

NATIONAL MARINE FISHERIES SERVICE PROCEDURE 01-120-01

Effective on: November 17, 2016

To be reviewed on: October 1, 2029

Fisheries Management

Ecosystem-Based Fisheries Management Road Map

NOTICE: This publication is available at: <https://www.fisheries.noaa.gov/national/laws-policies/fisheries-management-policy-directives>

Authors names: Jason Link and Yvonne deReynier
Offices: F and SF

Certified by: Kelly Denit
Office: SF

Type of Issuance: Revision, September 2024

SUMMARY OF REVISIONS:

- Clarify the links between EBFM and other NOAA Fisheries policies, guidance documents, efforts, programs and initiatives, including efforts that address the need for climate-ready fisheries.
- Better articulate the management aspect of EBFM and the need to approach EBFM as an adaptive process where science and management will always need to be updated, improved, iterated, etc. for better integration of its science and management programs.
- Better integrate socio-economic, habitat, climate change, ecological, ocean-use, and ocean condition information and needs throughout all EBFM Guidelines, particularly clarifying the need for climate-ready fisheries.

Signed _____

A special thank you to those who contributed to this document:

Y. deReynier, C. Harvey, J. Link, W. Morrison (eds.), J. Cudney, D. Dick, T. Ford, K. Gore, J. Gove, E. Hazen, J. Hermsen, M. Karnauskas, S. Lewis, S. Large, T. Loughran, S. Lucey, M. McPherson, S. Oakes, J. Peterson, J. Pirtle, T. Rankin, J. Samhour, H. Sagar, E. Siddon, H. Takade-Heumacher, B. Vogt, K. Zanowicz

Table of Contents

Executive Summary	2
1 Background, Purpose, Scope, and Resources of the EBFM Road Map	2
Background	3
Purpose	4
Scope and Resources	5
2 Implementation of EBFM	7
Guideline 1 - Implement ecosystem-level planning	7
Guideline 2 - Advance our understanding of ecosystem processes	12
Guideline 3 - Prioritize vulnerabilities and risks to ecosystems and their components	18
Guideline 4 – Explore and address trade-offs within an ecosystem	22
Guideline 5 – Implement ecosystem considerations into management	28
Guideline 6 – Support ecosystem resilience via monitoring and adjusting of management actions	33
3 Execution of the EBFM Road Map and Effective Dates	37
4 References	39
Appendix A: EBFM Guidelines, Goals, and Action Items	45
Appendix B: Focus Areas for EBFM Science and Management Conferences	51
Appendix C: List of Acronyms and Abbreviations	53

Executive Summary

The National Oceanic and Atmospheric Administration's (NOAA's) National Marine Fisheries Service (NOAA Fisheries) strongly supports implementation of Ecosystem-Based Fisheries Management (EBFM) as the best practice for management of living marine resources. In 2024, NOAA Fisheries updated its EBFM Policy, which provides the background, definition, rationale, and legislative context for implementing EBFM under relevant mandates.

The purpose of this Road Map is to provide specific actions under each goal identified in the EBFM Policy that will guide and enhance NOAA Fisheries' efforts to implement the Policy over the next five years. This includes specific actions aimed at advancing climate-ready decision-making, which includes climate-informed science and management for trust resources and habitats. NOAA Fisheries' EBFM Policy provides six Guidelines to implement EBFM, builds on past progress, and clarifies NOAA Fisheries' commitment to integrating its management programs for living marine resources and their habitats.

The NOAA Fisheries EBFM Road Map provides a national implementation strategy for the Policy. This Road Map describes how to operationalize the Policy's six Guidelines, each of which is organized with three Goals, and then one or more Action Items to implement each Goal. These Guidelines are:

1. Implement ecosystem-level planning.
2. Advance our understanding of ecosystem processes.
3. Prioritize vulnerabilities and risks to ecosystems and their components.
4. Explore and address trade-offs within an ecosystem.
5. Implement ecosystem considerations into management.
6. Support ecosystem resilience via monitoring and adjusting of management actions.

This Road Map's Guidelines, Goals, and the Action Items are actionable steps for implementing EBFM within NOAA Fisheries. NOAA Fisheries will review and, as appropriate, update the Road Map every five years. This will enable NOAA Fisheries to address further guidance on EBFM or as the needs of NOAA Fisheries and its partners evolve.

1 Background, Purpose, Scope, and Resources of the EBFM Road Map

NOAA's National Marine Fisheries Service (NOAA Fisheries) strongly supports implementation of Ecosystem-Based Fisheries Management (EBFM) as the best practice for management and stewardship of living marine resources. Doing so enables better engagement with, information to, and education for management partners, stakeholders, and the public.¹ NOAA Fisheries relies on EBFM to improve decisions with and for management partners on the trade-offs among and

¹ NOAA Fisheries' management partners commonly include: Regional Fishery Management Councils, interstate Marine Fisheries Commissions, Regional Fishery Management Organizations, States, Tribes, Indigenous communities, other NOAA line offices, and other Federal offices and agencies.

between fisheries (commercial, recreational, ceremonial, and subsistence), aquaculture, protected resources conservation and recovery,² biodiversity, habitat management and restoration, and other human values and needs in communities that depend on ocean-related ecosystem services. Additionally, accelerating climate change not only affects the physical environment, but also living habitats, whole ecosystems, human communities, and ocean use priorities, and thus is an important consideration of EBFM.

Coordinated implementation of EBFM across mandates will lead to greater efficiency and will enable NOAA Fisheries to consider trade-offs that affect, or are affected by, fisheries. EBFM is an adaptive process requiring regular updates to improve and integrate science and management programs. The updated 2024 EBFM [Policy](#) and Road Map outline specific actions to advance how NOAA Fisheries integrates social, economic, habitat, climate change, ecological, ocean-use, and ocean condition information needs with policy planning. Understanding ecosystems and how they are altered by climate change allows NOAA Fisheries to better respond to the needs of management partners, stakeholders, and the public.

Background

NOAA Fisheries has been moving towards EBFM for decades (NMFS 1987, EPAP 1998, Link 2002a, Link 2002b, SAB 2006, NOAA 2006, Levin et al. 2008, Levin et al. 2009), and first developed and implemented its EBFM Policy and Road Map in 2016 (NMFS 2016a, NMFS 2016b). The 2016 EBFM Policy and Road Map provided management context and broad science priorities that informed NOAA and NOAA Fisheries' ecosystem work (e.g., integrated ecosystem assessments (IEAs)), and strengthened internal capacity to produce ecosystem science and information for fisheries management. Through these efforts, NOAA Fisheries helped develop best practices for identifying oceanographic, biological, social and economic indicators for fisheries management.

NOAA Fisheries' EBFM Policy (NMFS 2024) defines EBFM as: *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.* The mandates outlined in the EBFM Policy require NOAA Fisheries to use the best scientific information available to manage U.S. marine fisheries, which drives continuous evaluation of and improvement to the nation's understanding of living marine resource science, conservation, and management.

² "Protected resources" include all mammals, turtles, fish, and invertebrates managed by NOAA Fisheries that are either listed as threatened or endangered under the Endangered Species Act (ESA), or that are protected under the Marine Mammal Protection Act (MMPA).

In response to this, and to NOAA Fisheries' internal deadline of reviewing its EBFM Policy by December 2023, NOAA Fisheries updated its [EBFM Policy](#) in 2024, providing the background, definition, rationale, and legislative context for implementing EBFM under relevant mandates.

The EBFM Policy provides six Guidelines for implementation depicted in an ongoing loop (see Figure 1) to show that EBFM is a process and a destination. The Guidelines do not need to be followed in the order depicted, but instead should be implemented to meet regional needs. Some regions may want to start with Guideline 3 to better understand vulnerabilities and risks before clarifying ecosystem level goals and objectives. The six Guidelines are:

1. Implement ecosystem-level planning.
2. Advance our understanding of ecosystem processes.
3. Prioritize vulnerabilities and risks to ecosystems and their components.
4. Explore and address trade-offs within an ecosystem.
5. Implement ecosystem considerations into management.
6. Support ecosystem resilience via monitoring and adjusting of management actions.

The EBFM Policy also provides three Goals for each of the six Guidelines. To facilitate implementation of the Policy, this Road Map identifies Action Items to implement the Goals under each of the six Guidelines. More information and detailed guidance on the Action Items needed to continue developing and implementing EBFM is presented in Section 2.0.

Purpose

The purpose of this Road Map is to provide specific actions under each Goal identified in the EBFM Policy that will guide and enhance NOAA Fisheries' efforts to implement the Policy over the next five years. It will advance climate-informed science and management planning and climate-ready decision-making³ for trust resources⁴ and habitats. U.S. managed marine and estuarine ecosystems are vast and diverse, and are intricately entwined with each other as well as the effects of Earth's changing climate. NOAA Fisheries' obligation to optimize the benefits from fisheries within each U.S. marine ecosystem lies at the heart of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), which mandates fishery conservation and management measures to ensure that wild-caught fisheries support a supply of food and other products, as well as recreational benefits, on an ongoing basis without compromising the long-term abilities of our ecosystems to provide those benefits to the nation into the future. EBFM recognizes the interconnectedness of ecosystem components as essential to supporting resilient

³ Climate-ready trust resource management decision-making *operationally* considers and manages for the effects on, mitigation of, and adaptation to the many ways in which climate change can affect targeted and other trust resource populations, fisheries, and the communities associated with them.

⁴ NOAA Fisheries' trust resources are the living and nonliving natural resources managed by the United States, any State, an Indian tribe or Alaska Native corporation, or a local government.

and productive ecosystems and to supporting associated human communities, activities, and well-being.

This Road Map is also intended to coordinate EBFM efforts among NOAA Fisheries' regional Fisheries Science Centers (FSCs), Regional Offices (ROs) and headquarters offices, Regional Fishery Management Councils (Councils), interstate Marine Fisheries Commissions, Regional Fishery Management Organizations, States, Tribes, Indigenous communities, and other critical domestic and international partners, stakeholders, and NOAA line offices. The Road Map supports multiple mandates, and is not an additional requirement for meeting those mandates. Many EBFM efforts are already underway within and beyond NOAA Fisheries, and this Road Map will leverage existing efforts to more effectively coordinate among them. The goal of EBFM and this Road Map is to more efficiently use existing work and knowledge by improving coordination and integration across NOAA Fisheries.

This Road Map outlines a refined process for NOAA Fisheries to implement EBFM and describes expected future work with partners, stakeholders, and the public. NOAA Fisheries recognizes the role that management partners play in shaping priorities, policy, and approaches for trust resources management and EBFM implementation. This Road Map offers Action Items for science and management processes that build on the historic scope of NOAA Fisheries' work, and in connections with partners. The timing of the execution of Road Map's Action Items is based on priority, need, scope, and resourcing. Some Action Items may be aspirational for some or all regions, while others will be readily achieved. NOAA Fisheries supports nationwide consistency across common issues, while remaining flexible to varying regional EBFM implementation strategies. EBFM continues to evolve with changing conditions and access to information. This Road Map is focused on the progress NOAA Fisheries and its partners can make over the next five years in understanding and managing NOAA trust resources in a more holistic manner.

Scope and Resources

EBFM must be scalable and flexible to account for the geographic scope of different management actions and the ecosystems they affect. Living marine resource management must occur at multiple spatial, temporal, and governance scales that differ within and across major U.S. jurisdictions. NOAA Fisheries' six EBFM Policy Guidelines are flexible enough to accommodate different geographic or governance scales while providing consistent national guidance.

The 2016 EBFM Road Map emphasized and focused on the U.S. Large Marine Ecosystems (Sherman 1991) and partnerships with the Councils. This updated EBFM Road Map recognizes that management challenges often occur at scales smaller than large marine ecosystems as well as across ecosystems and ocean basins. Addressing challenges at varying spatial scales and with partners across multiple jurisdictions can ultimately support ecosystem resiliency.

