# NOAA Fisheries Ecosystem-Based Fishery Management Western Road Map Implementation Plan (WRIP) – PUBLIC REVIEW DRAFT

The comment period on this PUBLIC REVIEW DRAFT **ends September 30, 2018**. Comments may be sent via email to NOAA Fisheries: nmfs.westcoast-ebfm@noaa.gov.

**Table of Contents**



## *1.0 Introduction*

In 2016, NOAA's National Marine Fisheries Service (NOAA Fisheries) released its Ecosystem-Based Fisheries Management (EBFM) Policy and Road Map. For 2018 and beyond, the EBFM Road Map suggests that NOAA Fisheries develop regional Road Map implementation plans, to take into account the particular nature and challenges of each U.S. marine ecosystem. NOAA Fisheries' West Coast Regional Office, Northwest Fisheries Science Center, and Southwest Fisheries Science Center (collectively, NOAA Fisheries West Coast) together drafted this Western Road Map Implementation Plan (WRIP) for the California Current Ecosystem (CCE). This WRIP organizes key regional objectives, outlines progress in achieving them, and spells out future directions. While this document is in part about following the EBFM Road Map, it also lays important groundwork to strengthen future research, policy, and management decisions.

EBFM requires thinking about resources, policies, and management in a different way than we have in the past, and combining that new way of thinking with a better understanding of ecosystem conditions and processes. For example, our investigations of the 2014–16 marine heat wave showed that higher ocean temperatures resulted in harmful algal blooms along the west coast that caused widespread contamination in Dungeness crab, and that moved the prey of humpback whales from their historic offshore feeding grounds to more inshore waters. While these marine heat wave effects may seem separate from each other, the harmful algal blooms delayed the start of the Dungeness crab fishery and moved humpback whales into unusual feeding spaces, bringing Dungeness crab fishing gear and humpback whales into the same spaces at the same time. Ultimately, the effects of the marine heat wave included an unusual spike in whale entanglements with crab gear. Piecing these clues together to better understand how we can reduce human interactions with whales took ecosystem-level thinking.

Our California Current Ecosystem is an eastern boundary current upwelling system that extends roughly from the southern end of Canada's Vancouver Island southward to the tip of Mexico's Baja Peninsula. The U.S. West Coast Exclusive Economic Zone (EEZ), from 3 to 200 nautical miles offshore, lies within the CCE. The Pacific Fishery Management Council (PFMC) guides federal fisheries management off the U.S. West Coast under the authority of the Magnuson–Stevens Fishery Conservation and Management Act (MSA). PFMC voting members include representatives from the states of Washington, Oregon, California, and Idaho, and a representative from an Indian tribe with federally recognized fishing rights. Numerous tribes with fishing rights for salmon, halibut, groundfish, and other species participate in the PFMC process. NOAA Fisheries considers PFMC and these western states and tribes key partners in regional EBFM implementation, and PFMC has already taken substantial steps toward EBFM. Beyond their participation in the PFMC process, western states and tribes manage marine and estuarine fisheries that overlap with or include the same species as federal-waters fisheries. Close and ongoing coordination between these entities is essential to successful regional fisheries management efforts.

Other key partners in implementing regional EBFM could include: partners within NOAA, such as the five West Coast National Marine Sanctuaries and the three Integrated Ocean Observing System (IOOS) Regional Associations (Central and Northern California, Northwest, and Southern California); our federal partner agencies, like the United States Fish and Wildlife Service, the Army Corps of Engineers, and the Bureau of Ocean Energy Management; the Pacific States Marine Fisheries Commission, which coordinates tri-state west coast fisheries management and collects essential fisheries data; state and tribal fisheries and natural resource management agencies; the many international fisheries management and science organizations with overlapping jurisdictions over CCE species; fisheries industry participants, and environmental and other non-

government organizations; coastal fishing communities and coastal zone management organizations; and academic institutions with expertise in marine science and management.

NOAA Fisheries, PFMC, western states and tribes, and the public have together laid a strong foundation for EBFM with our work to end overfishing, rebuild overfished stocks, conserve forage fish, minimize bycatch, identify and protect essential fish habitat, develop supporting ecosystem science, and develop a Fishery Ecosystem Plan (FEP). Over the next five years, NOAA Fisheries plans to continue to support that work by researching key ecosystem questions such as the ongoing and anticipated effects of climate change on the CCE. We will prioritize work that helps us better understand our ecosystem's natural climatic variability and its short- and long-term effects on trophic interactions and fisheries harvest. We will explore opportunities to integrate EBFM into regulatory decision-making processes. We will also continue to support our partners' efforts to develop EBFM conservation and management measures that take into account the region's unique biophysical system, socio-economic challenges, and cultural principles. Finally, we view this WRIP as the first five-year iteration of a longer-term plan to coordinate regional research and ideas that build a strong foundation for future ecosystem science and EBFM. We welcome ideas from our partners, stakeholders, and the public on working towards west coast EBFM in this next five years and beyond.

## *2.0 EBFM Policy and Road Map Guiding Principles and Action Items*

NOAA Fisheries' May 2016 EBFM Policy has six Guiding Principles for national EBFM:

1. Implement ecosystem-level planning.
2. Advance our understanding of ecosystem processes.
3. Prioritize vulnerabilities and risks of ecosystems and their components.
4. Explore and address trade-offs within an ecosystem.
5. Incorporate ecosystem considerations into management advice.
6. Maintain resilient ecosystems.

The National EBFM Road Map is organized around those Guiding Principles, and suggests action items for each Guiding Principle. Action items are identified in the Road Map as potential short-, medium-, or long-term accomplishments. This WRIP describes U.S. West Coast EBFM implementation plans for the next five years, 2018–22. We do not address medium- or long-term unfunded Road Map action items. We also do not address Road Map action items that NOAA Fisheries' headquarters plans to pursue for national, rather than regional, application. Sections 2.1 through 2.6 discuss how NOAA Fisheries plans to address action items under each of

the Road Map's Guiding Principles, providing examples of work in progress and work anticipated for the 2018–22 period. We also discuss potential future actions that we cannot develop during 2018–22, but which may be useful to consider in EBFM planning beyond this first five-year Road Map implementation period. Section 3 provides the NOAA Fisheries West Coast engagement strategy for this WRIP. References cited in the WRIP are listed in Section 4, and Section 5 provides a list of abbreviations and acronyms used in this WRIP.

### 2.1 Guiding Principle 1 – Implement ecosystem-level planning

From EBFM Policy: *NOAA Fisheries supports the use of Fishery Ecosystem Plans (FEPs) or similar documents to describe and integrate ecosystem goals, objectives, and priorities for fisheries and ecosystem research, conservation, and management across multiple fisheries within an ecosystem. This includes:*

- *Facilitate continued participation of external federal, state (including territories), council, commission, tribal, industry, and other non-governmental partners in the EBFM process;*
- *Support and provide guidance or assistance to execute FEPs that are used as umbrella strategic planning documents to guide coordination and trade-off evaluation among Fishery Management Plans (FMPs,) related documents, and other ecosystem components.*

Guiding Principle 1 reflects a new way of thinking about fisheries and resource management, looking at key questions not in isolation, but as parts of a larger whole. We have already made substantial strides toward this goal through our ongoing work with PFMC and its committees and processes. One area of future focus is translating that work for both internal and external audiences. To that end, Guiding Principle 1 suggests that we develop an engagement strategy for each regional implementation plan, which this WRIP provides in Section 3.

