial Current, which approaches the islands from the East. Marine habitat types are divided into two general categories in the Hawaiian Archipelago FEP, benthic/demersal (associated with the seabed) or pelagic (open water). The benthic environment encompasses intertidal zones, seagrass

beds, mangrove forests (an expanding invasive species), extensive shallow coral reefs, deep reefs, slopes, banks, seamounts, and deep ocean floor. These complex habitats support diverse species assemblages and economically valuable and commonly harvested species, including a large variety of reef fish and bottom fish, spiny lobster, octopus and more. Pelagic habitats in the region are also highly productive, and contain complex food webs which support pelagic fisheries (e.g., for tuna and Dolphin) that constitute the largest and most valuable commercial fishery in the region (Tissot et al. 2009). In 2016, commercial landings of finfish and shellfish totaled 35 million pounds for a revenue of over $118 million (NMFS 2018). Recreational angling and subsistence fisheries are also key to economic productivity and community well-being, with the recreational sector creating 1,061 jobs in 2014. Reef-fish fishing for recreational, subsistence, and cultural purposes (i.e., non-commercial) is the second largest fishery with an annual average catch of nearly 406,000 pounds between 2003 to 2013 (Gove et al. 2019). The aquarium fishery is also significant, with an average of $1.35 million in revenue between 2003 to 2017 (Gove et al. 2019).

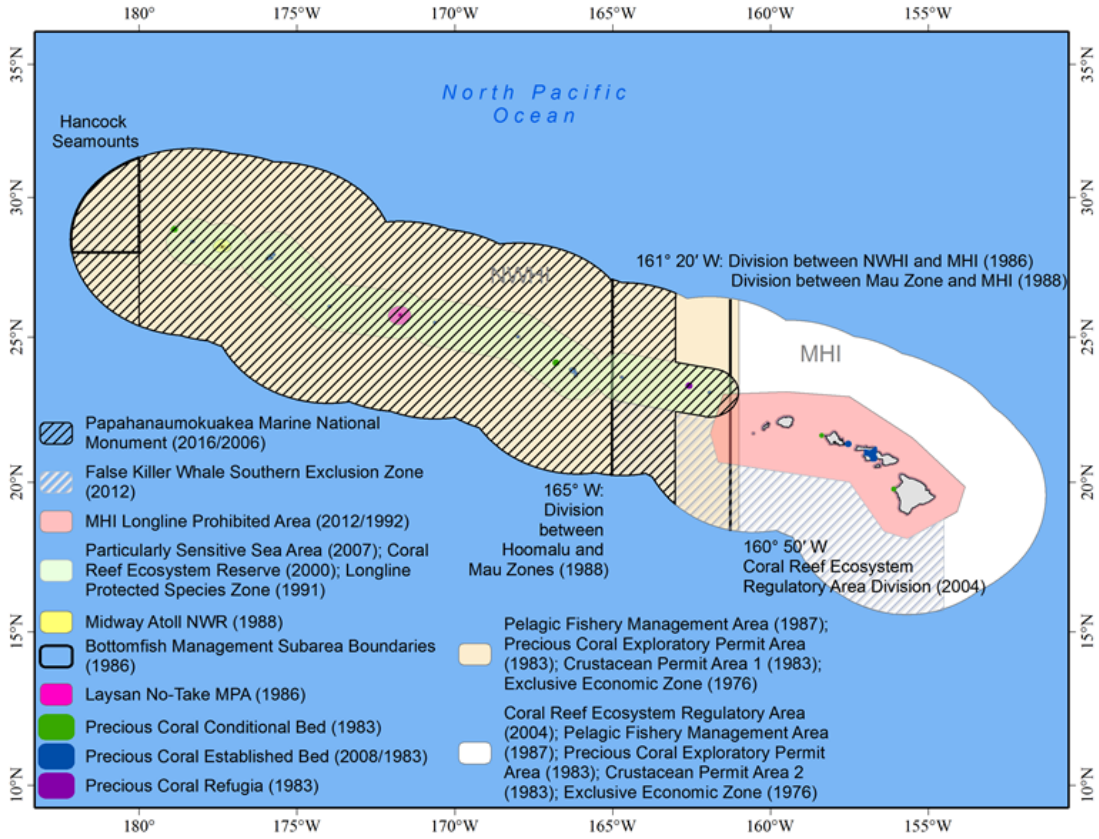


**Figure 2.20.** Hawaiian Archipelago EEZ, fishery management areas, and Paphanaumokuakea Marine National Monument (Source: Western Pacific Council).