NOAA's IEA approach is a science framework for integrating and synthesizing a wide range of inputs, information, and efforts. IEAs are used domestically and internationally to translate marine ecosystem science into a range of management advice. The IEA approach serves as a model for NOAA Fisheries to continue to advance its science capabilities at its FSCs, and can also provide outputs useful for management decisions in multiple venues. To implement this EBFM Road Map, NOAA Fisheries needs improved engagement and coordination between existing programs, new initiatives, temporary funding plans, and headquarters offices that support ecosystem and climate science. These include but are not limited to the NOAA IEA program, the Climate, Ecosystems, and Fisheries Initiative (CEFI), planning for Bipartisan Infrastructure Law (BIL) and Inflation Reduction Act (IRA) funding, and the headquarters Offices of Habitat Conservation, Protected Resources, Science and Technology, and Sustainable Fisheries. NOAA Fisheries recognizes that the scope of science needed to support EBFM must draw from the input and ideas of a wider array of partners.

The initial 2016 Road Map called for each headquarters office, FSC, and RO within NOAA Fisheries to develop sets of milestones to address EBFM. Although NOAA Fisheries' headquarters and each of the RO-FSC partnerships in the country created Road Map implementation plans, the development of similar documents arising from many recent strategic planning documents makes that approach duplicative and therefore not recommended as part of the updated Road Map. To make EBFM activities an integral part of the annual budget planning process going forward, NOAA Fisheries will prioritize EBFM milestones in regular annual strategic planning processes at each Financial Management Center within NOAA Fisheries. Within 18 months of the release of this Road Map, each NOAA Fisheries FSC, RO, and headquarters office⁵ will bring Action Items and other elements of this Road Map into milestones in their own strategic planning priorities, documents, and actions. NOAA Fisheries will seek efficiencies by working with appropriate regional management partners and stakeholders to align or coordinate these milestones with other related ecosystem activities, climate priorities, and required statutory obligations.

Rising awareness of and interest in addressing impacts of changing climate and ocean conditions bring new opportunities and challenges for NOAA Fisheries' work. This Road Map will harmonize efforts to meet those opportunities and challenges in a more integrated and systematic manner. Supporting climate-ready fisheries, fishing communities, and science and management planning for trust species and habitat is not a separate mission from implementing EBFM. Through this new iteration of the Road Map, NOAA Fisheries will improve connections between science and management processes to better account for and understand variations among ecosystems, and to accelerate the responsiveness of managers to the effects of climate variability and change on fisheries and trust resources. NOAA Fisheries' experience under its resource

⁵ Including the headquarters Offices of Sustainable Fisheries, Habitat Conservation, Science and Technology, and Protected Resources. The NOAA Fisheries Atlantic Highly Migratory Species Management Division will include their milestones in the appropriate document.

conservation and management mandates and the 2016 EBFM Policy and Road Map have shown that working together towards ecosystem-based goals creates successes that build on each other for positive outcomes for our trust resources and fishing communities.

2 Implementation of EBFM

This section of the Road Map expands on the EBFM Policy, providing greater detail for each of the Guidelines and delineating, in broad terms, NOAA Fisheries’ priorities for continued advancement toward EBFM. To operationalize EBFM, NOAA Fisheries needs to incorporate and align the EBFM Guidelines, Goals, and Action Items into future plans through geographic strategic plans; annual guidance memoranda; annual priorities, goals, milestones, and strategic planning documents; and staffing and performance plans. In particular, FSCs, ROs, and headquarters offices will include priorities in planning documents’ milestones and completed work that:

1. Represent progress on a single action or Guideline;
2. Represent coordinated progress on multiple, connected actions or Guidelines directed at a particular issue or need;
3. Together connect actions spanning Guidelines 1 through 6.

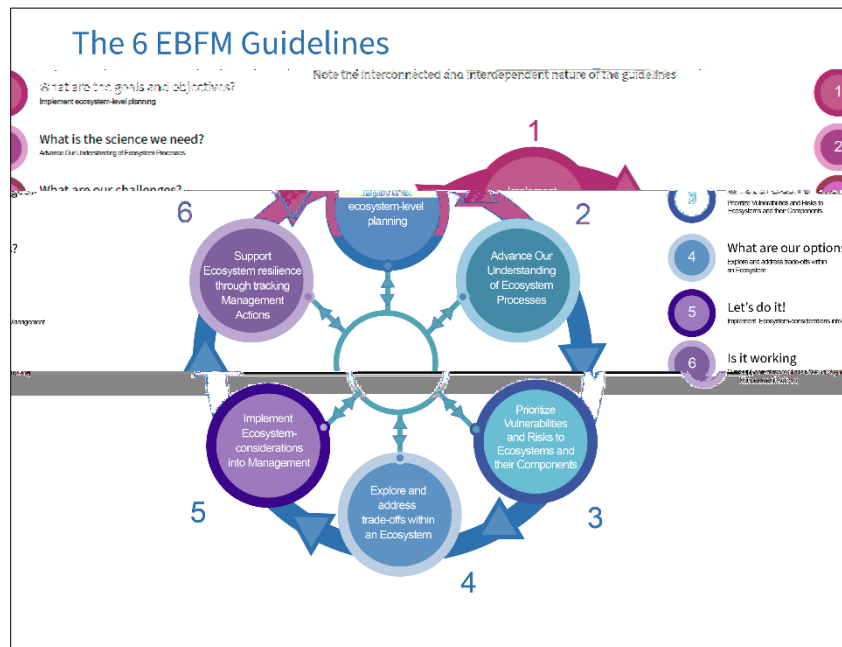


Figure 1: The 6 EBFM Guidelines, with plain language descriptions inset.

Successful implementation of the Road Map’s Action Items will be based on priority, need, scope, and resourcing.

Guideline 1 - Implement ecosystem-level planning

Guideline 1 calls for developing and implementing ecosystem-level planning in cooperation with management partners and stakeholders. NOAA Fisheries anticipates that regions will vary with respect to interest in and knowledge of ecosystem-level planning, which will lead to diverse approaches to EBFM and ecosystem-level planning. Identifying ecosystem-oriented goals and

objectives at regional levels are important for guiding NOAA Fisheries' work on EBFM, climate-ready fisheries, and new science efforts under CEFI and other funding programs.

NOAA Fisheries cannot implement EBFM without significant engagement from its partners and interested stakeholders. NOAA Fisheries acknowledges the time and effort management partners have devoted to relevant strategic planning documents. Many partners use these strategic planning documents to describe and integrate ecosystem goals, objectives, and priorities across multiple fisheries and to plan for the effects of various pressures on fisheries within an ecosystem. Under Guideline 1, NOAA Fisheries' Goals are:

- a. Support and provide guidance or assistance in the development and execution of Fishery Ecosystem Plans (FEPs), or other umbrella strategic planning documents, to describe and integrate ecosystem goals, objectives, and priorities for fisheries and ecosystem research (including climate-related), conservation, and management across multiple fisheries within an ecosystem.
- b. Incorporate EBFM goals and objectives, including anticipated climate impacts, into NOAA Fisheries operational and strategic planning and prioritization at all agency levels.
- c. Facilitate EBFM coordination across all elements of NOAA and its partners.

Ecosystem-level planning and communication will clarify long-term ecological, economic, and social goals, objectives, and priorities across NOAA Fisheries' multiple mandates and in partnership with its diverse stakeholders.

Goal 1.a: NOAA Fisheries will support and provide guidance or assistance in the development and execution of FEPs, or other umbrella strategic planning documents, to describe and integrate ecosystem goals, objectives, and priorities for fisheries and ecosystem research (including climate-related), conservation, and management across multiple fisheries within an ecosystem.

FEPs are policy planning documents that the Councils, NOAA Fisheries, and related partners may use to describe ecosystem objectives and priorities for fishery science and management, and to inform development of, or replace, fishery management plans (FMPs) or FMP amendments. Policymakers, including the Councils and NOAA Fisheries, can use strategic planning documents like FEPs to better understand interactions between environmental processes and human activities, and the cumulative effects of our actions on the environment. FEPs may be used to provide information on the fundamental physical, chemical, biological, and social and economic structures and functions of ecosystems. They can be valuable for describing the relationships between living marine resources, the physical environment, human benefits from those resources, and other human activities that affect living marine resources and their habitats and biodiversity. They can also outline ecosystem-scale policy priorities and the decision frameworks and processes for incorporating ecosystem information and considerations into management. Prior to and since the development of the 2016 EBFM Road Map, NOAA Fisheries

staff have been participating in working groups at Councils and in other organizations to support the development and implementation of FEPs and other strategic planning documents (e.g., [SAFMC 2009](#), [NPFMC 2015](#), [PFMC 2022](#)). Recognizing the excellent and ongoing work happening within Councils, NOAA Fisheries (Wilkinson and Abrams 2015, Marshall et al. 2018), and elsewhere, NOAA Fisheries will use the following Action Item to develop annual and longer-term milestones to implement Goal 1.a:

Action Item 1.a.1: Assist living marine resource management partners in their development of new, or revised, ecosystem-level goals and objectives within FEPs or other ecosystem-wide strategic planning documents.

In 2024 and beyond, NOAA Fisheries will implement Goal 1.a by appointing NOAA Fisheries staff, as requested, to the working groups and other advisory bodies that support the mission and goals of NOAA Fisheries' management partners in developing FEPs and strategic planning documents. NOAA Fisheries will support goals and objectives that help make U.S. fisheries climate-ready, among other priorities, including those that align with this EBFM Road Map's Action Item 3.c.1, which calls for mitigating risk by identifying and improving existing regulatory responses to potential rapid within-year changes in catch rates of target species and bycatch rates of non-target and protected resources.

Goal 1.b: NOAA Fisheries will incorporate EBFM goals and objectives, including anticipated climate impacts, into NOAA Fisheries operational and strategic planning and prioritization at all agency levels.

NOAA Fisheries' mission is to provide science-based conservation and management for trust resources, and for sustainable fisheries and aquaculture. A forward-thinking, ecosystem-based perspective on implementing NOAA Fisheries' mission and mandates is needed under rapidly changing climate, social, and economic conditions. Goal 1.b is about ensuring that national and regional operational and strategic planning documents, milestones, and actions address ecosystem-based and climate-ready management of fisheries and trust resources, and planning for multiple ocean uses. Lessons learned from different regional approaches and priorities developed to implement NOAA Fisheries' 2015 Climate Science Strategy and 2016 EBFM Policy and Road Map are the foundation for future action.

Incorporating EBFM goals and objectives into operational and strategic planning has included maintaining positions for a Senior Scientist for ecosystem-based management and a national EBFM coordinator, and the national and regional IEA programs. Operational EBFM also includes updating the national Stock Assessment Improvement Plan ([Lynch et al. 2018](#)) and the national marine Habitat Assessment Improvement Plan ([Peters et al. 2018](#)), and establishing ecosystem-oriented terms of reference for stock assessments around the nation (see Guideline 5 below). For 2024 and beyond, NOAA Fisheries will use the following Action Item to develop annual and longer-term milestones to implement Goal 1.b:

Action Item 1.b.1: Include and prioritize EBFM Road Map Action Items in key regional and national strategic and operational documents.

The Road Map can help build NOAA Fisheries' climate-ready science and management programs and can support multiple ocean use planning. To do this, Action Items of this Road Map need to be included in NOAA Fisheries strategic planning and prioritization. Road Map Action Items also need to be included and prioritized in reviews and future iterations of operational guidance documents.⁶

NOAA Fisheries uses a variety of operational and strategic planning processes to prioritize its work. Strategic plans and annual guidance documents set priorities across programs and research areas for NOAA Fisheries' ROs, FSCs, and headquarters offices. Topic-specific operational guidance documents set national priorities for work within those specialty focus areas. By including, addressing, and coordinating EBFM and climate-readiness in NOAA Fisheries' operational and strategic planning work, actions taken under Goal 1.b will set up work to be conducted under Guidelines 2 through 6.

Goal 1.c: NOAA Fisheries will facilitate EBFM coordination across all elements of NOAA Fisheries and its partners.

The 2016 EBFM Road Map included Action Items to develop engagement strategies to facilitate the participation of partners and stakeholders in the EBFM process. Effective implementation of EBFM will require close coordination and collaboration with management partners. Successful coordination and collaboration have been particularly evident where NOAA Fisheries has supported and maintained staff teams to jointly share and address science and management concerns around these large-scale and strategic issues.