Guiding Principle 1 supports regional FEP development. PFMC adopted its FEP in April 2013, in part to develop a better and shared understanding of its priorities for the larger ecosystem. From the FEP's Purpose and Need statement:

> *The purpose of the FEP is to enhance the PFMC's species-specific management programs with more ecosystem science, broader ecosystem considerations, and management policies that coordinate Council management across its Fishery Management Plans and the CCE. An FEP should provide a framework for considering policy choices and trade-offs as they affect FMP species and the broader CCE.*

The FEP coordinates PFMC's ecosystem-based conservation and management initiatives across its FMPs. NOAA Fisheries participates in PFMC's ecosystem initiative development process and supports PFMC in part through work conducted under the California Current Integrated Ecosystem Assessment (CCIEA) program. The CCIEA program combines science and interpretation to highlight and explain changes, trends, and shifts in the ecosystem and what they mean for the human communities that depend on the CCE. The NOAA Fisheries Northwest and Southwest Fisheries Science Centers (NWFSC and SWFSC) collaborate on the CCIEA program, including the development and presentation of an annual California Current Ecosystem Status Report (ESR) that has become an important opportunity to take stock of ongoing ecosystem changes and their implications.

Guiding Principle 1 also prioritizes a review of any overlapping jurisdictions in each region, to plan for coordination on EBFM. PFMC and NOAA Fisheries have jurisdiction over the U.S. EEZ off Washington, Oregon, and California. Overlapping jurisdictions, including those with western states and tribes, for particular fish and fisheries are accounted for and described in PFMC's FMPs. NOAA Fisheries West Coast coordinates formally and informally, as appropriate, with colleagues at the Alaska Fisheries Science Center and the Alaska Regional Office, and with staff at the Pacific Islands Science Center and the Pacific Islands Regional Office. International science and management entities that address West Coast fish or fisheries are described in PFMC's FEP at Section 3.5.4.

In keeping with Guiding Principle 1, NOAA Fisheries West Coast staff have supported PFMC's EBFM work since 2009. We participate in PFMC's Ecosystem Workgroup, and in the Scientific and Statistical Committee's (SSC) Ecosystem-Based Management Subcommittee, and in numerous other advisory bodies within the PFMC process. Our Science Centers submit annual ESRs to PFMC's March meetings, summarizing information and analyses from the CCIEA.

| Table 1: Action Items to Implement Ecosystem-Level Planning | | | |
|---|---|---|---|
| Road Map # | Road Map Action Item | Road Map Timing | Associated Milestone |
| 1a2 | Develop regional EBFM engagement strategy. | Short-term | See Section 3 of this WRIP. |
| 1a3 | Develop best practices where there are overlapping jurisdictions. | Medium-term | NOAA Fisheries coordinates with western states and tribes directly, and on federal fisheries issues through PFMC, which is the sole fishery management council with jurisdiction in the CCE. Overlapping jurisdictional issues on management of particular species or species groups will continue to be managed through regional fisheries management organizations (RFMOs). NOAA Fisheries staff are available, as requested, for coordination on ecosystem issues through RFMOs and other relevant bodies. |
| 1a5 | NOAA Fisheries supports any Ecosystem Plan Development Teams, Ecosystem Committees, or equivalent groups that Councils establish. | Continuing | NOAA Fisheries staff are members of the PFMC Ecosystem Workgroup, Habitat Committee, and the Ecosystem-Based Management Subcommittee of the SSC. NOAA Fisheries staff will continue to supply PFMC with an annual ESR. |
| 1b3 | Assist Councils, Commissions, RFMOs, and other bodies, as requested, in their development of new, or revision of existing, FEPs. | Continuing | NOAA Fisheries staff participated in the development of the Pacific Coast FEP, and participate in its ongoing implementation. No other body has requested assistance in FEP development. |

## 2.2 Guiding Principle 2 – Advance our understanding of ecosystem processes

From EBFM Policy: *NOAA Fisheries shall work to better understand the broader suite of ecosystem processes, drivers, threats, status, and trends of the nation's marine ecosystems to inform all levels of management advice, including:*

- *Conduct science to understand ecosystems.*
- *Provide Ecosystem Status Reports for each Large Marine Ecosystem.*

Many people who are familiar with the CCE have observed and have been curious about ecosystem processes and changes, seeking more insight into the factors driving them and where these processes are leading. In recent years, our unusually warm water temperatures and a strong El Niño have, in some cases, driven dramatic shifts in conditions and species that affect industries and communities. While science has shed light on those shifts, such as the particular sensitivity of California sea lions to changing temperatures, many questions remain, especially about whether the shifts are temporary or indications of long-term changes in the ecosystem.

Guiding Principle 2 recommends advancing resources to conduct scientific investigations to answer such questions and inform EBFM. However, this call for advancing resources occurs during a trend toward level or decreasing budgets and declines in federal staffing. Both Science Centers are working on research prioritizations to plan for this trend, taking into account recommendations at recent science program reviews. To implement this Guiding Principle, we plan to begin with inventories of EBFM mandates, priorities, drivers, risks, tools, and current projects and partnerships (Action 2a1), so that we know where gaps lie (Action 2a2). NOAA Fisheries West Coast is assessing how these efforts fit with other agency initiatives, such as the Western Regional Action Plan (WRAP) to implement the National Climate Science Strategy (NCSS), the Stock Assessment Improvement Plan (SAIP), the Habitat Assessment Improvement Plan (HAIP), the Ecological Forecasting Roadmap, and others.

Guiding Principle 2 asks that we develop capacity to conduct end-to-end ecosystem studies. End-to-end studies comprise both empirical and experimental research, which are essential for generating data, and ecosystem models, which incorporate data and theory into simulations that can help us understand ecosystem dynamics from the past or anticipate dynamics in the future. Models to support EBFM range from relatively simple (e.g., a single species with some environmental drivers) to full end-to-end models that simulate components from physical drivers all the way to human systems. We will conduct a gap analysis of where our data collection and ecosystem modeling are addressing, or failing to address, the various needs that make up a fully integrated end-to-end science effort in support of EBFM mandates, goals, and objectives. The gap analysis should include whether studies or capabilities exist, and if they are at appropriate spatiotemporal scales, sampling intensities, and complexity to address EBFM needs (Action 2a2).