### 2.7.2 Fishery Ecosystem Plan Development

Fisheries management in the West Pacific was organized under species-based FMPs since the 1980s. As EBFM principles and practices became increasingly encouraged by NOAA and other

agencies, the Western Pacific Council recommended the development and implementation of place-based FEPs in 2005 (Figure 2.21). The region was divided into five FEP jurisdictions: the Hawai‘i Archipelago, American Samoa Archipelago, Mariana Archipelago, Pacific Remote Islands, and cross-region Pelagic zone fisheries.

The unique management approach adopted by the Western Pacific region was to subsume all FMP authority and regulations into all-encompassing FEPs. The four island-based FEPs incorporated all benthic and demersal species management unit FMPs within their designated jurisdiction, whereas the Pelagic FEP assimilated management of all pelagic species within EEZs and domestic high seas fisheries throughout the Western Pacific region. Each FEP "identifies management goals and objectives, delineates geographical boundaries, fosters increased coordination and community participation through various advisory bodies and an appropriate management structure, designates managed species, and details applicable fishery regulations" (WPRFMC 2017). FMP integration is achieved within each FEP document through the inclusion of dedicated chapters on fisheries descriptions (e.g., history, status, bycatch reviews, species unit MSY and OY) and management programs (e.g., fishery regulations, seasons, closures, gear types), as well as the broader ecological and socioeconomic ecosystem context and management regime into which these metrics fit.

The Hawai‘i Archipelago FEP employs a general, bottom-up management approach and decision-making process. The approach is institutionalized within the FEP structure by incorporating a variety of panels comprised of diverse stakeholders and by fostering community member input at public meetings. Western Pacific Council bodies directly engaged in the FEP process include:

- FEP Advisory Panel – comprised of sub-panels that advise the Western Pacific Council on ecosystem issues and fishery management implications, and include diverse stakeholders
- Archipelagic and Pelagic FEP Plan Teams – oversee continuing development and implementation of the FEPs, produce annual stock assessment and fishery evaluation (SAFE) reports
- FEP Standing Committees – review information and recommendations presented by FEP Advisory Panel, FEP Plan Team, the SSC, and any other relevant panels, synthesize recommendations prior to Western Pacific Council actions; comprised of Western Pacific Council members
- Fishing Industry Advisory Committee – provides information from an industry perspective to advise FEP document and amendments
- Regional Ecosystem Advisory Committees – consists of council members, government representatives, and NGO members engaged in land-based or non-fishery ecosystem issues that may influence fishery resources
- Community Development Program, Community Demonstration Projects Program, Marine Education and Training Program – increase participation of indigenous communities and fishery stakeholders

The Western Pacific Council also requests information and recommendations from other internal committees (e.g., SAFE Report reviews from the Marine Planning and Climate Change Committee and others), and aims to increase collaboration with external engaged agencies, such

as regional and national governing bodies who may contribute components necessary for successful EBFM research and implementation.