NOAA Fisheries' communication and coordination work includes both broad communication items aimed at the public (such as news releases, articles, and websites) and targeted communication items like reports to partner management organizations. Building on the communication and coordination Action Items from the 2016 EBFM Road Map, NOAA Fisheries will use the following Action Items to develop annual and longer-term milestones to implement Goal 1.c:

⁶ For example, Stock Assessment Improvement Plan, Stock Assessment Terms of Reference, Habitat Assessment Improvement Plan, recovery plans for ESA-listed species, National Coral Reef Resilience Strategy, Watershed Management Plans, IEA three-year work plans, NOAA Fisheries Climate Science Strategy Plans, CEFI decisional support guidance, etc.

Action Item 1.c.1: Establish and maintain joint staff EBFM and/or climate teams for each major U.S. management region⁷ to ensure planning and coordination across headquarters Offices, Regional Offices, and Science Centers.

Action Item 1.c.2: Develop, coordinate, and disseminate a national EBFM communication plan, including regular national reporting on progress towards EBFM Road Map Action Items.

Action Item 1.c.3: Ensure and actively facilitate ongoing dialog between NOAA Fisheries Science Centers, Regional Offices, and management partners to ensure coordinated efforts to advance EBFM.

NOAA Fisheries' staff teams, working cooperatively to address ecosystem and climate issues across different areas of program responsibility, have successfully collaborated to improve NOAA Fisheries' responsiveness to ecosystem and climate challenges (e.g., Bastille et al. 2020, Clay et al. 2020, Spooner et al. 2021). Action items under Goal 1.c support staff and leadership collaboration, call for continuing or establishing formal collaborations, and ensure that staff participating in these collaborative teams are recognized for their work.

Communication for EBFM and climate-ready science and management can highlight successes, promote collaboration and learning across regions, and support sharing scientific information with partners, stakeholders, and the public. NOAA Fisheries will update and improve its efforts to build public and general understanding of what EBFM is, why it is important in preparing for the future, and where to focus work conducted under this Road Map. This work also includes updating and maintaining ecosystem-oriented webpages,⁸ fish habitat pages,⁹ climate vulnerability assessment pages,¹⁰ and others; developing strategies and then implementing them for more widespread dissemination of key ecosystem reports (e.g., ecosystem status reports (ESRs)); and supporting the NOAA Library's popular EBM/EBFM seminar series. For 2024 and beyond, NOAA Fisheries will improve its communication of ecosystem and climate information with decision-makers and the public, using more iterative communication processes (e.g., Townsend et al. 2019), tailoring communication products for particular audiences (e.g., [AFSC 2023](#)), and revamping NOAA Fisheries' EBFM and climate-ready web presence.

⁷ Typically Regional Office and Fisheries Science Center staff working together to support NOAA Fisheries' missions and projects under the MSA, ESA, and MMPA.

⁸ Integrated Ecosystem Assessment Program. <https://www.integratedecosystemassessment.noaa.gov/>
National Marine Ecosystem Status website. <https://ecowatch.noaa.gov/>
Distribution Mapping and Analysis Portal. <https://apps-st.fisheries.noaa.gov/dismap/DisMAP.html>
Predictive Spatial Modeling Tool. <https://www.fisheries.noaa.gov/atlantic-highly-migratory-species/new-scientific-paper-published-noaas-highly-migratory-species>

⁹ Essential Fish Habitat Mapper. <https://www.habitat.noaa.gov/apps/efhmapper/>
Essential Fish Habitat Data Inventory. <https://www.habitat.noaa.gov/application/efhinventory/>
Deep Sea Coral and Sponge Map Portal. <https://www.ncei.noaa.gov/maps/deep-sea-corals/mapSites.htm>

¹⁰ Climate Vulnerability Assessments. <https://www.fisheries.noaa.gov/national/climate/climate-vulnerability-assessments>

In support of Goal 1.c, NOAA Fisheries will develop clear and concise science communication that helps managers and the public understand the potential impacts of near-term climate variability and climate anomalies on managed fish stocks, fisheries, protected resources, and their habitats. NOAA Fisheries will prioritize improving science communication so that it better serves underserved coastal communities that are often disproportionately affected by climate variability and change. NOAA Fisheries will also report on progress-to-date under the 2016 EBFM Road Map, and will provide a retrospective report on successes and challenges in implementing the 2016 EBFM Road Map. The NOAA Fisheries EBFM Workgroup will also report to the Leadership Council on progress and gaps under the 2024 EBFM Road Map every two years, beginning in 2026.

Understanding the perspectives and priorities that management partners and stakeholders bring to EBFM must be a priority effort for NOAA Fisheries under this Road Map. In addition to improving NOAA Fisheries' broad communication efforts, communication planning on EBFM and climate will ensure more direct communications and coordination with management partners and stakeholders. NOAA Fisheries will ensure that it is consulting and engaging with domestic and international partners on EBFM, and ensure collaboration and government-to-government consultation or engagement with Federally recognized Tribes and Indigenous communities as appropriate.

Goal 1.c (and Action Item 1.c.3) will ensure EBFM and climate-related projects are collaborative and coordinated where needed. Many ongoing efforts within and external to NOAA Fisheries (e.g., with management partners) address similar challenges and thus will be more successful if the work is coordinated to ensure efforts are collaborative and non-duplicative. NOAA Fisheries will work with partners to determine best options for ongoing communication and collaboration.

Guideline 2 - Advance our understanding of ecosystem processes

NOAA Fisheries' scientific efforts under Guideline 2 support national living marine resource management goals and obligations with a better understanding of ecosystem processes, drivers, threats, status, and trends of the nation's marine ecosystems. Science efforts for an ecosystem-based approach include understanding the human dimensions of fisheries and fishery-dependent communities, and of relevant ecological processes that operate across ecosystem boundaries.

To further develop science that recognizes the physical, biological, economic, and social complexities of managing living resources as an integrated system, NOAA Fisheries' Goals are:

- a. Conduct science under a diverse suite of disciplines to understand ecosystem processes, drivers, and threats, including work from the CEFI and other, ongoing and anticipated science endeavors.
- b. Provide regular ecosystem status report updates and similar reports to ensure they inform regional decision-making processes.

- c. Prioritize science in alignment with priority ecological, economic and social objectives identified in Guideline 1 above so that a deeper understanding can better inform management advice.

Ecosystem-level science is characterized by multidisciplinary information, collaborations and coordination, and a drive to understand processes important to living marine resources within and across ecosystems. This Guideline builds on NOAA Fisheries' progress under the 2016 EBFM Road Map to improve national and regional awareness of our ecosystems' statuses, trends, and processes.

Goal 2.a: NOAA Fisheries will conduct science under a diverse suite of disciplines to understand ecosystem processes, drivers, and threats, including work from the Climate, Ecosystems, and Fisheries Initiative and other, ongoing and anticipated science innovations.

Since the implementation of the 2016 EBFM Road Map, NOAA Fisheries has worked under a variety of scientific disciplines to better understand a broad suite of ecosystem drivers, threats, processes, benefits, and services. This 2024 Road Map continues that needed scientific work, taking advantage of the infusion of temporary funds from Inflation Reduction Act (IRA) and Bipartisan Infrastructure Law (BIL) implementation that support CEFI and other initiatives. NOAA Fisheries will integrate scientific work across disciplines (especially human dimensions); conduct climate-ready science for trust species, habitats and ecosystems; improve connections between science and management processes; and address gaps in our understanding to help develop climate-ready fisheries and management. NOAA Fisheries will use the following Action Items to develop annual and longer-term milestones to implement Goal 2.a:

Action Item 2.a.1: Advance resources and build capacity to conduct science in support of EBFM, including through collaborative research and citizen science.

Action Item 2.a.2: Expand, develop, and maintain data streams and the production of information, and review archived data to update it where appropriate.

Action Item 2.a.3: Conduct biennial EBFM science and management workgroups and conferences.

NOAA Fisheries will expand operational capability to assess risks, evaluate management options, and provide robust advice on adapting to changing ecosystem and climate conditions. Research and capacity are needed for incorporating ecosystem considerations and interdisciplinary science into traditional and non-traditional methods for assessing fish stocks and protected resources, as well as aquaculture and seafood production. Research and capacity are also needed for characterizing, protecting, and restoring habitats and ecosystems, and for considering the effects of multiple ocean uses on living marine resources in a future of climate variability and change. Existing critical work, such as at-sea surveys and other ocean observation

methods, must be maintained to continue to support fisheries management, trust resource management, habitat conservation, and ecosystem assessments. NOAA Fisheries must improve the nation’s understanding of the effects of climate and ocean variability and change on living marine resources and habitats to prepare for the coming decades.

Under Goal 2.a, NOAA Fisheries will advance resources and capacity to conduct science to support EBFM. A variety of scientific efforts are needed to understand ecosystem considerations within stock assessments, as part of risk tables, or using other mechanisms to account for the effects of environmental conditions on fisheries, trust species, and habitats. Annual performance milestones under Goal 2.a (in conjunction with Goal 1.c) could include:

- Developing a working team of stock assessors and ecosystem scientists to explore relationships between environmental indices and trust resources’ stock abundance;
- Evaluating degraded habitat for its restoration priorities, its costs, and the potential effects of climate variability and change on that habitat;
- Modeling the effects of climate variability and change on critical life history stages of trust resources, the suitability of essential fish habitat (EFH) for managed species, and the availability of critical habitat to protected resources over the long-term;
- Modeling the combined effects of climate and ecosystem variability with social and economic impacts on fishery and protected resource depletion and recovery, fisheries, and fishing communities; and
- Updating ecosystem-level food web models with more and newer food habits data.

As NOAA Fisheries continues to implement EBFM, additional information will be needed from an array of scientific disciplines, including those addressing climate and human dimensions. Data available to support EBFM varies considerably across regions, and a clear understanding of data, data needs, data sharing plans, and associated plans to fill data gaps is needed. At-sea surveys provide critical data and observations to help us understand current and changing ocean conditions, while also serving as platforms from which to build additional capacity to address emerging stressors directly or indirectly related to climate change (e.g., ocean acidification, harmful algal blooms, and offshore wind). Options for better inclusion of fishermen’s ecological knowledge and Indigenous Knowledge are needed to inform and enrich many aspects of NOAA’s work, to better understand Earth and ocean systems, and to fulfill responsibilities for managing culturally important species. NOAA Fisheries relies on higher-level NOAA and Federal policies and guidance documents to guide its understanding of the collection and use of Indigenous Knowledge, such as the NOAA Procedures for Government-to-Government Consultation with Federally Recognized Indian Tribal Governments, and NOAA Guidance and Best Practices for Engaging and Incorporating Indigenous Knowledge in Decision-Making.¹¹

¹¹ NOAA Tribal Consultation Handbook. https://www.noaa.gov/sites/default/files/2023-07/NOAA_Tribal_Consultation_Handbook_2023_FINAL.pdf; NOAA Indigenous Knowledge Guidance. https://www.noaa.gov/sites/default/files/2023-07/NOAA_IK_Guidance_FINAL_2023_1.pdf.

Future revisions of NOAA Fisheries' internal Data Acquisition Plans should complement and support EBFM data needs.

Under the 2016 EBFM Road Map, NOAA Fisheries conducted biennial EBFM science, modeling and management conferences and supported workgroups to share successes and challenges and build relevant knowledge (Slater et al. 2017, Townsend et al. 2020, Morrison et al. 2022). In 2024 and beyond, NOAA Fisheries will continue to hold regular EBFM science and management conferences that share knowledge and identify priority science for management needs. NOAA Fisheries will also convene NOAA staff workgroups to address particular science or management challenges. Based on this Road Map's Action Items, Appendix B recommends a non-exhaustive list of focus areas for NOAA Fisheries EBFM-associated science and management conferences or focused workgroups, including those under this Goal 2a.

Goal 2.b: NOAA Fisheries will provide and update regular ecosystem status reports and similar reports to ensure they inform regional decision-making processes.