At Action 2a4, Guiding Principle 2 asks us to develop and maintain core data and information streams. NOAA Fisheries participates in a variety of CCE observing efforts, including the California Cooperative Oceanic Fisheries Investigations (CalCOFI, established in 1949) and NWFSC's Newport hydrographic line (since 1996). Shorter-term observing systems that help capture environmental variability include the Trinidad Head line (similar to the Newport line). Each effort collects an extensive suite of physical, chemical, and biological measurements. NOAA Fisheries conducts multiple fishery-independent survey cruises to collect information about the distribution and abundance of groundfishes, coastal pelagic species, and salmonids. These surveys also collect oceanographic data that provide spatial scaling and context for our models, and biological data that support stock assessments. NOAA Fisheries supports other sampling of protected species, particularly near seabird and marine mammal breeding grounds, including the CCE work of the National Marine Mammal Laboratory. Surveys also provide information on

species and organisms that may not be of prime commercial importance, but which have important ecosystem roles. Tagging programs track survival rates, movements, and habitat use of focal fish and protected species. Advanced sampling technologies survey shelf and slope seafloor communities. Our Fisheries Observer Program provides critical fishery-dependent data needed for stock assessments and for quantifying bycatch rates. NOAA Fisheries social scientists collect data on economic and social conditions in fishing-dependent coastal communities. These data streams are made publicly available via services such as the Coastwatch Environmental Research Division Data Access Program (ERDDAP) data server and NWFSC's Fisheries Resource Analysis and Monitoring (FRAM) data warehouse, and continued support and development of these portals is essential for understanding ecosystem processes and status. The suite of NWFSC and SWFSC observation efforts for tracking trends in the CCE and its living marine resources and human communities are listed in detail in Table 1 of the WRAP (NMFS 2016, pp. 28–31).

NOAA Fisheries depends on other NOAA line offices, other state, federal, and tribal agencies, and academia for critical data and other scientific information. Environmental indices used to describe conditions from basin to regional scales and interannual to interdecadal time frames are derived largely from NOAA data from the Office of Oceanic and Atmospheric Research (OAR) and the National Weather Service, and from partner academic institutions. These indices summarize critical conditions like wind speed and direction, atmospheric pressure, sea surface temperature, and ocean currents. OAR also monitors CCE ocean chemistry through a variety of sampling platforms. The CoastWatch program provides satellite data, and the National Ocean Service's IOOS has three west coast regional associations that provide collated access to coastal and nearshore observations between the U.S. borders with Canada and Mexico. Finally, NOAA Fisheries partners with federal, state, local, and tribal agencies in monitoring west coast freshwater environments and habitats, which are critical to our anadromous species.

NOAA Fisheries West Coast is already meeting the Guiding Principle 2 milestone for ESRs (Action 2b2). Scientists from the CCIEA team have produced an annual California Current ESR for PFMC since 2014. Ecosystem status reporting on the west coast significantly predates the CCIEA reports: the CalCOFI partnership has been publishing annual "State of the California Current" papers in its journal CalCOFI Reports since 1994. CalCOFI Reports represent one of the earliest significant steps within NOAA Fisheries toward informing EBFM. Work to improve our ESR development process is ongoing and includes: tailoring the ESR to PFMC needs through Initiative 2 of the FEP; maintaining a dedicated CCIEA website with indicator plots, trend analyses, brief descriptions, and data downloads; and developing a five-year plan for improving the California Current ESR.

| Table 2: Action Items to Advance our Understanding of Ecosystem Processes | | | |
|---|---|---|---|
| Road Map # | Road Map Action Item | Road Map Timing | Associated Milestone |
| 2a1 | Advance resources to conduct EBFM. | Continuing | • Inventory EBFM mandates, priorities, drivers, risks, tools, current projects, and partnerships.<br>• Align inventories with research prioritizations at both Science Centers, in consultation with Regional Office, PFMC, and other key partners.<br>• Ensure complementarity with broad agency planning processes (SAIP, HAIP, NCSS, Ecological Forecasting Roadmap) and with high-priority recommendations from FY16 ecosystem science program reviews at SWFSC, NWFSC.<br>• Invest in training for proposal writing that supports applications to diverse funding providers. |
| 2a2 | Develop capacity for NOAA Fisheries to conduct end-to-end ecosystem studies. | Medium-term | • Conduct gap analysis of west coast science related to end-to-end science efforts:<br>1. Identify data sources, monitoring and experimental studies, social science survey projects, and other data-collection capabilities.<br>2. Identify statistical and process-based modeling studies and/or capabilities.<br>3. Identify matches/mismatches of scale between data collection/modeling efforts and the management needs they are intended to support.<br>4. Prioritize data collection gaps, analysis/modeling capacity gaps, and scale mismatches identified in steps 1–3.<br>• Identify and pursue high-impact, cost-effective ways to close gaps and increase capacity.<br>• Invest in training for proposal writing, particularly for areas of low capacity: monitoring of intermediate trophic levels, models of intermediate complexity, social and economic sciences, etc. |
| 2a4 | Develop and maintain core data and information streams. | Continuing | • Develop online tools to support a CCE data clearinghouse with multiple potential user interfaces, in keeping with NOAA's strategy to implement the national Public Access to Research Results policy (NOAA 2013).<br>• Maintain long-term monitoring programs and surveys; coordinate and prioritize data and information streams. |
| 2b2 | Establish routine, regular, and dynamic reporting of ESRs for each LME. | Medium-term | • Continue providing ESR for PFMC.<br>• Enact ESR improvements per the National ESR working group process.<br>• Learn from/engage with other regional ESR developers. |

## 2.3 Guiding Principle 3 – Prioritize vulnerabilities and risks to ecosystems and their components

From EBFM Policy: *NOAA Fisheries should evaluate and address the individual and cumulative drivers for the physical, chemical, biological, social, and economic components of marine ecosystems. This should take into account the comprehensive and systematic risk, vulnerability, and susceptibility of living marine resources and ecosystems, including:*

- *Identify the ecosystem-level, cumulative risk (across living marine resources, habitats, ecosystem functions, and associated fisheries communities) in each region and the relative vulnerability to human and natural pressures.*
- *Identify the individual and cumulative pressures that pose the most risk to those vulnerable resources and dependent communities.*

Guiding Principle 3 calls for a variety of risk assessments: system-wide, habitat-based, and based in fishing community vulnerability. Risk assessments identify and ideally quantify the probability and magnitude of deleterious events (Harwood 2000, Burgman 2005, Holsman et al. 2017). Risk assessments can serve as a first step to identify the stocks or habitats that most need management strategy evaluations (Levin et al. 2008). The CCIEA program began exploring protocols for conducting regional habitat risk assessments in 2012 (Samhouri et al. 2012), and remains active in the development of risk assessment methodology (Holsman et al. 2017). Ideally, an ecosystem risk assessment would begin at the ecosystem scale, identifying overarching pressures and species likely to be at risk for subsequent, more-focused efforts. While the west coast has not yet established an ecosystem-scale risk assessment, multiple risk analysis efforts are underway to identify vulnerabilities of managed species.