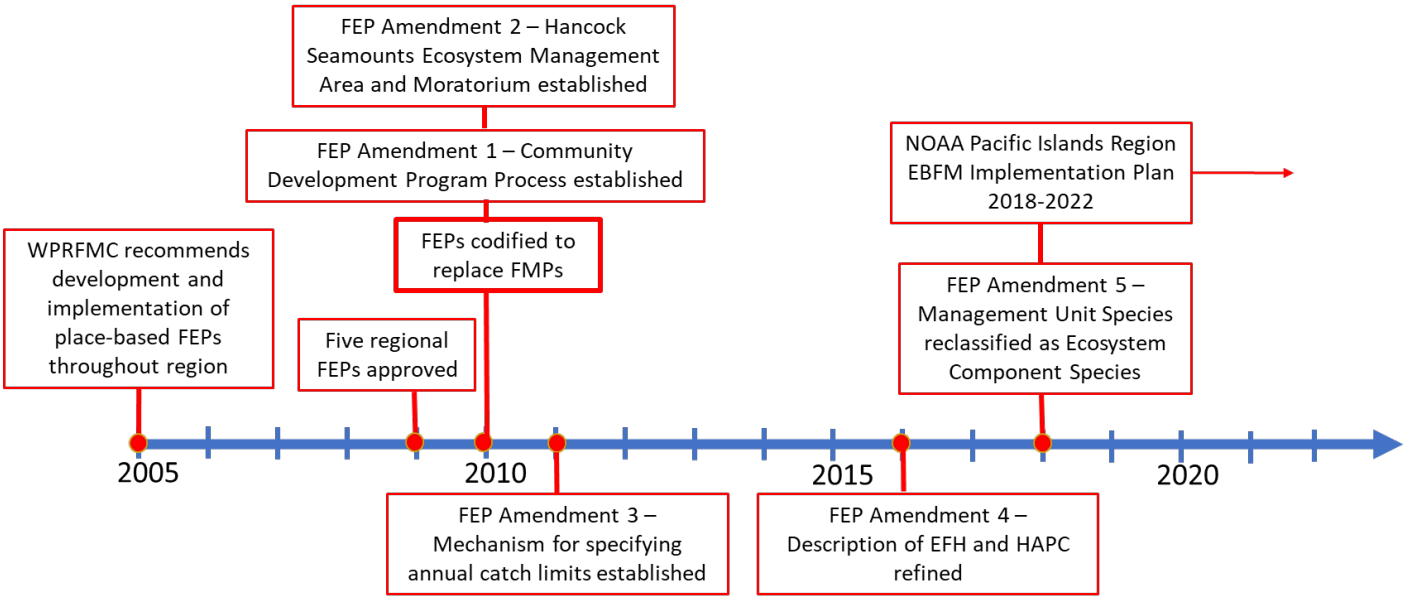


**Figure 2.21.** West Pacific Region FEP development timeline.

As part of NOAA Fisheries' IEA work in the region, conceptual ecosystem models were charted from participatory mapping of stakeholder understanding of ecosystem services and influential threats on a local basis. This small-scale approach offers spatial specificity and a transferable template for other locations. Local knowledge and management are uniquely able to address stakeholder concerns on ecosystem pressures within local manageable areas, and they often capture human dimensions that may otherwise be overlooked in ecosystem assessment and management practices. For example, in a conceptual ecosystem model for West Hawai'i, stakeholders highlighted cultural benefits from ecosystem services as the most vulnerable to change.

### 2.7.3 Resulting Management Actions

The Hawaiian Archipelago is geographically isolated, which limits cross-boundary conflicts with the exception of migratory pelagic fishery issues. However, cultural and political disparities amongst islands create challenges in coordination of government agencies and management policies. Involvement of indigenous communities is also considered in the governing process. To accommodate for inter-island differences and to gather local fisheries information, a strong emphasis has been placed on community co-management (Tissot et al. 2009). Co-management goals are supported through direct participation of local communities in public meetings and programs specially designed to help incorporate local and traditional knowledge. This focus on bottom-up collaboration allows for the creation of incremental, adaptive, community-supported practices and conflict resolution within fisheries management. This management approach also has a long history within native Hawaiian culture in the traditional ahupua'a community-based

and watershed-based conservation model, in which an island and its surrounding waters are divided into wedge-shaped areas from mountain to sea, as well as subdivisions within each wedge. The local chief and residents within each area participate in a decentralized decision-making process to reach consensual solutions for environmental use and protection that support traditional cultural values (Minerbi 1999).

Modern management – community established MMAs

In 2006, the Papahanaumokuakea Marine National Monument was established, which is the largest contiguous conservation area in the U.S. under full protection status, encompassing 582,578 square miles. Commercial fisheries are prohibited within the monument, but some cultural practices and sustenance fishing is permitted. Nearly 35% of the coastal area of Western Hawai'i are included in various forms MMAs, that are cooperatively managed between the state and local communities.