One of NOAA Fisheries' core tasks is to monitor the status of our marine ecosystems and to share information with managers, stakeholders, and the public about drivers and threats that influence how ecosystems function. NOAA Fisheries delivers ecosystem status reports (ESRs) and related documents to Councils and other partners that summarize ecosystem status. This improves understanding of local ecosystem conditions and changes that affect not only individual fisheries but also the connections between and among fisheries and other ecosystem components. NOAA Fisheries also provides, or reviews, contextual single- and multi-species ecosystem and social and economic information. To improve development and delivery of ESRs and related products in 2024 and beyond, NOAA Fisheries will use the following Action Items to develop annual and longer-term milestones to implement Goal 2.b:

Action Item 2.b.1: Provide support and information for development and review of new or updated ESRs.

Action Item 2.b.2: Include ESR support duties as a significant percentage of personnel performance plans, for a sufficient number of personnel in each Financial Management Center.

Action Item 2.b.3: Expand and coordinate regional and national efforts to develop and disseminate ecosystem indicators that support multiple decision support products and reach across Councils and other management partners.

NOAA Fisheries will support internal (e.g., leadership) and external (e.g., Councils, decision-makers, and management partners) requests to initiate new or update existing ESRs or similar documents. In regions where ESRs or similar documents have multi-year histories, NOAA Fisheries will support requests for collaborative review and update processes to assess the utility and clarity of information provided.

ESRs should reflect and provide information in response to decision-makers' established goals and objectives. ESRs may also be used to meet resource management objectives outside of the fisheries management process, such as for EFH consultations on non-fishing actions, for addressing species managed under multiple jurisdictions, understanding the effects of multiple ocean use sectors on trust resources and fisheries, understanding and addressing human well-being, understanding and articulating the roles of managed and unmanaged species in food webs, or aiding National Marine Sanctuaries information needs.

Ecosystem approaches to single-species management can provide additional avenues for scientific exploration that ultimately build valuable information to support larger-scale EBFM. NOAA Fisheries will coordinate indicator development and data management for multiple decision support products, including ecosystem and socioeconomic profiles and risk tables (see Guideline 3 below), at varying scales from single-species to whole ecosystems and across multiple ecosystems.

NOAA Fisheries will direct resources to develop, expand, and coordinate regional and nationwide efforts to make web-based ESRs and ecosystem indicators available and understandable to the public. Under this Road Map, NOAA Fisheries will expand and coordinate regional and national efforts to disseminate ecosystem indicators at scales relevant to management, including for vulnerable habitat components of our ecosystems and for prioritized single species. NOAA Fisheries will support its staff in improving reporting automation, so as to make ESRs and ecosystem indicators less burdensome for staff to produce and easier for managers and the public to access.

Goal 2.c: NOAA Fisheries will prioritize science in alignment with priority ecological, economic, and social objectives identified in Guideline 1 above so that a deeper understanding can better inform management advice.

Under Goal 2.c, NOAA Fisheries will attend to both the EBFM goals and objectives articulated under Guideline 1 and to emerging fisheries management issues to prioritize science to support decision-making. NOAA Fisheries will work internally and with partners to develop management on-ramps¹² to provide ecosystem and climate information to managers where appropriate and useful. Further, NOAA Fisheries' science will support urgent concerns and challenges associated with making decisions about protected resources conservation and recovery, as well as habitat characterization, restoration, and conservation. NOAA Fisheries will

¹² Here, an on-ramp is a step in the fisheries science and management decision-making process where ecosystem and climate information can be included or considered in making or supporting decisions. Examples of on-ramps include incorporation of ecosystem and climate information directly into a stock assessment, into a risk-table or risk-policy to identify appropriate buffers, when revising spatial management areas (no-take areas, habitat areas of particular concern, essential fish habitat), in bycatch mitigation policies and measures, when identifying aquaculture opportunity areas, when considering options across targeted taxa, etc.

use the following Action Items to develop annual and longer-term milestones to implement Goal 2.c:

Action Item 2.c.1: Identify, prioritize, research, and address key ecosystem and climate questions, as defined by EBFM and climate staff teams working internally (see Goal 1.c.1) and with external management partners and stakeholders.

Action Item 2.c.2: Assess the science needs, assets, and gaps associated with management on-ramps for bringing ecosystem science into key decision-making processes, as noted in Goals 1.a and 5.b.

NOAA Fisheries will examine its efforts to deliver scientific information to management partners that addresses goals and objectives outlined in FEPs or similar strategic planning documents. For regions without ecosystem-relevant strategic planning documents, NOAA Fisheries will work under this goal and Goal 1.a to ensure that scientific information is made available to support emerging goals and objectives.

NOAA Fisheries’ teams identified in Goal 1.c can assess and articulate regional decision-makers’ ecosystem and climate science needs (including ecological, social, and economic components), and develop science plans to address those needs in coordination with other efforts such as IEA, CEFI, and protected resources and habitat programs. For each science need identified, managers and scientists should ensure the decision-making process provides a clear on-ramp for using the scientific information. NOAA Fisheries will work internally and with external management partners to co-develop new management on-ramps when they do not exist. Direct engagement between scientists and management partners will ensure that scientists understand the policy questions addressed by managers, and ensure that staff and management partners understand the benefits and limits of NOAA Fisheries’ best available ecosystem and climate science (Townsend et al. 2020, see Figure 2).



Figure 2: Outline of the steps for incorporating information for ecosystem models into management, adapted from Townsend et al. 2020.

Guideline 3 - Prioritize vulnerabilities and risks to ecosystems and their components

As environmental changes move ecosystems into novel conditions, it will be important to understand which species, habitats, fisheries, and communities are vulnerable to these changes. Guideline 3 brings together concepts from ecosystem science and U.S. living marine resource management laws to improve our understanding of the individual and cumulative drivers for the physical, chemical, biological, social, and economic components of marine ecosystems. Together, these concepts help prioritize the management needs of the most vulnerable ecosystem components. By understanding and managing for ecosystem sustainability, managers can work to buffer fish and protected resources, fisheries, habitats, and human communities within those ecosystems against the negative effects of changing climate and ocean conditions, shifting social and economic conditions, and increasing demands on resources across a wide range of human activities. Under Guideline 3, NOAA Fisheries' goals are:

- a. 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 changing conditions, including from biophysical and human pressures.
- b. Identify the individual, cumulative, nonlinear, and nonstationary pressures and potential “black swan”¹³ events that pose the most risk to those vulnerable resources and dependent communities.
- c. Prioritize management options for mitigating risk, enhancing resilience, and improving adaptive capacity within existing decision-making processes.

This 2024 update builds on the significant work conducted since 2016 on [climate vulnerability assessments](#) (2016 Action Item 3.b.3) for fish and invertebrate species, marine mammals, sea turtles, fishing communities, and marine habitats.

Goal 3.a: NOAA Fisheries will 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 changing conditions, including from biophysical and human pressures.

To date, NOAA Fisheries has looked at risks, vulnerabilities, and opportunities with two main tools: climate vulnerability assessments and ecosystem risk assessments. Both have been valuable for increasing science and management understanding of species- and stock-specific challenges associated with a changing climate and how different human activities and ecosystem changes cumulatively affect our ecosystems over time.

¹³ A black swan event is a surprising event, usually a rapid catastrophic loss, that is difficult to predict but can have large consequences (e.g., an Unusual Mortality Event for a marine mammal stock).

For 2024 and beyond, Action Items under Goal 3.a will continue to focus on these two tools. NOAA Fisheries will use the following Action Items to develop annual and longer-term milestones to implement Goal 3.a:

Action Item 3.a.1: Conduct climate vulnerability assessments (CVAs) for living marine resources, habitats, and coastal communities; identify gaps or needed updates in existing CVAs; and identify new and existing on-ramps for use in management.

Action Item 3.a.2: Conduct ecosystem-level risk assessments to identify existing and emerging stressors, opportunities, vulnerabilities, and cumulative impacts most likely to affect our ability to meet management goals and objectives.

The CVAs conducted under Guideline 3 since the 2016 EBFM Road Map have supported decision-makers in understanding the vulnerabilities of species, habitats, and fishing communities to the effects of climate change. CVAs contribute to our understanding of the effects of changing climate and ocean conditions on the abundance, distribution, and phenology of individual species and stocks, as well as to whole-picture views of the effects on multiple species within a common ecosystem. NOAA Fisheries will continue to conduct new CVAs on species, habitats, and communities that have not yet been assessed, so that CVAs may be used to support fisheries management, species recovery, and habitat restoration and protection under climate change ([NMFS 2023a](#), [NMFS 2023b](#)).

Under the 2016 EBFM Road Map, NOAA Fisheries led the development of a general ecosystem risk assessment approach that spans system complexity (single species to full ecosystem) and data availability (qualitative to quantitative; [Holsman et al. 2017](#), [Rankin et al. 2023](#)). Although climate change weighs heavily on species and habitat management now and into the future, it is not the only challenge facing trust resources. Risk assessments help us understand the cumulative effects of natural and human-induced challenges within marine ecosystems and can guide management decisions for vulnerable species, habitats, and communities. Risk assessments can be completed at multiple levels for data-rich and data-poor situations ([Holsman et al. 2017](#)). In some situations, NOAA Fisheries will use broad-scale vulnerability assessments to direct future research on higher resolution risk assessments using a triage approach.

Goal 3.b: NOAA Fisheries will identify the individual, cumulative, nonlinear, and nonstationary pressures and potential “black swan” events that pose the most risk to those vulnerable resources and dependent communities.

While Goal 3.a addresses broad-scale risks to large categories of ecosystem components, particularly under changing climate and ocean conditions, Goal 3.b emphasizes the need to examine the effects of particular and cumulative pressures on the most vulnerable resources and communities. In recent years, the U.S. marine environment has been subject to an increasing number of ecological shifts outside of historic norms. Under Goal 3.b, NOAA Fisheries will

develop early warning systems for ecological surprises, particularly those types that may have historically triggered large-scale population collapses. NOAA Fisheries will build capacity to address rapid environmental shifts, using these Action Items to develop annual and longer-term milestones under Goal 3.b:

Action Item 3.b.1: Research and apply methodologies for identifying or predicting significant and disproportionately impactful pressures and events within managed marine ecosystems.

Action Item 3.b.2: Identify those habitats, species, and human communities that are most vulnerable to pressures and events and evaluate management mitigation measures.

In recent years, several U.S. marine species have been subject to surprising die-off events, such as the Alaska snow crab population crash ([Szuwalski et al. 2023](#)), the sea star wasting disease ([Hamilton et al. 2021](#)), and the [manatee unusual mortality event](#). Other resources, such as Alaska salmon, are demonstrating nonstationary relationships to environmental forcing ([Litzow et al. 2019](#)). NOAA Fisheries must research past “black swan” events for their causes, and must develop methods for identifying the ecosystem conditions that give rise to surprising die-offs or other ecological shifts. NOAA Fisheries will also identify potential improvements in existing regulatory responses to rapid within-year changes in managed species populations.

Using the CVAs and risk assessments from Goal 3.a, NOAA Fisheries will work under Goal 3.b to evaluate the effectiveness of management programs to support our most vulnerable species, habitats, and communities into the future. NOAA Fisheries will identify those habitats most vulnerable to the potential combined effects of climate change and human development, and will identify habitats most in need of interventions to support those vulnerable species most at risk. NOAA Fisheries will improve its identification of fishing communities most vulnerable to shifts in the availability of fisheries target species, and support more rapid recovery of species of cultural significance to indigenous and remote human communities. NOAA Fisheries will also share its findings with its management partners, other agencies, and the public, so that this information may help others better understand the cumulative effects of human activities and management programs on the environment and communities.

Goal 3.c: NOAA Fisheries will prioritize management options for mitigating risk, enhancing resilience, and improving adaptive capacity within existing decision-making processes.

Using the science conducted under Goals 3.a and 3.b, work under Goal 3.c will focus on improving management processes and regulatory responses to near-term ecological shifts, “black swan” events, and other pressures and opportunities. NOAA Fisheries will assess adaptive capacity in federal fisheries, particularly those that may be affected by the responsiveness of federal regulations to large-scale shifts in the abundance and distribution of managed species.

NOAA Fisheries will use the following Action Items to develop annual and longer-term milestones to implement Goal 3.c:

Action Item 3.c.1: Identify potential improvements for existing regulatory responses to rapid within-year changes in catch rates of target species and bycatch rates of non-target and protected resources to mitigate risks.