The NWFSC and SWFSC are jointly conducting climate vulnerability assessments for federally managed CCE fish stocks and protected species (Action 3a1). The fish-focused climate vulnerability assessments will ultimately be linked to climate vulnerability assessments for fishing communities (Action 3b3). End-to-end ecosystem models, discussed under Guiding Principle 2, have already been used to inform the risks to the CCE from fishing, as part of the Groundfish Harvest Specifications Environmental Impact Statement (PFMC 2014). These models can also show how fishing and climate change together may affect marine species, and how those effects propagate through the food web. Together, the end-to-end ecosystem models of Guiding Principle 2 and the risk assessments of Guiding Principle 3 link to our WRAP on climate science and implement the EBFM Road Map.

Guiding Principle 3 calls for protocols on regional habitat risk assessments (Action 3a2). The CCIEA habitat team has helped complete a PFMC-sponsored pilot risk assessment on habitat-

based impacts on four groundfish species (Yergey et al. 2016), which is expected to support completion of a new groundfish essential fish habitat (EFH) FMP amendment in 2018. NOAA Fisheries has also assessed the vulnerability of different habitats to fishing and non-fishing impacts (PFMC 2004, PFMC 2012, NMFS 2013) on the premise that certain habitat types (e.g., biogenic habitat) would be differentially susceptible to impacts such as bottom trawling. More recently, the same concept has been applied to examine vulnerability of four groundfish species to various anthropogenic impacts (Yergey et al. 2016).

In keeping with Guiding Principle 3, we completed a Habitat Assessment Prioritization for the West Coast in 2014, identifying FMP fish species likely to benefit from new habitat science that would help inform their stock assessments (Action 3b2). Under the NOAA Fisheries Habitat Enterprise Strategic Plan and under the EBFM Road Map, NOAA Fisheries intends to conduct risk assessments to identify key habitat areas at high risk for hazards such as oil spills, and to help prioritize conservation of habitat where it can improve the ecosystem's resilience and the resilience of communities and economies within the ecosystem.

Guiding Principle 3 also suggests that NOAA Fisheries conduct fishing community vulnerability assessments (Action 3b3). These vulnerability assessments have been employed for other U.S. regions (Jacob et al. 2012, Jepson and Colburn 2013, Himes-Cornell and Kasperski 2015) and at the U.S. national level. The Human Dimensions group at NWFSC has completed initial community vulnerability assessments for coastal port communities, quantifying social vulnerability of communities and commercial fishery dependence. Work is ongoing to ground-truth the initial assessment scores, and to develop an indicator for recreational fisheries dependence. An important next step is to link community vulnerability with exposure to risk. West coast work will link community vulnerability assessments with climate vulnerability assessments, and connect community vulnerability indices to single species and ecosystem studies.

| Table 3: Action Items to Prioritize Vulnerabilities and Risks to Ecosystems and their Components | | | |
|---|---|---|---|
| Road Map # | Road Map Action Item | Road Map Timing | Associated Milestone |
| 3a1 | Conduct systematic risk assessments for relevant NOAA ecosystems. | Long-term, continuing | • Identify overarching pressures on west coast species.<br>• Complete climate vulnerability assessments for west coast species. |
| 3a2 | Explore protocols for conducting regional habitat risk assessments for those areas known to serve important ecological functions for multiple species groups, or that will be especially vulnerable or important in the face of climate change. | Medium-term | • Conduct risk assessments to identify key habitats at high risk for hazards, such as oil spills, and to help prioritize conservation of habitat where it can improve ecosystem resilience, and the resilience of communities and economies within the ecosystem (protocols explored in Samhouri et al. 2012, methodology from Holsman et al. 2017). |
| 3b1 | Ensure that factors which impact 800+ U.S.-managed species are being considered. | Continuing | • Inventory existing risk assessments.<br>• Identify opportunities to link existing risk assessments to investigate 1) cumulative impacts and/or 2) propagating risk.<br>• Conduct risk assessments for non-fishing pressures on seabirds, marine mammals (Hazen et al. 2017), groundfish, and coastal pelagic species.<br>• Develop climate vulnerability assessments for non-fish protected species. |
| 3b2 | Conduct Habitat Assessment Prioritization for west coast. | Medium-term | Task Completed (see Habitat Assessment Prioritization for the West Coast) |
| 3b3 | Conduct fishing community vulnerability assessments for west coast. | Short-term | • Initial stage of community vulnerability assessments complete. Ground-truth with interviews, then link to species' climate vulnerability assessments.<br>• Conduct shift-share analysis of geographic distribution of fishery landings across west coast fishing ports to assess long-run changes in the distribution of fishing activity across ports, and to test hypotheses regarding the drivers of shifting geographic patterns of landings (e.g., climate, regulatory changes, economies of scale). |

## 2.4 Guiding Principle 4 – Explore and address trade-offs within an ecosystem

From EBFM Policy: *In close cooperation with its partners, NOAA Fisheries supports the consideration of and efforts to take into account various trade-offs when considering the cumulative effects of decision making processes on the ecosystem, including:*

- *Analyze trade-offs to optimize total benefits from all fisheries within each ecosystem or jurisdiction; by taking into account regional socio-economic considerations and ecosystem-specific policy goals and objectives (e.g., MSA, MMPA, ESA, National Aquaculture Act, etc.) that may apply.*
- *Develop management strategy evaluation capabilities to better conduct ecosystem-level analyses that provide ecosystem-wide management advice.*

This Guiding Principle focuses on trade-off analysis through multiple and linked models. For instance, linking models across an ecosystem allows scientists to balance the effectiveness of different management options for certain fisheries, taking into account their advantages and impacts. Comparing or blending outputs from multiple models allows scientists to explore the impacts of their assumptions about model structure (Action 4a3). While comparing and combining output from multiple models is a common approach with weather forecasting and global climate models, it is in more nascent stages with applied population dynamics and ecosystem modeling. Our scientists should apply best practices and principles identified in recent efforts focused around multimodel inference, including work by the Ocean Modeling Forum and the report of the Third National Ecosystem Modeling Workshop (NEMoW 3). Multimodel inference use should continue and be expanded on the west coast, but is dependent on adequate modeling capacity (Actions 2a2 and 4a1).

We have been actively involved in developing review processes for diverse ecosystem science and tools (Action 4a4). Members of PFMC's SSC and representatives from the Center for Independent Experts conducted a 2014 review of the California Current Atlantis end-to-end ecosystem model, to test and confirm the model's use for informing strategic PFMC fisheries management questions. The SSC Ecosystem-Based Management Subcommittee and CCIEA team have established annual reviews of ecosystem science and methodologies contributing to the CCIEA, to ensure that we are providing the best scientific information available to the PMFC process.

Guiding Principle 4 recommends developing functional system-level management strategy evaluations (MSEs, Action 4b1). MSEs allow scientists and managers to simulate fisheries decision-making and test the performance of harvest strategies, monitoring, and assessments

against specified management objectives. System-level MSEs that include more than one fishery are an opportunity for investment, and may improve our decision-making, and ultimately our management of trust resources. Ongoing west coast MSEs focus on a single fishery at a time: Pacific whiting/hake, North Pacific albacore, and sablefish. These MSEs focus on developing climate-informed management strategies that are robust to variability or directional changes in ocean conditions. Research recently funded by NOAA's Climate Program Office via the Modeling, Analysis, Predictions, and Projections and Coastal and Ocean Climate Applications projects will also develop MSEs exploring Pacific sardine and albacore tuna management, and environmentally informed spatial bycatch risk of leatherback turtles in the swordfish fishery (Action 4b2).