The West Hawai'i Integrated Ecosystem Assessment Ecosystem Status Report summarizes a suite of ecosystem indicators that track the status of the region's marine ecosystem and help assess the efficacy of management's decision-making in West Hawai'i. The indicators include, ecological indicators, climate indicators, and social indicators. Observed declines in reef fishes due to the aquarium trade triggered the establishment of Fish Replenishment Areas (FRAs) in West Hawai'i in 1999. Importantly, reef fish indicators can provide a fisheries independent assessment and basis for evaluating the efficacy of the three primary management designations in West Hawai'i: MPAs (prohibition of fishing), FRAs (prohibition of aquarium fish collection only), and open areas (fishing allowed). In the report, significant differences in key fish indicators were observed between management designations and suggest a clear and positive influence of fisheries management on the structure and function of coral reef fish communities in protected areas. Juvenile Yellow Tang were singled out as an indicator species because they comprise 82% of the total catch in the region's aquarium fish fishery, and their abundance is important to the region's fisheries management. The indicators of climate include coastal sea level, a precipitation index, the North Pacific Gyre Oscillation, El Niño/La Niña, the Pacific Decadal Oscillation, sea surface temperature, and projections of future sea surface temperature. The social indicators include population growth, numbers of visitors and their spending, impervious surfaces, amount of effluent, measurements of fisheries catches, and commercial fisheries revenues and engagement. Together, these indicators provide insight into the status of the region's ecosystems.

### 2.7.4 Summary of Best Practices and Lessons Learned

Best Practices

- Traditional management measures, including a form of community based, integrated watershed and coastal management, managing on watershed-based upland areas and linked coastal areas, called ahupua'a.
- Extensive use of MPAs, MMAs, and FRAs are designed with community input and are frequently co-managed.
- Community councils are directly involved in choice and implementation of management rules and areas

- FMPs are subsumed under archipelago based FEPs.
- Change is conducted on an incremental and adaptive basis.

Lessons Learned

- Council panels foster broad community engagement and bottom-up management guidance.
- Managing an enormous area can include large MMAs in remote areas.

# CHAPTER 3. SUMMARY OF LESSONS LEARNED AND RECOMMENDATIONS FOR THE GULF COUNCIL

## 3.1 Gulf FEP Status and Needs

Following the mandates and guidance of NMFS, the Gulf Council is developing a FEP to better incorporate EBFM into their management practices. Each of the nation's RFMCs has embarked on the same path, yet each region has unique physical, ecological, social, cultural, and governance characteristics. The range of issues addressed, and the methods and techniques to address them, provide a rich and wide diversity of examples for the Gulf Council to consider. The Gulf is distinct from other regions and requires a tailored approach. Some of the issues addressed and techniques used in other regions are highly relevant to the Gulf, others, less so. Adding EBFM as a priority increases the Council's existing workload and resource needs. The Gulf Council is already burdened with their existing workload. Implementing EBFM through various means is expensive and requires dedicated staff, budget and institutional support. Additional resources will be needed, but this document aims to guide efficiency and prioritization in FEP development. This Chapter attempts to organize the best practices and lessons learned from each region's case study in order to guide the Gulf Council's efforts.

Importantly, the Gulf Council has made great strides in their development of EBFM but the activities and examples have become embedded within standard activities, assessments and actions. For example, the Gulf Council considers ecosystem effects in stock assessments and adjusts models accordingly (e.g., Red Grouper impacts from red tide). The Council also uses MMAs to address spawning protection and multi-species management (e.g., HAPCs, EFH designations and MPAs such as Madison Swanson and Steamboat Lumps Marine Reserves). The objective of the FEP is to provide an overarching framework that will systemize EBFM implementation, by incorporating existing activities and actions, prioritize new actions and use effective techniques and methods to address priority ecosystem issues.

## 3.2 Best Practices and Lessons Learned from other RFMC's Experiences

The case studies have identified the best practices and lessons learned from each of the seven RFMCs. We have selected 10 categories that we believe represent the most applicable methods and important issues addressed. They have been prioritized from top to bottom in terms of their potential priority, importance, and utility for the Gulf FEP (Table 3.1). In the remainder of this section we briefly describe each of the 10 methods or issues and the best examples of their implementation. We recommend that the Gulf Council implement the Gulf FEP using the first five.