Action Item 3.c.2: Identify where outreach to management partners and affected communities with interacting authorities and interests needs to be initiated or strengthened and assist in developing policies that address risk and uncertainty from climate and other ecosystem drivers.

Action Item 3.c.3: Develop and test management strategies, recovery strategies, and habitat restoration approaches that are robust to rapid environmental change, extreme conditions, and data uncertainties.

Identifying and improving regulatory responses to ecosystem change will require a range of efforts, including:

- Increasing the speed of data delivery to monitors and managers to better support annual and in-season fishery management actions;
- Incorporating additional social science and community engagement;
- Supporting the exploration of more flexible or adaptive management frameworks;
- Conducting surveys and outreach to understand the potential effects of and responses to ecosystem vulnerabilities;
- Collaborating with communications teams on effective communication and translation of concepts of risk, vulnerability, and uncertainty; and
- Improving and streamlining how NOAA Fisheries analyzes the cumulative effects of management actions.

Understanding that ecological surprises are, by their nature, less predictable than expected interannual variability, NOAA Fisheries will need to discuss, analyze, and develop robust management strategies that can perform well under predictable variability and better understand the sensitivities in performance of management strategies to extreme conditions.

NOAA Fisheries supports collaborations internally and with regional, national, and international management partners, including Councils, to develop policies that address risk and uncertainty from climate and other ecosystem drivers. Across all these partnerships, exploration of approaches to mitigate and adapt to risks, whether said risks are foreseen precisely or barely at all, is needed. Considerations should include approaches that allow for the adaptation of management as well as latitude for autonomous, real-time adaptation by fishery participants in response to changing conditions. Approaches will need to be tailored to the multiple mandates that guide NOAA Fisheries and our partners.

Expanded capacity to understand severe environmental shifts is essential; however, aiming to predict every severe event that causes risks to fisheries and fishing communities, trust species, and habitat would be impracticable. For many surprise events, it may be difficult to understand the optimal immediate management reactions to those events. As NOAA Fisheries continues to implement model simulations to test management strategies, building that knowledge will help NOAA Fisheries and its management partners better address uncertainty in science and management into the future. Management strategy evaluation (MSE) is more fully addressed under Guideline 4; here in Action Item 3.c.3, NOAA Fisheries is specifically calling for evaluating the robustness of management strategies to the higher-risk events discussed throughout Guideline 3. Furthermore, given the challenges of predictability, NOAA Fisheries is also proposing the exploration of robust strategies to mitigate and adapt to a range of plausible (even if indeterminate) risks.

Guideline 4 – Explore and address trade-offs within an ecosystem

Guideline 4 captures the intersection between ecosystem science and management priorities for living marine resources, where NOAA Fisheries and its partners must evaluate trade-offs between activities and components within ecosystems. Expanding on NOAA Fisheries' work under the 2016 EBFM Road Map, the goals for Guideline 4 are:

- a. Include climate considerations explicitly in the evaluation of the dynamics and trade-offs of living marine resource management in a regional ecosystem.
- b. Analyze trade-offs with respect to optimizing benefits from all fisheries within each ecosystem or jurisdiction, including protected resources and habitat considerations, acknowledging all objectives may not be achievable simultaneously, by accounting for all ecosystem-specific policy goals and objectives.
- c. Conduct management strategy evaluations that include ecosystem-level analyses that provide ecosystem-wide management advice and inform harvest control rules and other management decisions, consistent with statutory requirements.

Since 2016, NOAA Fisheries has made significant progress on developing MSE expertise and analyses, and has supported trade-off evaluations in marine ecosystems nationwide. For 2024 and beyond, NOAA Fisheries will continue to support and expand MSE work, and will ensure that trade-off evaluation supports climate-ready fisheries and managed species, and supports balancing the benefits to the nation from living marine resource management. NOAA Fisheries will ensure collaboration with management partners and users to ensure analyses produce outcomes that have a tangible management impact, as many of the tools identified here can require extensive time and resources and may not directly align with management timelines.

Goal 4.a: NOAA Fisheries will include climate considerations explicitly in the evaluation of the dynamics and trade-offs of living marine resource management in a regional ecosystem.

This Road Map’s Action Items under Guidelines 1–3 will prepare NOAA Fisheries, its management partners, and stakeholders for understanding ecosystem- and taxa-specific science and management priorities, and the risks to and vulnerabilities of our ecosystems and their components, in order to adequately evaluate trade-offs among management objectives. That shared ecosystem-scale knowledge and understanding will help the nation develop climate-ready fisheries. Under Goal 4.a, NOAA Fisheries will leverage capacity and resources to build climate-ready science and management for more informed assessment of trust species, habitats, human dimensions, and ecosystems. To understand and support climate-ready fisheries, as well as climate-ready science and management planning for trust species and habitat, NOAA Fisheries will use these Action Items to develop annual and longer-term milestones under Goal 4.a:

Action Item 4.a.1: Conduct scenario planning to explore living marine resource and coastal community dynamics under current and future ocean conditions and to consider multiple objectives across fisheries and ocean uses.

Action Item 4.a.2: Develop and expand capacity of fisheries, habitat, protected resources, and integrated ecosystem assessments to explore ecosystem dynamics under extreme events and changing ocean conditions.

Action Item 4.a.3: Develop a framework for identifying and assessing fishing fleet behavior, including fishing location choices and changes in shoreside support sectors, to support fisheries management planning and planning for other ocean uses under climate change and other extreme events.

Scenario planning is a facilitated strategic thinking and planning process developed to help decision-makers explore alternate potential future states and consider the range of decisions that may arise in preparing for the future. NOAA Fisheries uses scenario planning to better understand the potential effects of changing climate and ocean conditions on decision-making trade-offs for our trust species and fisheries (Borggaard et al. 2019, Borggaard et al. 2020, Frens and Morrison 2020, deReynier et al. 2023). NOAA Fisheries will continue to use scenario planning to strategize with management partners and stakeholders to explore marine resource management challenges under climate change. Policy recommendations emerging from scenario planning exercises can help NOAA Fisheries and its management partners develop on-ramps for applying ecosystem and climate science in decision-making processes, and can provide testable scenarios for ecosystem model simulations of management robustness under a range of future conditions (as in Action Item 4.c.3).

NOAA Fisheries’ Next Generation Stock Assessment Enterprise (Lynch et al. 2018) includes explicit steps for expanding the scope of the stock assessment paradigm so that it is more holistic

and ecosystem-linked. Similarly, NOAA Fisheries' Habitat Assessment Improvement Plan (Peters et al. 2018) includes recommendations to support habitat research and assessments to improve stock assessments and support EBFM Guidelines, particularly in the context of climate change. This Road Map supports NOAA Fisheries' goals of expanding single-species stock assessments and habitat assessments, and of using research-track assessments to test new ideas and to bring ecosystem and climate information into assessments.

NOAA Fisheries' social and economic science programs will have opportunities under CEFI and other funding efforts to develop [national](#) and regional strategies for expanding social and economic science capacity to support the human well-being goals of EBFM and NOAA Fisheries' national Equity and Environmental Justice Strategy.¹⁴ Social and economic science includes various disciplines with different approaches to understanding and modeling human interests, needs, well-being, and benefits from living marine resources. Identifying and assessing fishing fleet behavior, particularly fishing location choices over time, has become increasingly important with the rise of alternative ocean industries such as offshore wind energy and ocean aquaculture, and as climate change has begun to affect fish stock distribution and abundance. NOAA Fisheries' Social Indicators for Coastal Communities characterize community well-being for coastal communities engaged in seafood production activities, providing indicators of community vulnerability, gentrification pressure, fishing dependence, and vulnerability to storm surge and sea-level rise.¹⁵

For designing and reviewing fisheries allocation programs, it is necessary to understand fishing community vulnerability and dependence on fishery resources, the rights of Indigenous peoples and dependence of Indigenous communities on fishery resources, historic fleet behavior, and potential future fleet behavior. This understanding will also inform fishing permit programs within restricted geographic areas, fishing area conservation restrictions, permitting and consultations on marine aquaculture developments, and other geography-based management measures. Changes in shoreside sectors and services such as seafood processing and marketing, support for vessels and gear, and composition and infrastructure of working waterfronts will also affect fishery resource access, whether those changes are driven by climate, markets, or other forces. Under Goal 4.a, NOAA Fisheries will better integrate the methods and approaches of social and economic science with natural science in support of EBFM.

¹⁴ NOAA Fisheries EEJ Strategy. <https://www.fisheries.noaa.gov/s3/2023-05/NOAA-Fisheries-EEJ-Strategy-Final.pdf>

¹⁵ NOAA Social Indicators for Coastal Communities. <https://www.fisheries.noaa.gov/national/socioeconomics/social-indicators-coastal-communities>

Goal 4.b: NOAA Fisheries will analyze trade-offs with respect to optimizing benefits from all fisheries within each ecosystem or jurisdiction, including protected resources and habitat considerations, acknowledging all objectives may not be achievable simultaneously, by accounting for all ecosystem-specific policy goals and objectives.

Under Goal 4.b, NOAA Fisheries acknowledges that trade-offs are occurring and that wise management of marine ecosystems includes understanding and preparing for optimal decision-making across all fisheries, commercial and non-commercial. NOAA Fisheries will address the risks and vulnerabilities identified for our ecosystems using multi-disciplinary science to analyze the trade-offs made in managing living marine resources and habitat. NOAA Fisheries will use the following Action Items to develop annual and longer-term milestones to implement Goal 4.b:

Action Item 4.b.1: Develop procedures and fora to identify, evaluate, and minimize conflict within and across fisheries, habitats, protected resources recovery, and human well-being priorities at near-term and long-term time scales.

Action Item 4.b.2: Expand capacity of fisheries, habitat, protected resources, and ecosystem assessments to explore multi-species harvest, conservation, and recovery policies and guidance on setting multi-species annual catch limits.

Ocean resource users and managers continuously make trade-offs in their decisions, regardless of whether those trade-offs are acknowledged in decision-making. Managers implement these trade-offs by setting annual catch limits for each species or species complex that are below the biological limits of overfishing for those species or complexes. But the mere existence of the single-species limits gives the impression that all species might be fished up to their respective limits simultaneously. The scientific advice leading to annual catch limits needs to be augmented with more accounting for the interacting effects that fisheries have on different species and their habitats, the effects that species have on each other, the effects that fisheries have on each other, and the interacting effects between seafood markets, seafood supply, fishing vessel costs and earnings, and fisheries. NOAA Fisheries will bring together different scientific disciplines to better identify the trade-offs made for marine ecosystems and managed resources, potentially building off of possible future trade-offs identified in the scenario planning in Action Item 4.a.1, and conferring with Councils and other management partners to support communication and coordination between scientists and managers.

NOAA Fisheries will develop trade-off analysis approaches, multi-disciplinary toolkits, best practices, communication tools, and plans for sustainable staffing to support those tools and processes. NOAA Fisheries will also seek to establish national guidance on and approaches for handling common and known trade-offs. To address potential effects of climate change in a more coordinated manner, NOAA Fisheries will explore multi-species harvest and conservation policies and guidance that account for interactions between and among species, habitats, and human activities and communities. For example, since habitat and forage are aspects of the

ecosystem that impact multiple fisheries and protected resources simultaneously, NOAA Fisheries will develop and expand upon approaches to explore implications of habitat or forage-related considerations for multiple species.

Science to support trade-off decision-making includes but is not limited to better understanding of:

- Predator-prey relationships, particularly including trophic roles and diet data;
- Interactions between fisheries, including gear impacts, bycatch, and discard rates;
- Life history and habitat needs of managed species;
- Effects of human activities on the role of habitat in food webs;
- Spatial and temporal patterns of different ecological processes, fisheries, and other human activities; and
- Effects of changes in seafood production levels on regional economies and industries that support or depend on the fishery sector.

To improve the use of economic analyses and information in fisheries management, NOAA Fisheries will prioritize rigorous quantitative integration of economic data into assessment models and processes (e.g., portfolio analysis) to evaluate changes in benefits to the nation associated with shifting fishery harvest levels in U.S. marine ecosystems. To improve its use of economic analyses and information in fisheries management, NOAA Fisheries also needs to prioritize rigorous quantitative collection and integration of economic and social data into the stock, protected resource, and ecosystem assessment models so that we can evaluate changes in benefits to the nation associated with shifting fishery harvest levels in U.S. marine ecosystems.