For areas where MSA objectives overlap with ESA or MMPA mandates, such as for protected species bycatch, additional ecosystem-based risk analyses may be needed. Specifically, bycatch of protected species can serve as a bottleneck that constrains catch of target species fisheries and economic opportunities. Oceanographically based predictive modeling approaches can be used to spatially segregate target species from bycatch species at multiple temporal scales (Hazen et al., in press). Similar models have been used to identify areas of increased ship-strike risk for baleen whales, and could be used to estimate gear entanglement risk as well. These dynamic ocean modelling tools can also be combined with ocean forecasts and downscaled climate projections to offer spatial management advice at multiple temporal scales. Additionally, dynamic ocean modelling tools can provide information that fisheries participants use voluntarily, or can be used to assess and inform potential spatial management areas that flex with changing ocean conditions.

| Table 4: Action Items to Explore and Address Trade-Offs Within the Ecosystem | | | |
|---|---|---|---|
| Road Map # | Road Map Action Item | Road Map Timing | Associated Milestone |
| 4a1 | Assess and bolster ecosystem and living marine resource modeling needs. | Continuing | • NWFSC recently completed (Sept 2017) an inventory and gap analysis of its ecosystem modeling capacity.<br>• Continue developing models that support time-series and spatial analysis, ecosystem forecasting (short- and long-term), and nowcasting.<br>• Continue engagement with PFMC to ascertain management and stakeholder needs and complementary modeling solutions.<br>• Continue engagement with ecosystem modelers (via IEA, NEMoW, SAIP, Ocean Modeling Forum, ad hoc workshops, etc.) to stay up-to-date on ecosystem modeling innovation.<br>• Continue to recruit post-docs and staff with ecosystem modeling and MSE skills that are presently underrepresented. |
| 4a3 | Encourage and expand the use of multimodel inference. | Continuing | • Use gap analysis in 2a to identify how existing models/research efforts could be better linked or compared.<br>• Develop coupled model of fish, fishing effort, and fishing communities to understand fisheries responses and resiliency to climate variation.<br>• Explore sardine population dynamics in the context of environmental, food web, and fishing interactions using three models of varying complexity. |
| 4a4 | Establish suitable review venues and deliberative bodies for ecosystem models and associated information in each FSC region. | Medium-term | • Continue annual reviews of CCIEA science by the PFMC's SSC.<br>• Participate in the albacore MSE to be conducted under the International Scientific Committee for Tuna and Tuna-Like Species, and the whiting/hake MSE conducted under the Pacific Whiting Treaty.<br>• Advance methods for social indicator development and develop guidelines for best available social science. |
| 4b1 | Develop functional system-level MSEs. | Medium-term | • Both Centers have recently hired MSE coordinators.<br>• Review how existing ecosystem models on the west coast could be used to explore system-level MSEs.<br>• Identify needs for new modeling capacity to explore system-level MSEs with multiple tools.<br>• Develop MSEs for Pacific whiting/hake, North Pacific albacore, and sablefish. |
| 4b2 | Explore novel Harvest Control Rules and develop associated guidelines, especially to test and explore robust ecosystem-level strategies. | Long-term | • Support potential MSE work through analyses and model development, such as a life-cycle based model of sablefish recruitment.<br>• Continue developing and exploring productivity-based control rules in the California Current Atlantis ecosystem model.<br>• Support climate–fisheries management strategy evaluations for California sardine, albacore, and swordfish as part of a NOAA-funded Coastal and Ocean Climate Applications project. |

## 2.5 Guiding Principle 5 – Incorporate ecosystem considerations into management advice

From EBFM Policy: *NOAA Fisheries recognizes the value of placing its resource management efforts into a broader ecosystem context. Living marine resource management should consider best available ecosystem science in decision-making processes (within our legal and policy frameworks), including:*

- *Develop and monitor ecosystem-level reference points.*
- *Incorporate ecosystem considerations (as determined from the risk analysis under Guiding Principle 3) into appropriate living marine resource assessments, control rules, and management decisions.*
- *Provide integrated advice for other management considerations, particularly applied across multiple species within an ecosystem.*

NOAA Fisheries actions under Guiding Principle 5 may be useful in support of PFMC's FEP review and update, tentatively scheduled to begin in September 2018. The CCIEA team anticipates exploring measures of cumulative impacts on coupled natural and social systems within the CCE (Action 5a2). This work could compare individual and cumulative effects of drivers, stressors, and alternate future states in ecosystem models or scenario-planning exercises. Domains of potential drivers and stressors may include: climate variability and long-term climate change; ocean acidification; upwelling; hypoxia; changes in primary productivity; changes in frequency, intensity, and distribution of harmful algal blooms; decadal-scale shifts in dominant forage taxa; changes in higher-order predator population status; changes in human population and distribution; changes in amount and distribution of fishing effort; and nonfishing human activities (shipping, energy development, nutrient loading, pollution, nonindigenous species, etc.).

Guiding Principle 5 actions that are already underway for the west coast include identifying best practices for incorporating ecosystem considerations into management decisions (Action 5b3). The review processes described under Guiding Principle 4 for the Atlantis ecosystem model and for annual CCIEA contributions to the PFMC process also help to identify best practices under Guiding Principle 5. We are also exploring statistical and mechanistic modeling approaches to account for shifting species distributions and changing productivity in the development of scientific advice for fisheries management.

Similar to Guiding Principle 3, Guiding Principle 5 recommends habitat-focused actions, such as exploring protocols for considering ecosystem-level information in EFH reviews and in identifying

habitat areas of particular concern (Action 5c1). NOAA Fisheries' HAIP (NMFS 2010) and the NWFSC and SWFSC Habitat Assessment Prioritization for the West Coast (Blackhart 2014) both discuss our ability to characterize EFH as reliant, in part, on our understanding of managed species' interactions with each other and with their physical environment. We lack much of the basic data needed to simply map west coast EFH by species distribution, as well as the data needed to characterize species interactions so as to meet the MSA's definition of EFH, "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." To address the habitat-specific actions under Guiding Principle 5, we are investigating habitat indicators that are more mechanistic and process-oriented. For example, we are exploring whether habitat conditions related to specific periods in salmon and groundfish life histories are correlated with overall population status. Over the longer term, a more quantitative approach for identifying marine EFH for individual species by those species' distribution would require investment in high-resolution mapping, among other habitat identification tools. Implementing the HAIP and the EBFM Road Map to address species' interactions with each other and their environments would also require investing in long-term improvements to our food habits data collection and analysis at both of our Science Centers.