**Table 3.1.** Comparison of RFMCs' use of Fishery Ecosystem Planning Issues and Methods.

| Issues/Methods Addressed by FEPs | Fishery Management Council | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Western Pacific** | **North Pacific** | **Pacific** | **New England** | **Mid Atlantic** | **South Atlantic** | **Caribbean** |
| Visioning | | | | | | | |
| Issue-Based Action Modules | | | | | | | |
| Stakeholder Engagement | | | | | | | |
| Cooperative Research and Citizen Science | | | | | | | |
| Extra Jurisdictional Issues | | | | | | | |
| Regional Subdivisions | | | | | | | |
| Conceptual and Ecosystem Models | | | | | | | |
| Annual IEAs | | | | | | | |
| Climate Change Mitigation | | | | | | | |
| MMAs | | | | | | | |

Key: Green: Good examples that could be adopted by the Gulf Council.
Gray: Approach initiated or used with some success
White: Limited or no use

Developing a Common Vision

All RFMCs in the nation have developed the common vision of the need for EBFM and have begun to incorporate ecosystem considerations in various aspects of their existing processes including stock assessments, setting annual ACLs, multi-species FMPs, and EFH and HAPC designations. The North Pacific and Western Pacific Councils are particularly advanced in considering EBFM in all of their management decisions; the Mid-Atlantic Region included visioning in creating an ecosystem focused strategic plan. In addition, RFMCs have invested in visioning with good examples emerging from subregional area planning efforts (e.g., Georges Bank, Bering Sea, Hawai'ian Archipelago); specific issues (e.g., climate mitigation in the North Pacific and Western Pacific); and programs (e.g., Citizen Science in the South Atlantic and via Action Modules and Ecosystem Issues in the North Pacific and Pacific Regions, respectively). Visioning can be an important aspect of stakeholder engagement. There will never be enough data or model accuracy to guide decision making completely, but with a common vision,

Councils can use MSE to help select "no-regret" decisions and take bold action in the face of uncertainty.

Issue-Based Actions

The nation's best examples are "Action Modules" used by the North Pacific Council and "Ecosystem Initiatives" used by the Pacific Council. These Councils have developed frameworks for issue prioritization and selection, as well as organized processes to empanel task forces, develop conceptual models, formally engage stakeholders, define objectives, tasks, timelines for product delivery, and regular Council review. These initiatives are used to generate actionable management guidance to Councils and have led to enforceable changes in FMPs. We suggest the term Fishery Ecosystem Issues to describe a parallel, issue-driven process as a primary building block in the Gulf FEP.

Stakeholder Involvement

Bottom-up, stakeholder-driven approaches to Fishery Ecosystem Planning have been used effectively with a variety of techniques and in various aspects of the planning process around the nation. The Western Pacific and North Pacific are exemplary in this aspect. Based on an ancient history of community-based management in Oceania, nearly all management decisions in the Western Pacific are made with broad stakeholder input through various formal committees and working groups, focused on both local and extra-jurisdictional issues using a holistic, precautionary approach and fully accounting for the non-harvested value of ecosystem components. Highly experienced, older, but still active fishers play a key role in bottom-up planning. Targeted education and outreach programs can help build stakeholder understanding of EBFM and thereby build their support. Well-developed diagrams and artist renditions that illustrate ecosystem linkages and connections can be valuable in this regard (e.g., for the North Pacific, Figure 2.5). One of the most effective ways to develop stakeholder involvement and buy-in is through cognitive mapping, i.e. using interviews to capture stakeholders' conceptual models (mental models) of Fishery Ecosystem Issues (see below). Addressing issues framed and illustrated in these ways is generally more acceptable than top-down, ecosystem model-driven approaches. Stakeholders can also be engaged through Cooperative Research and Citizen Science (see below).

Cooperative Research and Citizen Science

The NEFSC's Fisheries Monitoring and Research Division has an entire branch dedicated to Cooperative Research. This, exemplary and multi-faceted program includes a "Study Fleet" of over 50 commercial vessels that actively participate in fisheries dependent, fisheries independent and environmental sampling. The South Atlantic has also developed a Citizen Science Program which has begun to generate valuable results and has engaged (often reluctant) recreational anglers in research (Scamp discard project). The FISHStory project also provides a unique citizen science model whereby historical photos are uploaded by stakeholders and analyzed online by volunteer Citizen Scientists, to inform managers about species and size composition of landings from before modern and standardized landings data were collected.