Understanding and building the governance pathways and management on-ramps for new science will require NOAA Fisheries to support strategic planning efforts for climate change conducted internally and by management partners, provide policy guidance on multi-species and multi-criteria decision-making, and provide review of and guidance on where flexibilities could be added into fisheries regulations processes and frameworks. For both science and management, methodologies can be routinely revisited to incorporate new data as appropriate, and to evaluate methodologies' performance.

Goal 4.c: NOAA Fisheries will conduct management strategy evaluations that include ecosystem-level analyses that provide ecosystem-wide management advice and that inform harvest control rules and other management decisions, consistent with statutory requirements.

One of NOAA Fisheries' significant successes under the 2016 EBFM Road Map was building capacity to design and conduct MSEs, which are structured analytical tools¹⁶ designed to identify

¹⁶ See the NOAA Fisheries Integrated Toolbox, which has multiple "drawers" for various analytical methods and foci, some of which can assist in conducting MSEs. <https://noaa-fisheries-integrated-toolbox.github.io/>

and operationalize strategies for managing fisheries that are robust to several types of uncertainty. MSEs can balance and assess trade-offs among multiple economic, social, and biological objectives. NOAA Fisheries was given the opportunity to add one new MSE position per Science Center, and those six new positions have produced a diverse array of MSE work across U.S. marine ecosystems (e.g., hake in the Pacific Northwest, herring in New England, summer flounder in the Mid-Atlantic, dolphin fish in the Southeast, pelagic species on the West Coast). For 2024 and beyond, NOAA Fisheries will use MSEs to devise and test management procedures that can achieve multiple ecosystem and fisheries management objectives while the ecosystems are undergoing rapid climate-driven changes. Where Councils and other NOAA Fisheries management partners have developed the ecosystem goals and objectives envisioned under Guideline 1, MSEs can explore practical methods for implementing goals and objectives through fisheries management measures. NOAA Fisheries will use the following Action Items to develop annual and longer-term milestones to implement Goal 4.c:

Action Item 4.c.1: Develop MSEs to assess management options to mitigate and prepare for the risks and vulnerabilities identified under Guideline 3 to meet the ecosystem goals and objectives identified under Guideline 1.

Action Item 4.c.2: Develop MSEs in collaboration with management partners that address manager and stakeholder needs and leverage existing public engagement processes.

Action Item 4.c.3: Develop and maintain capacity to conduct whole-ecosystem MSEs to test the robustness of living marine resource management plans and policies to ecosystem-scale changes.

Moving beyond NOAA Fisheries' basic capacity building for MSEs, this Road Map supports greater connections between MSEs and NOAA Fisheries' science and policy work under all EBFM Guidelines. While much progress to date has focused on single-species MSEs, multi-species and ecosystem-level MSEs should be connected to the risks identified under Guideline 3, the multi-species stock assessments explored under Goal 4.a, and the ecosystem goals and objectives developed under Guideline 1. As populations and distributions of managed species shift under climate variability and change, so do the interactions between those species and the need for considering new approaches to multi-species and -fisheries management. Several recent opportunities have provided resources across a range of NOAA responsibilities that increase its ecosystem modeling capacity and its ability to respond to stakeholder priorities for habitat restoration and conservation.

NOAA Fisheries will improve its collaboration with its management partners so that MSE processes better reflect partners' questions, issues, and priorities for living marine resources and ecosystems. Where possible and appropriate, NOAA Fisheries will use existing public discussions of manager and stakeholder priorities to develop MSEs. NOAA Fisheries will also

improve its engagement with stakeholders, including those from underrepresented and vulnerable communities, and community partners to develop and identify resource management needs under different mandates.

NOAA Fisheries aspires to develop whole-ecosystem MSEs to test management measures and programs against individual and cumulative ecosystem-scale changes and trade-offs that span fisheries, aquaculture, protected resources, habitat conservation, and human well-being endpoints. In some regions, NOAA Fisheries has made great progress in developing end-to-end ecosystem models that can support whole-ecosystem MSEs (Kaplan et al. 2021). NOAA Fisheries' existing workshop processes (e.g., EBFM science and management conferences, national ecosystem modeling workshops, regional and national IEA meetings, etc.) can be used to launch plans for ecosystem-scale MSEs in more regions.

NOAA Fisheries will maintain a working group of staff MSE experts who will, among other duties, work with CEFI teams to ensure that CEFI planning is linked to existing and planned MSE efforts (Peterson and Walter 2023). NOAA Fisheries will also improve efforts to communicate its plans for and results of MSEs with its partners, stakeholders, and the public with increased web-based reporting.

Guideline 5 – Implement ecosystem considerations into management

Guideline 5 recognizes NOAA Fisheries' intent to ensure that actions taken under the 2024 EBFM Road Map improve connections between science and management processes, and particularly support the development of fishery management advice and regulations for climate-ready fisheries. The Policy and Road Map also reinforce the need to consider species interactions, habitat quality and quantity, and social and economic connections in decision-making for fisheries and conservation. To facilitate the use of ecosystem science and EBFM policy to address the challenges of a changing ocean environment under Guideline 5, NOAA Fisheries' Goals are:

- a. Develop and monitor ecosystem-level reference points.
- b. Incorporate ecosystem considerations, climate uncertainties, and an understanding of consequences and trade-offs into appropriate living marine resource management decisions. Explore and test regulatory options to incorporate climate change, ecosystem considerations, and other related features into management decisions, advice, and options.
- c. Provide integrated advice across multiple habitats and species (both targeted and protected) within an ecosystem.

For 2024 and beyond, NOAA Fisheries will build on the capacity and expertise developed through the 2016 EBFM Road Map, and the Action Items under Guideline 5 will explore

supporting management partners in their efforts to incorporate ecosystem information into decision-making processes. NOAA Fisheries will also refine its methods and practices for providing ecosystem science advice to decision-makers so as to address a fuller suite of species, habitats, and policy concerns.

Goal 5.a: NOAA Fisheries will develop and monitor ecosystem-level reference points.

An ecosystem-level reference point (ELRP) is an ecosystem harvest level or indicator with one or more associated benchmarks (i.e., targets, limits, or thresholds) to identify, monitor, or maintain desirable ecosystem conditions and functions (Morrison et al. 2024). In support of Guidelines 2 and 3, NOAA Fisheries has developed ecosystem indicators to inform decision-makers of the status and vulnerabilities of U.S. marine ecosystems. Action items under Guideline 4 will help decision-makers better understand how their decisions may affect more and less vulnerable components of the marine environment. Under Goal 5.a, NOAA Fisheries will use the following Action Item to explore whether and how to develop and implement ecosystem-level targets, limits, or thresholds that may help sustain ecosystems and ecosystem services into the future:

Action Item 5.a.1: Develop and implement best practices for identifying and estimating ELRPs for ecosystem-level biodiversity, resilience, and persistence, taking into account the potential effects of climate variability and change on marine ecosystems.

For decades, NOAA Fisheries has focused on single-species management and on understanding the life histories of managed species, particularly those that support marine fisheries. This work has been important to maintaining U.S. seafood supplies, commercial fishery sectors, aquaculture, and recreational fishing opportunities. But with increasing climate extremes in recent years, the nation needs to better understand when and whether ecosystem regime shifts or tipping points—points of rapid and enduring change from one set of ecological conditions to another—may occur (Morrison et al. 2024). With increasing climate extremes and other drivers such as market disruptions, global economic and trade factors, and other social changes, it is important that we examine fisheries production in a systematic manner to improve the nation’s stewardship of living marine resources and associated ecosystems.

NOAA Fisheries’ direction from the 2016 EBFM Road Map included delineating, evaluating, and exploring best practices for estimating and using system-wide or aggregate group harvest limits, ecosystem production measures, and other ELRPs to inform management decisions. For 2024 and beyond, NOAA Fisheries will continue to develop its understanding of the use of ELRPs—reviewing ecosystem goals, objectives, vulnerabilities, and risks identified under Guidelines 1-4—to draft ELRPs that support management needs. NOAA Fisheries intends to explore various types of ELRPs beyond just aggregate harvest limits, such as ecosystem carrying capacity for interacting groups of protected resources, biodiversity characteristics needed to

maintain ecosystem functions, habitat extent and quality needed to support stable trophic relationships in an ecosystem, and shifting ecosystem productivity for fisheries target species under climate change.

NOAA Fisheries will use existing workshop opportunities to develop a national framework for understanding potential ELRPs for ecosystem overfishing and for ecosystem-level biodiversity, resilience, and persistence. ELRPs for ecosystem overfishing should address ecosystem estimates of productivity, including those associated with oceanographic change (e.g., in productivity), and should improve the understanding of effects of any depletion on the nation's ability to ensure the sustainability of living marine resources. ELRPs for ecosystem-level biodiversity, resilience, and persistence should consider whether resilience or persistence is possible under climate change and may include indicators that focus on functional diversity within ecosystems.

Goal 5.b: NOAA Fisheries will incorporate ecosystem considerations, climate uncertainties, and an understanding of consequences and trade-offs into appropriate living marine resource management decisions as well as explore and test regulatory options to incorporate climate change, ecosystem considerations, and other related features into management decisions, advice, and options.

In order to use ecosystem science in support of more resilient and persistent ecosystems, NOAA Fisheries needs to review and update its approaches to fisheries management. Using the best scientific information available under EBFM allows us to evaluate ecosystem and climate uncertainties to support management partners in achieving their desired outcomes for managed resources, and in preventing unintended consequences from management actions for the larger suite of living marine resources. National-level reviews and updates of regulatory and policy guidance can support management partners by creating science and management that is responsive to challenges like a changing climate. Ideas generated through the strategic planning processes can help living marine resource managers and partners improve conservation and management measures by taking into account and allowing for variations among, and contingencies in, fish stock and protected resources' populations and distributions; accounting for the shifting needs of fisheries over interannual or long-term periods; and considering both near- and long-term habitat identification and conservation needs. Under Goal 5.b, NOAA Fisheries will use the following Action Items to take advantage of ideas generated in support of climate-ready fisheries, species, and habitat by developing annual and longer-term milestones:

Action Item 5.b.1: Develop ecosystem- and climate-ready terms of reference for fish and protected resources stock assessments, habitat assessments, and ecosystem assessment analyses, reviews, and decision-making processes.

Action Item 5.b.2: Update regulatory language that provides guidance on MSA national standards, MSA and MMPA bycatch mitigation, ESA recovery planning and

implementation, and EFH refinements and consultations to ensure that language addresses EBFM principles and supports climate-ready fisheries, species, and habitats.

With eight regional fishery management Councils, Secretary-managed Atlantic highly migratory species fisheries, three interstate Marine Fisheries Commissions, multiple coastal States and federally recognized fishing Tribes and Indigenous communities, and multiple Regional Fishery Management Organizations for internationally managed species, the United States has various management processes to discuss and test ideas to support EBFM and climate-ready fisheries. NOAA Fisheries will support efforts within these different entities to develop management on-ramps for ecosystem information and to create flexible and nimble fisheries management programs that support climate-ready fisheries and fishing communities. One focus area will be improving terms of reference for assessments of fish, protected resources, habitats, and ecosystems to ensure they include some rigorous evaluation of climate or ecosystem considerations.

NOAA Fisheries regularly reviews and updates internal policy directives and guidance, such as the EBFM Policy and Road Map and guiding regulatory language like the MSA National Standard Guidelines (50 CFR 600.310 *et seq.*). In 2023, for example, NOAA Fisheries published a new policy directive on addressing climate change in EFH consultations ([NMFS 2023a](#)) and an updated policy directive on addressing climate change in NOAA Fisheries' ESA decisions ([NMFS 2023b](#)), and issued an advance notice of proposed rulemaking and request for comments on updating guidelines for National Standards 4, 8, and 9 of the MSA (88 FR 30934, May 15, 2023). Reviewing and updating internal policy directives and regulatory guidance will allow NOAA Fisheries to harmonize its policies for fisheries and trust resources with its approach to climate change, support development of periodic priorities and guidance documents, ensure revisiting methodologies to evaluate performance and incorporate best available science, and provide opportunities for management partners to develop new management measures to support climate-ready fisheries and EBFM. This internal harmonization will serve as a valuable precursor to supporting management partners across all regions in the development of on-ramps for ecosystem science decision-support products.