The EBFM Road Map considers the protected species priorities under Guiding Principle 5 to be potential long-term actions, which in part means that they are dependent on uncertain future funding. However, our climate science under the WRAP could support future management reviews of long-term protected species recovery plans in keeping with the Road Map (Action 5c5). Within the next 5+ years, we are planning to test climate-informed management strategies for protected species, project future conditions for particular salmon stocks under varying climate conditions, and examine the economic and social effects of changes in water supply and habitat protection actions.

| Table 5: Action Items to Incorporate Ecosystem Considerations into Management Advice | | | |
|---|---|---|---|
| Road Map # | Road Map Action Item | Road Map Timing | Associated Milestone |
| 5a2 | Explore best measures of cross-pressure and cumulative impacts in an ecosystem, in conjunction with Principle 3. | Short- to Medium-term | • Conduct simulation analyses in end-to-end qualitative or mechanistic models to explore cumulative impacts of high-priority stressors identified from risk analyses and vulnerability assessments. Collaborate across Region and Centers to select pilot projects for incorporating these analyses into National Environmental Policy Act (NEPA) cumulative impacts analyses.<br>• Project physical and biogeochemical parameters at much finer scales (resolutions of ~10 km or less) than are currently available from global models. |
| 5b3 | Identify best practices for incorporating ecosystem considerations into management decisions. | Medium-term | • Continue participation in national ESR working group.<br>• Develop and incentivize partnerships between ecosystem scientists and stock assessment authors to write ecosystem considerations sections in single-species stock assessments. |
| 5b4 | Establish ecosystem-related TORs for stock assessments, stock assessment reviews, and support ecosystem-related TOR for status review groups, harvest control rules, and science and statistical committee review processes. | Continuing | • Action is underway with PFMC's SSC and its Ecosystem-Based Management Subcommittee. See: Terms of Reference for the Groundfish and Coastal Pelagic Species Stock Assessment Review Process. |
| 5c1 | Explore protocols for considering ecosystem-level information in EFH reviews, identifying ecosystem-level habitat areas of particular concern, and setting habitat conservation objectives and/or indicators. | Medium-term | • Evaluate and prioritize freshwater habitat restoration alternatives to find robust and cost-effective allocations of agency funds and effort.<br>• Conduct mid-trophic (groundfish) food habits workshop to bring food habits scientists together for coastwide research planning.<br>• Develop gap analysis for benthic habitat information, including mapping. |
| 5c5 | Review long-term protected species recovery plans to ensure they account for the potential effects of short- and long-term climate change, particularly relating to alterations to food web structure. | Long-term | • Examine climate-driven future scenarios for U.S. West Coast hydrology and stream temperature to support freshwater lifestage management of protected salmon and sturgeon.<br>• Develop models that characterize adaptive evolutionary and plastic responses to climate change impacts across the full lifecycle of selected salmon and steelhead stocks.<br>• Examine potential changes in water supply and habitat protection actions for their economic and social effects beyond impacts on protected species recovery. |

## 2.6 Guiding Principle 6 – Maintain resilient ecosystems

From EBFM Policy: *NOAA Fisheries recognizes that its mandates are intended to sustain resilient and productive LMR populations and habitats, to maintain overall ecosystem structure and function, and to support the contributions that fisheries make to the socio-economic resiliency of coastal human communities. EBFM needs to develop operating protocols to maintain resilient ecosystems. Actions in support of these mandates include:*

- *Evaluate ecosystem-level measures of resilience to maintain core ecosystem structure, biodiversity, production, energy flow, and functioning.*
- *Evaluate coastal fishing community well-being.*

Guiding Principle 6 takes EBFM the final step by providing value to human communities by promoting resiliency in ecosystems and in the human economies that depend on them. The actions under Guiding Principle 6 focus on the valuable services that ecosystems provide in supporting the wellbeing and resilience of human communities. The NOAA Science Advisory Board recently received a report from its Ecosystem Sciences and Management Working Group on ecosystem services valuation methods and best practices, which serves as nationwide guidance on those methods and practices (Action 6a2, ESMWG 2016, Wallmo et al. 2016).

As discussed under Guiding Principles 4 and 5, we are interested in developing an end-to-end framework to identify climate-resilient management strategies for the CCE and to evaluate the impacts of climate change on U.S.-managed marine species and fishing communities within the ecosystem. To that end, NWFSC, SWFSC, and external collaborators are in the first year of a four-year project that will model the linkages between several state and federal fisheries in the CCE and explore how interannual climate variability affects this system of fisheries and associated fishing communities (Action 4a3, 6a3).

Guiding Principle 6 is linked to Guiding Principle 3 through Actions 3b3, *Conduct Fishing Community Vulnerability Assessments*, and 6b2, *Adopt Community Vulnerability Analyses to a Broader Range of Cumulative Factors.* We are looking into expanding community vulnerability indicators to consider a broader range of factors, in keeping with requests from PFMC and west coast states. In particular, we are assessing recreational fishing data to develop community-level indices of connections (reliance and engagement) to recreational fishing, so that we may have recreational fishing indices that parallel existing commercial fishing indices for west coast communities. Also in response to public interest, we are adapting the community social vulnerability and fisheries reliance index to analyze community-level data relevant to harmful algal blooms, and to develop a harmful algal bloom impacts index for west coast communities.

Similarly, the potential effects of ocean acidification on west coast ecosystems and human communities are significant, so we are exploring how the scale of exposure affects place-based human communities and their ability to adapt, under a project funded by the NOAA Ocean Acidification Program.

Table 6: Action Items to Maintain Resilient Ecosystems

| Road Map # | Road Map Action Item | Road Map Timing | Associated Milestone |
|---|---|---|---|
| 6a2 | Evaluate, conduct, and track ecosystem goods and services valuation methods and best practices. | Medium-term | • NOAA Technical Memorandum on ecosystem services from west coast ocean recreation, including recreational fishing for finfish. Evaluate economic impacts, at U.S. and region levels, resulting from spending associated with recreational ocean fishing.<br>• Conduct regional analyses of salmonid angler effort levels, angler preferences, and hatchery management practices. |
| 6a3 | Develop best practices for tradeoff evaluation with respect to overall ecosystem and community resilience and wellbeing. | Medium-term | • Develop proposals and analyses on regional tradeoffs between habitat management, salmon population recovery, and other water-use sectors.<br>• Conduct analyses linking environmental conditions, climate variability and change, target species distributions, fisheries management, and socio-economic metrics in coastal pelagic species and highly migratory species fisheries. Incorporate analyses results into appropriate NEPA cumulative impacts analyses. |
| 6b1 & 6b3 | Explore and track community health and wellbeing socio-economic metrics. | Medium-term | • Increase social science capacity to collect data on human wellbeing indicators previously developed by the Social Wellbeing Indicators for Marine Management (SWIMM) team (Breslow et al. 2014, Breslow et al. 2017).<br>• Complete NOAA Technical Memorandum assessing central California community wellbeing under Community [fishing] Quota Program.<br>• Assess whether the groundfish catch share program resulted in consolidation of groundfish landings among fishing ports through a port-level analysis of the spatial disproportionality of groundfish landings. |
| 6b2 | Adopt community vulnerability analyses to a broader range of cumulative factors. | Medium-term | • Assess correlations between coastal community social vulnerability and reliance/engagement in commercial and recreational fisheries.<br>• Assess effects of harmful algal blooms and ocean acidification upon wellbeing of coastal communities in exposed regions.<br>• Conduct shift-share analysis of geographic distribution of fishery landings across west coast fishing ports to assess long-term changes in the distribution of fishing activity across ports and to test hypotheses regarding the drivers of shifting geographic patterns of landings (e.g., climate, regulatory changes, economies of scale). |

## *3.0 Engagement Strategy*

One of the greatest challenges surrounding EBFM is translating its intent and concepts in ways that engage and involve the many internal and external stakeholders that will ultimately benefit from it—including the public and NOAA Fisheries ourselves. We have engaged with our partners and the public on ecosystem science and EBFM implementation for the last decade through many means, from public meetings to online presentations to numerous scientific publications. This engagement strategy for the WRIP will help us take the next step, as we actually put EBFM into practice in the coming five years.