Cooperative Research and Citizen Science play many important roles in Fishery Ecosystem Planning which include: building stakeholder support for concepts and underlying science, efficiently collecting important data for stock assessments (e.g., targeted sizes and ages) and

environmental monitoring (water quality), building fisher trust in the credibility of science for management, and putting some money in fishermen's pockets to participate in the management process. In many cases cooperative research allows some data to be collected that could not be collected any other way. Truly cooperative research occurs when stakeholders are involved fully and throughout the scientific process, beginning at the issue identification stage and continuing through hypothesis generation, sampling design and data collection, analysis and interpretation of results, and ultimately, in carrying resulting findings into the policy and management arena. Highly credible (to stakeholders, scientists and managers) management-relevant advice can be produced in this way.

Extra-Jurisdictional Issues

Many of the impacts on fishery resources are generated outside of the geography and jurisdiction of single RFMCs (e.g., coastal development, upland sources of pollution, and climate change). The New England, Mid Atlantic, South Atlantic and Gulf Councils work in partnership with adjacent and adjacent states to manage species that transcend jurisdictions. RFMCs also coordinate with other regional bodies (e.g., Atlantic States Marine Fisheries Commission) regarding highly migratory species, international bodies (e.g. the International Commission on the Conservation of Atlantic Tunas (ICCAT)), or directly with adjacent nations (e.g., New England Council engagement with Canada over cod and lobster management). Marine Reserve systems have also been designed to address transboundary stocks (e.g., for cod and scallops in transboundary areas managed by the New England and Mid-Atlantic Councils).

But impacts like water quality and climate change that affect marine resources are outside of the jurisdiction of the RFMCs. The Western Pacific Council has addressed integrated watershed and coastal management through their ancient system of ahapua'a. In some cases, Conservation NGOs have helped build consortiums to address such issues (e.g., Save the Bay Foundation and The Nature Conservancy in the Chesapeake Bay, have helped restore the primary nursery area for marine fishes in Mid-Atlantic Region). In some cases industry-based groups are developing partnerships with RFMCs, academics and others to address transboundary issues that are regulated by various agencies, (e.g., offshore wind farms in the Atlantic being addressed by the new ROSA consortium). Upland water quality issues are sometimes addressed through interagency task forces (e.g., the Mississippi River/Gulf of Mexico Hypoxia Task Force), but we have not found examples in which RFMCs have effectively used such consortiums to address direct impacts on federal fisheries.

There is a great need for broad collaboration with NGOs, academics, state and federal agencies, and others to address extra jurisdictional issues that negatively affect fisheries resources. Doing so can build fisher support for EBFM, in part because measures beyond simply ACL reductions may result. In many cases, however, new governance structures or institutions may be required to address extra jurisdictional issues – a process more akin to Ecosystem Management than EBFM.

Managing at Appropriate Subregional Scales

Subregional planning bodies or working groups have been established to focus management within those regions. Examples are provided within the Caribbean (Island Based FMPs); and Western Pacific ("place-based FEPs for individual Archipelagos including Hawai'i) where

management units are not contiguous. Subregional divisions have also been used to regionalize analysis and management, using task forces to focus on specific geographies (e.g., the FEPs developed for the Bering Sea in the North Pacific and for Georges Bank in New England). Yet when subregional boundaries are drawn to focus management, they are often flexible and issue-specific. Finally, some subregional management measures have been used to address within-region differences resulting from latitudinal gradients (e.g., in the South Atlantic where some species migrate seasonally and require subregional management measures). In all cases, RFMCs have found that subregional planning focus has increased specificity in resulting management recommendations with increased stakeholder engagement.