Goal 5.c: NOAA Fisheries will provide integrated advice across multiple habitats and species (both targeted and protected) within an ecosystem.

The 2016 EBFM Road Map focused strongly on the roles of marine fish and fisheries within our ecosystems, and on ecosystem science to support fisheries management. For 2024 and beyond, this Road Map more deliberately integrates NOAA Fisheries' multiple science and management responsibilities for harvested species and fisheries, for protected resources and their critical habitats, and for EFH and habitat conservation and restoration. NOAA Fisheries will use these Action Items to develop annual and longer-term milestones under Goal 5.c:

Action Item 5.c.1: Provide guidance for and examples of dynamic and flexible fisheries management measures that can respond to shifts in species' distribution and availability for all living marine resource taxa in an ecosystem.

Action Item 5.c.2: Build habitat (EFH and critical habitat) mapping and designation capacity to address the potential effects of climate change and to site, design, and implement habitat protection and priority restoration across all regions, with the goal of enhancing fish productivity and recovering protected resources.

Building on Goal 5.b, NOAA Fisheries will support its management partners under Goal 5.c in sharing examples of where and how living marine resource management can be made more flexible and responsive to environmental change, using domestic and international examples from fisheries and other natural resource management arenas, as well as testing these options using MSEs or other management tools as noted in Goal 4.c above. Fisheries management needs, data collection and delivery programs, and potential for climate-based fisheries disasters vary across U.S. regions. Similarly, protected resources conservation and recovery needs, potential interactions with different fisheries, and drivers of unusual mortality events will vary by region and under near-term climate variability and long-term climate change. For 2024 and beyond, NOAA Fisheries will assess the management flexibilities available to fisheries (Morrison and Termini 2016) and protected resources (NMFS 2023b) to develop guidance for managing these species under uncertainty.

The MSA and ESA both recognize the connection between healthy fish and protected resources' populations and resilient marine habitats. NOAA Fisheries' habitat science, restoration, and protection programs are linked to goals for recovering species listed under the ESA, and to improving habitat quality for all managed species. Climate change effects—particularly sea-level rise—in combination with drought, floods, and changing freshwater and estuarine flow dynamics, present new challenges for maintaining habitat that supports resilient and persistent populations of target and protected resources. Sea-level rise, exacerbated by storm surge, also affects fishing communities through inundation and damage to or destruction of docked vessels and port-based fisheries infrastructure. NOAA Fisheries has fishing community-level storm surge and sea-level rise indicators for some regions of the United States and is expanding the regions covered as data become available for new regions.

Under Goal 5.c, NOAA Fisheries will build on its IRA-funded work to improve basic habitat mapping and designation functions, improve landscape- and seascape-scale habitat restoration planning, and develop capacity to assess the potential effects of climate change and sea-level rise on future habitat suitability and availability to trust resources. In addition to the IRA, the BIL provided unprecedented funding for transformational habitat restoration that will improve habitats on a scale that will increase ecosystem services by improving population level benefits for listed species and enhancing the productivity of managed species and their prey.

Guideline 6 – Support ecosystem resilience via monitoring and adjusting of management actions

Under Guideline 6, NOAA Fisheries will monitor management actions taken in support of resilient ecosystems and will support adaptive management processes that improve regulatory responsiveness to near- and long-term environmental challenges. This EBFM Road Map will build NOAA Fisheries’ capacity to understand, support, and sustain resilient ecosystems. Mandates already require NOAA Fisheries and its partners to be flexible and responsive enough to adjust management programs in the face of natural and human-induced challenges. To ensure that living marine resource management actions support ecosystem resilience under Guideline 6, NOAA Fisheries’ Goals are:

- a. Evaluate ecosystem-level measures of resilience to maintain core ecosystem structure, biodiversity, production, energy flow, and functioning.
- b. Evaluate coastal fishing community well-being.
- c. Identify and track NOAA Fisheries–wide performance and success metrics for tracking progress toward meeting EBFM goals and objectives.

The 2016 EBFM Road Map’s Action Items under Guideline 6 focused on using social and economic science to understand the well-being of human communities. While this Road Map continues to address human well-being in Guideline 6, social and economic science priorities and actions are now more carefully woven into the full suite of Road Map Guidelines. Action items under Guideline 6 will also more directly support living marine resource management decisions across the spectrum of NOAA Fisheries’ responsibilities to fish and fisheries, protected resources, and habitats. Supporting ecosystem resilience over the long term is the great challenge of natural resource management under climate change, and a deeply held goal for NOAA Fisheries, management partners, and stakeholders.

Goal 6.a: NOAA Fisheries will evaluate ecosystem-level measures of resilience to maintain core ecosystem structure, biodiversity, production, energy flow, and functioning.

The U.S. National Academies of Sciences defines resilience as “the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events” (NAS 2012). NOAA has adopted this definition of resilience for its work across U.S. issues touching on our atmosphere, oceans, and coasts.¹⁷ Within the 2016 EBFM Road Map, NOAA Fisheries refined the resilience concept by noting: “There are elements of both resistance to and recovery from perturbations, and this can be applied to both biophysical and socio-economic systems in marine ecosystems. There are many metrics of resilience, and here the term is used generally and

¹⁷ NOAA Resilience 101: Science Helps America Withstand Wild Weather. <https://www.noaa.gov/resilience-101-science-helps-america-withstand-wild-weather>

conceptually rather than in any one of those specific mathematical formulations. . .” (NMFS 2016b).

Although that definition aptly explains the concept of ecosystem resilience, it leaves open questions regarding specific metrics of resilience. For 2024 and beyond, NOAA Fisheries will discuss many possible metrics of ecosystem resilience and narrow those down to a usable suite of metrics applicable across our mandates, including the National Environmental Policy Act (NEPA). NOAA Fisheries will develop annual and longer-term milestones through this Action Item under Goal 6.a:

Action Item 6.a.1: Develop operational definitions, measures, and thresholds of resilience that can be used across NOAA Fisheries’ range of mandates (MSA, MMPA, ESA, NEPA, Executive Orders, and others) and that can be applied to our ecosystems under a future of climate variability and change.

Developing operational definitions, measures, and thresholds of resilience will require careful research into NOAA’s and others’ past work on resilience and a thorough understanding of the meaning of resilience under major mandates. New considerations for ecosystem resilience and alternative frameworks like “persistence” under climate change and for different regions of the country must be taken into account. NOAA Fisheries’ existing workgroup and workshop processes can be used to sort through and pinpoint useful metrics of ecosystem resilience, including how to best balance the benefits of a national definition and metrics with the need for regional and local flexibility. NOAA Fisheries’ cross-mandate workgroups can be tasked with assessing the regional and national utility and applicability of resilience concepts under major mandates (e.g., OSTP 2023). NOAA Fisheries should consider whether the Resist-Accept-Direct framework¹⁸ used by other U.S. natural resource agencies ([National Park Service](#), U.S. Geological Survey, Fish and Wildlife Service) in planning for the effects of climate on species and habitats would also be useful for NOAA trust species, especially for habitat restoration and management in the face of climate change (see Schuurman et al. 2020).

Goal 6.b: NOAA Fisheries will evaluate coastal fishing community well-being.

As discussed under Guideline 2, NOAA uses diverse scientific disciplines to conduct ecosystem science, including economics and the social sciences. National Standard 8 of the MSA requires that NOAA Fisheries take into account the importance of fishery resources to fishing communities in order to provide for the sustained participation of such communities and, to the extent practicable, minimize adverse economic impacts on such communities. The MSA also requires NOAA Fisheries to ensure that fishery conservation and management measures are designed to provide a food supply to the nation, among other benefits. Under Goal 6.b, NOAA

¹⁸ Resist-Accept-Direct Framework. <https://doi.org/10.36967/nrr-2283597>

Fisheries will use these Action Items to develop annual and longer-term milestones to better understand and support human well-being:

Action Item 6.b.1: Develop and report on metrics for human well-being in fishing communities that address fishery benefits to the nation.

Action Item 6.b.2: Develop a framework for identifying seafood systems and seafood supplies that have been affected by fisheries and natural disasters, market forces, and more general ecosystem change, particularly by identifying and including traditional seafoods and culturally important fish species and stocks.

NOAA Fisheries has developed and explored several measures to characterize the resilience and statuses of coastal and fishing-dependent communities (Jepson and Colburn 2013, Colburn et al. 2016, Himes-Cornell and Kaspersky 2016, Mamula et al. 2019, Szymkowiak and Kasperski 2021). These measures need to continue to be monitored, analyzed, and updated where necessary and appropriate. Ocean-based seafood represents the largest sustainable supply of wild-caught food products in the nation, and maintaining a regular supply of healthy, natural seafood is important to numerous cultures and U.S. communities. Similarly, advances in and support for sustainable aquaculture are also needed to supplement the wild-caught products. Fishing communities face a wide array of pressures, including coastal inundation, sea-level rise, increased storm intensity and frequency, and other challenges associated with climate change (Colburn et al. 2016). These environmental pressures may be exacerbated or mitigated by shifting market forces. The connections of human well-being to ecosystem services and ecosystem resilience are internationally recognized and part of NOAA Fisheries' goals for the future, this EBFM Road Map, and the NOAA Fisheries Equity and Environmental Justice Strategy.

NOAA Fisheries will use one of the near-term EBFM science and management conferences identified in Goal 2.a to explore and report on three to five nationally applicable indicators of human well-being in fishing communities that address fishery benefits to the nation, and which can be supplemented as needed with regionally appropriate indicators of human well-being.

NOAA Fisheries has made significant efforts to develop indicators for EBFM and reports on hundreds of indicators from various scientific disciplines in ESRs and other scientific publications. For Goal 6.b in 2024 and beyond, NOAA Fisheries will take a disciplined national approach to identifying indicators of human well-being. Addressing the effects of climate change on marine and coastal ecosystems includes understanding the past effects of natural disasters and climate variability on U.S. ecosystems. Goal 6.b builds on work under Guidelines 3 and 5, the Seafood Strategy,¹⁹ and NOAA Guidance and Best Practices for Engaging and Incorporating Indigenous Knowledge in Decision-Making to consider food systems, supplies and supply

¹⁹ NOAA Fisheries National Seafood Strategy. <https://www.fisheries.noaa.gov/s3/2023-08/2023-07-NOAAFisheries-Natl-Seafood-Strategy-final.pdf>

chains, security, and sovereignty under past natural and fisheries disasters, to better prepare for the challenges ahead under climate change. NOAA Fisheries should assess U.S. methods for tracking seafood catch and disposition to better understand who is using and benefiting from U.S. seafoods. Over the longer term, NOAA Fisheries should develop a framework for monitoring the role of U.S. seafood in supporting resilient coastal and fishing-dependent communities as a source of food, recreation, and cultural commodity.

Goal 6.c: NOAA Fisheries will identify and track NOAA Fisheries-wide performance and success metrics for tracking progress toward meeting EBFM goals and objectives.

Goal 6.c provides practical steps for NOAA Fisheries to assess progress on the Action Items in this Road Map, including how well it is addressing the EBFM goals and objectives identified in Guideline 1. As discussed herein, this 2024 EBFM Road Map calls on NOAA Fisheries to operationalize EBFM by prioritizing the Road Map’s Action Items in planning documents like geographic strategic plans, annual guidance memoranda, annual priorities documents, and strategic planning documents. To ensure a transparent Road Map tracking process, NOAA Fisheries will use these Action Items to develop annual and longer-term milestones that implement Goal 6.c:

Action Item 6.c.1: Establish and report on EBFM performance measures.

Action Item 6.c.2: Review and track Action Items accomplished across NOAA Fisheries.

Each NOAA Fisheries FSC, RO, and headquarters Office plans shall include Action Items in this EBFM Road Map to leverage ongoing activities or explicitly identify those Action Items in applicable annual guidance memoranda, annual priorities, and strategic planning documents.