We discussed and listed our key external partners and stakeholders in Section 1. These represent only the starting point for EBFM engagement. Ultimately, our engagement should be as far-reaching and inclusive as EBFM itself, looking beyond individual processes, regulatory actions, and issues to help stakeholders, managers, and scientists understand how each fits into the larger picture of EBFM, and helping them understand their part in it. To this end, we plan to advance EBFM in the CCE through a variety of communication and engagement approaches and strategies that will inform and involve stakeholders, along three major approaches:

1. INFORM—We will build understanding of the CCE and its defining characteristics with balanced and objective information that helps NOAA Fisheries and our stakeholders understand the workings of the ecosystem. This will further help all of us understand the need for and purpose and benefits of EBFM, as well as the challenges and demands of putting it into practice. This approach will have definite internal and external components, recognizing that NOAA Fisheries West Coast employees must understand clearly the role of their work and priorities in EBFM, for they are both essential components of and advocates for the process.

2. CONSULT—EBFM will be a learning process in many ways, and we must learn from stakeholders as we proceed. We will seek out and create opportunities for consulting with stakeholders and partners about their views, reactions, and feedback on all elements of EBFM.

3. PARTNER—Finally, we will promote and foster existing and new partnerships across science and management, from research partners that will improve the depth and breadth of ecosystem research, to management partnerships that will help us apply EBFM throughout the CCE. Our progress will depend especially on continued close collaboration

within NOAA Fisheries West Coast, and we will use opportunities such as the presentation of the CCIEA's California Current Ecosystem Status Report and public processes involving new rules and/or regulations to promote and seek out new and additional partnerships.

Internal engagement is the first step. Internal, broad-scale engagement on this WRIP began in summer 2017, when the Northwest and Southwest Fisheries Science Centers and the West Coast Region formed a joint staff team to develop this WRIP. In late 2017, we conducted internal briefings to build support for and understanding of this plan within NOAA Fisheries, and to discuss the connections this plan may have to science and policy implementation plans for the Western Regional Action Plan on climate science. External engagement will be the next major step, but timing will depend on national rollout efforts. The optimal window for those efforts would be spring 2018, with a public comment period ending shortly after the September 2018 PFMC meeting.

An example of the wealth of opportunities for engagement has been PFMC's Climate and Communities Ecosystem Initiative. PFMC intends the initiative to build understanding of the short- and long-term impacts of climate change on the CCE, its conditions, and its inhabitants, and to identify ways to incorporate that understanding into decision-making. At the request of PFMC, NOAA Fisheries scientists provided educational webinars on:

- What do we expect to happen in the California Current under climate change?
- The state of the art for ecological forecasting at short-, medium- and long-term time frames.
- Distributional changes of CCE species and the impacts of climate change on species and species groups.
- Modeling changes in fishery participation and economic impacts in response to climate variation and climate change.

Such educational and informational efforts lay the groundwork for public release of this WRIP, which will make use of and update the Region's EBFM website. It will also include outreach to industry and interest groups and the news media. NOAA Fisheries West Coast Communications staff will coordinate web-based outreach across the Region's and Centers' EBFM and ecosystem science websites. The CCIEA program has been updating its website and anticipates rolling out a new version of its site in time for the public release of this draft WRIP.

## *4.0 References*


Blackhart, K. 2014. Habitat assessment prioritization for West Coast stocks. Report of the Northwest and Southwest Regional Habitat Assessment Prioritization Working Groups. NMFS White Paper, Office of Science and Technology, Silver Spring, Maryland. Available: www.st.nmfs.noaa.gov/Assets/ecosystems/habitat/pdf/Updated_WestCoast_HAP_Report.pdf (April 2018).

Breslow, S., D. Holland, P. Levin, K. Norman, M. Poe, C. Thompson, R. Barnea, P. Dalton, N. Dolsak, C. Greene, K. Hoelting, S. Kasperski, R. Kosaka, D. Ladd, A. Mamula, S. Miller, B. Sojka, C. Speir, S. Steinbeck, and N. Tolimieri. 2014. Human dimensions of the CCIEA: A summary of concepts, methods, indicators and assessments. *in* C. J. Harvey, N. Garfield, E. L. Hazen, and G. D. Williams, editors. The California Current Integrated Ecosystem Assessment: Phase III Report. Available: www.integratedecosystemassessment.noaa.gov/Assets/iea/california/Report/pdf/10.%20Human%20Dimensions_2013.pdf (April 2018).

Breslow, S. J., M. Allen, D. Holstein, B. Sojka, R. Barnea, X. Basurto, C. Carothers, S. Charnley, S. Coulthard, N. Dolsak, J. Donatuto, C. Garcia-Quijano, C. C. Hicks, A. Levine, M. B. Mascia, K. Norman, M. Poe, T. Satterfield, K. St. Martin, and P. S. Levin. 2017. Evaluating indicators of human well-being for ecosystem-based management. Ecosystem Health and Sustainability 3:1–18. DOI: 10.1080/20964129.2017.1411767

Burgman, M. 2005. Risks and decisions for conservation and environmental management. Cambridge University Press, UK.

ESMWG (Ecosystem Sciences and Management Working Group). 2016. An Assessment of the Use and Potential Use of Ecosystem Service Valuation within NOAA. A report from the NOAA Science Advisory Board. Silver Spring, Maryland. Available: sab.noaa.gov/ReportLibrary.aspx#11337161-ecosystem-sciences-and-management-working-group (April 2018).

Harwood, J. 2000. Risk assessment and decision analysis in conservation. Biological conservation 95(2):219–226.

Hazen, E. L., D. M. Palacios, K. A. Forney, E. A. Howell, E. Becker, A. L. Hoover, L. Irvine, M. DeAngelis, S. J. Bograd, B. R. Mate, and H. Bailey. 2017. WhaleWatch: A dynamic management tool for predicting blue whale density in the California Current. Journal of Applied Ecology 54: 1415-1428. DOI: 10.1111/1365-2664.12820.

Hazen, E. L., K. L. Scales, S. M. Maxwell, D. Briscoe, H. Welch, S. J. Bograd, H. Bailey, S. Benson, T. Eguchi, H. Dewar, S. Kohin, D. P. Costa, L. B. Crowder, and R. L. Lewison. In press. A dynamic ocean management tool to reduce bycatch and support sustainable fisheries. Science Advances.