Conceptual and Ecosystem Models

Complex ecosystem models and integrated social-ecological system models have been developed for each RFMC but have rarely (if ever) had sufficient data or explanatory sub-models to accurately predict future ecological conditions (e.g., Georges Bank Models in New England). In the most general terms, future scenario models of climate impacts have been used to educate and engage stakeholders (e.g., in the Pacific Region as facilitated by The Nature Conservancy). For more specific issues and regions, comprehensive and complex ecosystem models have been developed to guide management actions. This goal may eventually be achieved and permit quantitative weighting of management tradeoffs but has not done so to date. By contrast, conceptual models, developed from stakeholders' knowledge, particularly highly experienced fishermen, have often been used to guide research and management actions and build the extent and quality of stakeholder engagement (e.g., Dolphin Wahoo in the South Atlantic and for subsistence and traditional fisheries in the North Pacific). In order to be most useful, conceptual models are presented in highly accessible formats (e.g., fisher reliance on resources in the North Pacific and Dolphin-Wahoo seasonal dynamics in the South Atlantic). Nonetheless, some conceptual models have been developed that don't provide sufficient clarity to guide management as standalone products (e.g., Mental Modeler output for the Caribbean), but further analysis, distillation and explanation of mentals models can greatly expand their utility.

Annual Integrated Ecosystem Assessments and Ecosystem Status Reports

The IEA Program, a precursor to Fishery Ecosystem Planning, was designed to provide a framework for RFMCs to prioritize and monitor various ecosystem parameters that could together and individually offer a proxy snapshot of status and trends in regional ecosystem conditions and that could be used to support multi-species fishery and ecosystem management decisions. The North Pacific has an intensive, well-funded, long-term research and monitoring program that is conducted collaboratively with many academic institutions, industry organizations, as well as state and federal agencies. The program has allowed for detailed and comprehensive indicator tracking that can be visualized in time series and is documented in annual Ecosystem Status Reports (ESR). The program offers management guidance that is incorporated in nearly all management decisions in the region. The Pacific Council's Annual Ecosystem Status Reports are also highly valuable and are also streamlined and concise, i.e., less than 20 pages and supported by easily interpreted graphical summaries of indicator values and trends in relation to identified reference points. This style and frequency of ESRs would be ideal for the Gulf of Mexico but is unfeasible with present resources.

Climate Change Mitigation

Climate change has been identified as a major driver of ecosystem change by every RFMC in the nation particularly those with geographies that align with large latitudinal gradients. Achieving "climate ready fisheries" could only occur when resilience and sustainability are prioritized equally with maximizing catch, as codified in National Standards 1, 8, and 9 of MSA. The North Pacific Council initiated the Climate Action Plan in 2017, through an Action Module. The Caribbean Council has taken bold measures to create MPAs, in part to mitigate climate change effects. Mid-Atlantic and New England Councils together designate and manage adaptive spawning closures for cod, accounting for long-term trends and seasonal variations in spawning times and locations. The Pacific Council is engaged on a climate scenario planning process with The Nature Conservancy.

Marine Protected Areas

MPAs have been used extensively as an EBFM implementation tool in all regions, often because of the holistic benefits to the ecosystem and/or to specific resources. The North Pacific Council has designated huge areas for various purposes including avoiding interaction with protected species and marine megafauna, trawling exclusion zones, research areas, etc. and has chosen to "freeze the footprint" of allowable bottom trawling area as precautionary measure. Because of data limitations and the need for simple, holistic measures, the Caribbean and Western Pacific Councils have also set aside enormous areas of EFH, HAPC and MPAs. Community co-managed areas are common in the Western Pacific and North Pacific to accommodate and promote traditional, tribal and subsistence and local use and management. The South Atlantic Council designated EFH, HAPCs and SMZs to reduce fishing effects on deep-water corals, manage reef fishes and specifically to protect spawning reef fish. We find that though MPAs can serve as holistic, multi-species management tools, their utility and acceptance by stakeholders is vastly increased when MPAs are designed to meet specific goals, articulated prior to designation. In spite of piecemeal designation, it would be valuable to reconsider and redesign managed areas to be part of MPA networks, designed for mutual replenishment and to build system resilience.

## 3.3 Recommendations for the Gulf Council

Based on the summary of best practices and lessons learned from this study, LGL recommends that the Gulf FEP should be implemented through five priority actions:

1. Develop a common vision of EBFM in the Gulf
2. Use Fishery Ecosystem Issues to address specific priorities
3. Engage stakeholders fully and effectively
4. Build a Citizen Science and Cooperative Research Program
5. Address extra jurisdictional issues

Several of these actions are mutually reinforcing. Specific guidance, tools and mechanisms for implementation will be gleaned from this and other documents in preparation for the Gulf Council and provided in a forthcoming draft FEP.

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