Himes-Cornell, A., and S. Kasperski. 2015. Assessing climate change vulnerability in Alaska's fishing communities. Fisheries Research 162:1–11.

Holsman, K., J. Samhouri, G. Cook, E. Hazen, E. Olsen, M. Dillard, and K. Andrews. 2017. An ecosystem-based approach to marine risk assessment. Ecosystem Health and Sustainability 3(1): e01256. DOI: 10.1002/ehs2.1256.

Jacob, S., P. Weeks, B. Blount, and M. Jepson. 2012. Development and evaluation of social indicators of vulnerability and resiliency for fishing communities in the Gulf of Mexico. Marine Policy 29(10):16–22.

Jepson, M., and L. L. Colburn. 2013. Development of social indicators of fishing community vulnerability and resilience in the U.S. Southeast and Northeast regions. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-F/SPO-129. Available: http://sero.nmfs.noaa.gov/sustainable_fisheries/social/documents/pdfs/communities/2013/vulnerability_resilience_social_indicators.pdf(April 2018).

Levin, P. S., M. J. Fogarty, G. C. Matlock, and M. Ernst. 2008. Integrated Ecosystem Assessment. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-92.

Levin, P. S., M. J. Fogarty, S. A. Murawski, and D. Fluharty. 2009. Integrated ecosystem assessments: Developing the scientific basis for ecosystem-based management of the ocean. PLoS biology 7(1):e1000014.

NMFS (National Marine Fisheries Service). 2010. Marine fisheries habitat assessment improvement plan. Report of the National Marine Fisheries Service Habitat Assessment Improvement Plan Team. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-F/SPO-108. Available: www.st.nmfs.noaa.gov/ecosystems/habitat/publications/haip/index (April 2018).

NMFS (National Marine Fisheries Service). 2013. Groundfish Essential Fish Habitat Synthesis: A Report to the Pacific Fishery Management Council. Northwest Fisheries Science Center, Seattle, Washington. Available: swfsc.noaa.gov/publications/CR/2013/2013NMFS.pdf (April 2018).

NMFS (National Marine Fisheries Service). 2016. Western Regional Action Plan (WRAP), NOAA Fisheries Climate Science Strategy. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-565.

NOAA (National Oceanic and Atmospheric Administration). 2013. NOAA Plan for Increasing Public Access to Research Results. Available: www.glerl.noaa.gov/review2016/reviewer_docs/NOAA_PARR_Plan_v5.04.pdf (April 2018).

PFMC (Pacific Fishery Management Council). 2004. Appendix 3, Pacific Coast Groundfish Essential Fish Habitat, The Effects of Fishing Gears on Habitat: West Coast Perspective. Pacific States Marine Fisheries Commission, Portland, Oregon. Available: www.pcouncil.org//bb/2004/0604/C4b_At2_June04BB.pdf (April 2018).

PFMC (Pacific Fishery Management Council). 2012. Appendix J: Fishing gear impacts findings from Amendment 19 (EFH) to the groundfish FMP as compared to current information. Available: www.pcouncil.org/wp-content/uploads/App_J_Fishing_Gear_Impacts_EFH_Phase1_Sep2012.pdf (April 2018).

PFMC (Pacific Fishery Management Council) and NMFS (National Marine Fisheries Service). 2014. Draft Environmental Impact Statement (DEIS) for proposed Harvest Specifications and Management Measures for the Pacific Coast Groundfish Fishery and Amendment 24 to The Pacific Coast Groundfish Fishery Management Plan. Portand, Oregon and Seattle, Washington.

Samhouri, J. F., S. E. Lester, E. R. Selig, B. S. Halpern, M. J. Fogarty, C. Longo, and K. L. McLeod. 2012. Sea sick? Setting targets to assess ocean health and ecosystem services. Ecosphere 3(5):1–18.

Samhouri, J. F., and P. S. Levin. 2012. Linking land- and sea-based activities to risk in coastal ecosystems. Biological Conservation 145(1):118–129.

Wallmo, K., K. Bisack, D.Lew, and D. Squires. 2016. The Economics of Protected Marine Species: Concepts in Research and Management. Frontiers in Marine Science 3:183. DOI: 10.3389/fmars.2016.00183

Yergey M., K. Sherman, C. Greene, K. Shaeffer, J. Stadler, W. Wakefield, R. Walton, M. Hilgart, T. Lederhouse, L. Latchford, C. Phillis, J. Rice, P. Lawson, and K. Griffin. 2016. Fishery Specific Habitat Objectives - West Coast Pilot Draft Report. Available: www.pcouncil.org/wp-content/uploads/2016/11/IR5_SUP_ElectricOnly_FisherySpecificHabitatObjectivesWestCoastPilotFinalDraft_NOV2016BB.pdf (April 2018).

## *5.0 List of Acronyms and Abbreviations*

| | |
|---|---|
| CalCOFI | California Cooperative Oceanic Fisheries Investigations |
| CCE | California Current Ecosystem |
| CCIEA | California Current Integrated Ecosystem Assessment |
| EBFM | Ecosystem-Based Fisheries Management |
| EEZ | Exclusive Economic Zone |
| ERDDAP | Environmental Research Division Data Access Program [of NOAA's National Environmental Satellite, Data, and Information Service] |
| ESR | Ecosystem Status Report |
| FEP | Fishery Ecosystem Plan |
| FMP | Fishery Management Plan |
| FRAM | Fisheries Resource Analysis and Monitoring Division [of NOAA Fisheries NWFSC] |
| HAIP | Habitat Assessment Improvement Plan |
| IOOS | Integrated Ocean Observing System [of NOAA's Ocean Service] |
| MAPP | Modeling, Analysis, Prediction, and Projections |
| MSA | Magnuson–Stevens Fishery Conservation and Management Act |
| MSE | Management Strategy Evaluation |
| NEPA | National Environmental Policy Act |
| NMFS or NOAA Fisheries | National Marine Fisheries Service |
| NOAA | National Oceanic and Atmospheric Administration |
| NOAA Fisheries West Coast | collectively, the NOAA Fisheries West Coast Region, Northwest Fisheries Science Center, and Southwest Fisheries Science Center |
| NWFSC | Northwest Fisheries Science Center [of NOAA Fisheries] |
| OAR | NOAA Office of Oceanic and Atmospheric Research |
| PARR | Public Access to Research Results |
| PFMC | Pacific Fishery Management Council |
| RFMO | Regional Fisheries Management Organizations |
| SSC | Scientific and Statistical Committee [of PFMC] |
| SWFSC | Southwest Fisheries Science Center [of NOAA Fisheries] |
| SWIMM | Social Wellbeing Indicators for Marine Management |
| WCR | West Coast Region [of NOAA Fisheries] |
| WRAP | Western Regional Action Plan [for the National Climate Science Strategy] |
| WRIP | Western Road Map Implementation Plan [for the EBFM Road Map] |