By linking each of this Road Map’s Guidelines to annual or longer-term milestones (e.g., as provided through the NOAA electronic Annual Operating (eAOP) system), NOAA Fisheries commits to the work identified in this Road Map and to tracking its efforts to meet those milestones through existing workflow processes. NOAA eAOP administrators shall work with NOAA Fisheries to provide appropriate annual milestones for EBFM. The NOAA Fisheries’ workgroups identified in Guideline 2 shall track NOAA Fisheries’ regional and national action items, milestones, and accomplishments that support this Road Map, including work that may be conducted under CEFI, the NOAA Fisheries Climate Science Strategy, the National Data Acquisition Plan, and related strategic initiatives and documents. NOAA Fisheries will document climate and ecosystem successes where ecosystem information is used in marine resource management. This valuable activity will be supported by dedicated Knauss or Presidential Management fellowship recipients who will work with the EBFM Workgroup to compile progress. NOAA Fisheries’ Office of Communications shall work with the EBFM Workgroup to keep the public up-to-date with a brief annual summary of progress on Road Map Action Items via a public-facing website.

The Action Items under Goal 6.c are relatively simple and straightforward compared to the rest of the Action Items throughout the Road Map; however, these Action Items are essential to ensuring forward momentum on EBFM and supporting climate-ready fisheries. This 2024 Road Map is a resource that can be regularly consulted by NOAA Fisheries' FSCs, ROs, and headquarters offices in planning for and prioritizing work to accomplish NOAA Fisheries' mission. Tracking the inclusion of activities to support this Road Map's Action Items in the annual milestones for offices and Centers, and in individual performance plans (Goal 1.c) of NOAA Fisheries staff, will support an orderly implementation of the Road Map in 2024 and beyond.

3 Execution of the EBFM Road Map and Effective Dates

Overseeing and tracking the implementation of this plan will be the responsibility of the NOAA Fisheries Director of Scientific Programs and Chief Science Advisor in consultation with the Deputy Assistant Administrator for Regulatory Programs. The NOAA Fisheries Strategic Planning and Performance Evaluation Division of NOAA Fisheries' Office of Management and Budget will aid in the development of milestones and actions to support progress towards the goals of this Road Map, including through the administration of the NOAA eAOP. Coordination of EBFM efforts will be facilitated by the National EBFM Coordinator and the EBFM Workgroup.

The EBFM Policy and Road Map afford the opportunity to improve the nation's living marine resource management. Actions noted herein have longer-term timelines built into them that can help track progress toward EBFM implementation. NOAA Fisheries will review this guidance on a 5-year basis. Road Map implementation that builds upon existing efforts will start 1 month after the final clearance date of the Road Map. This Road Map will inform evaluation of NOAA Fisheries progress towards Road Map Action Items, taking resource availability into consideration.

This Road Map includes recommended actions to guide NOAA Fisheries as it continues to implement EBFM. These actions require active management. Some of the recommended actions are ongoing and will continue. Some of the recommended actions constitute new activities, where existing or new resources would have to be allocated to accomplish the actions. Close cooperation among NOAA Fisheries headquarters offices, ROs, FSCs, and NOAA Fisheries' management partners will be required to complete the trade-off analyses needed to inform decision-makers. This Road Map sets expectations for aiding management partners and guides the activities of NOAA Fisheries staff at a large number of offices and laboratories. For successful implementation, the connection between the actions recommended herein and the many laboratories, divisions, and branches of NOAA Fisheries is critical.

Once the Road Map is finalized, a protocol for providing national oversight among the FSCs, ROs, and headquarters offices will be developed and implemented through the EBFM

Workgroup (Goals 1.c and 6.c). The NOAA Fisheries EBFM Workgroup will be led by the National EBFM Coordinator and will include points of contact in FSC, RO, and headquarters office. Oversight for EBFM implementation will be based on best practices developed nationally and in alignment with the principles in this document. Annual updates through prioritization and milestone identification and completion will provide an evaluation of EBFM progress. This will be an evolutionary process, where progress will be based on previous accomplishments. EBFM is only achievable with broad support, and NOAA Fisheries and its many partners will benefit from implementing EBFM as described in this Road Map.

4 References

- Alaska Fisheries Science Center (AFSC, of the National Marine Fisheries Service). 2023. 2023 Eastern Bering Sea Ecosystem Status Report: In Brief. 3 p. <https://apps-afsc.fisheries.noaa.gov/REFM/docs/2023/EBSBrief.pdf>.
- Bastille, K., S. Hardison, L. deWitt, J. Brown J. Samhuri, S. Gaichas, S. Lucey, K. Kearney, B. Best, S. Cross, S. Large, and E. Spooner. 2020. Improving the IEA approach using principles of open data science. *Coastal Management*, 49(1): 72-89.
- Borggaard, D. L., D. M. Dick, J. Star, M. A. Alexander, M. Bernier, M. Collins, K. Damon-Randall, R. Dudley, R. Griffis, S. Hayes, M. Johnson, D. Kircheis, J. Kocik, B. Letcher, N. Mantua, W. Morrison, K. Nislow, V. Saba, R. Saunders, T. Sheehan, and M. Staudinger. 2019. Atlantic Salmon (*Salmo salar*) Climate Scenario Planning Pilot Report. Greater Atlantic Region Policy Series [19-05]. NOAA Fisheries Greater Atlantic Regional Fisheries Office. 89 p.
- Borggaard, D. L., D. M. Dick, J. Star, B. Zoodsma, M. A. Alexander, M. J. Asaro. L. Barre, S. Bettridge, P. Burns, J. Crocker, Q. Dortch, L. Garrison, F. Gulland, B. Haskell, S. Hayes, A. Henry, K. Hyde, H. Milliken, J. Quinlan, T. Rowles, V. Saba, M. Staudinger, and H. Walsh. 2020. North Atlantic Right Whale (*Eubalaena glacialis*) Scenario Planning Summary Report. NOAA Tech. Memo. NMFS-OPR-68, 88 p.
- Clay, P. M., J. Howard, D. S. Busch, L. L. Colburn, A. Himes-Cornell, S. Rumrill, S. Zador, and R. B. Griffis. 2020. Ocean and coastal indicators: understanding and coping with climate change at the land-sea interface. *Climatic Change*, 163(4), 1773-1793.
- Colburn, L., M. Jepson, C. Weng, T. Seara, and J. Weiss. 2016. Indicators of Climate Change and Social Vulnerability in Fishing Dependent Communities Along the Eastern and Gulf Coasts of the US. *Marine Policy* 74: 323-333.
- deReynier, Y., C. Dahl, C. Braby, G. Kirchner, R. Lincoln, T. Moore, C. Niles, C. Ridings, J. Samhuri, J. Star, S. Stohs, and J. Ugoretz. 2023. U.S. Pacific Coast Federal Fisheries Scenario Planning Summary Report. NOAA Tech. Memo. NMFS-OSF-12, 157 p.
- Ecosystem Principles Advisory Panel. 1998. Ecosystem-Based Fishery Management: A Report to Congress. Silver Spring, MD: National Marine Fisheries Service. 54 p. <https://repository.library.noaa.gov/view/noaa/23730>.
- Frens, K. and W. Morrison. 2020. Scenario Planning: An Introduction for Fishery Managers. U.S. Dept. of Commerce, NOAA. NOAA Technical Memorandum NMFS-OSF-9, 38 p. DOI : <https://doi.org/10.25923/x3jn-8h73>.
- Hamilton, S. L., V. R. Saccomanno, W. N. Heady, A. L. Gehman, S. I. Lonhart, R. Beas-Luna, F. T. Francis, L. Lee, L. Rogers-Bennett, A. K. Salomon and S. A. Grave. 2021. Disease-driven

mass mortality event leads to widespread extirpation and variable recovery potential of a marine predator across the eastern Pacific. *Proc.R.Soc.* B288: 20211195.

<https://doi.org/10.1098/rspb.2021.1195>.

Himes-Cornell, A. and S. Kasperski. 2016. Using socioeconomic and fisheries involvement indices to understand Alaska fishing community well-being. *Coastal Management*, 44(1): 36-70.

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

Jepson, M. and L. Colburn. 2013. Development of social indicators of fishing community vulnerability and resilience in the US Southeast and Northeast regions. U.S. Dept. of Commerce., NOAA Technical Memorandum NMFS-F/SPO-129, 64 p.

https://repository.library.noaa.gov/view/noaa/4438/noaa_4438_DS1.pdf.

Kaplan, I. C., S. K. Gaichas, C. C. Stawitz, P. D. Lynch, K. N. Marshall, J. J. Deroba, M. Masi, J. K. T. Brodziak, K. Y. Aydin, K. Holsman, H. Townsend, D. Tommasi, J. A. Smith, S. Koenigstein, M. Weijerman, and J. Link. 2021. Management strategy evaluation: allowing the light on the hill to illuminate more than one specie. *Frontiers in Marine Science* 8: 624355. <https://doi.org/10.3389/fmars.2021.624355>.

Levin, P. S., M. J. Fogarty, G. C. Matlock, and M. Ernst. 2008. Integrated ecosystem assessments. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-92. <https://repository.library.noaa.gov/view/noaa/3578>.

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.

<https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.1000014>.

Link, J. S. 2002a. Ecological Considerations in Fisheries Management: When Does It Matter? *Fisheries* 27(4): 10-17.

Link, J.S. 2002b. What Does Ecosystem-Based Fisheries Management Mean? *Fisheries* 27(4): 18-21.

Litzow, M., L. Ciannelli, C. Cunningham, B. Johnson, and P. Puerta. 2019. Nonstationary effects of ocean temperature on Pacific salmon productivity. *Canadian Journal of Fisheries and Aquatic Sciences*. 76(11): 1923-1928. <https://doi.org/10.1139/cjfas-2019-0120>.

Lynch, P. D., R. D. Methot, and J. S. Link (eds.). 2018. Implementing a Next Generation Stock Assessment Enterprise. An Update to the NOAA Fisheries Stock Assessment Improvement Plan. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-183, 127 p. doi: 0.7755/TMSPO.183.

Mamula, A., C. Kohler, R. Kosaka, A. Varney, and K. C. Norman. 2019. West Coast Fishing Communities Socio-Economic Data Model: technical documentation and guidelines for use. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-621. 140 p. <https://doi.org/10.25923/8g05-v821>.

Marshall, K. N., P. S. Levin, T. E. Essington, L. E. Koehn, L. G. Anderson, A. Bundy, C. Carothers, F. Coleman, L. R. Gerber, J. H. Grabowski, E. Houde, O. P. Jensen, C. Möllmann, K. Rose, J. N. Sanchirico, and A. D. M. Smith. 2018a. Ecosystem-Based Fisheries Management for Social-Ecological Systems: Renewing the Focus in the United States with Next Generation Fishery Ecosystem Plans. *Conservation Letters* 11(1). doi: 10.1111/conl.12367.

Morrison, W. E., and V. Termini. 2016. A Review of Potential Approaches for Managing Marine Fisheries in a Changing Climate. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OSF-6, 35 p.

Morrison, W., T. L. Rankin, S. A. Oakes, C. J. Harvey, S. Lucey, E. Keiley, M. Mackey, K. Abrams, and K. Osgood (editors). 2022. Investigating and Improving Applications of Ecosystem Status Reports in U.S. Fisheries Management. Report from a 2021 Workshop organized by the National Marine Fisheries Service Ecosystem-Based Fisheries Management Working Group. U.S. Dept. of Commerce., NOAA. NOAA Technical Memorandum NMFS-OSF-11, 44 p.

Morrison, W. E., Oakes, S. A., Karp, M. A., Appelman, M. H., and J. S. Link. 2024. Ecosystem-level reference points: Moving toward ecosystem-based fisheries management. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science*, 16, e10285. <https://doi.org/10.1002/mcf2.10285>.

National Academies of Sciences, Engineering, and Medicine. 2012. Disaster Resilience: A National Imperative. Washington, DC: The National Academies Press. <https://doi.org/10.17226/13457>.

National Oceanic and Atmospheric Administration. 2006. NOAA Response to: The External Review of NOAA's Ecosystem Research and Science Enterprise, A Report to the NOAA Science Advisory Board, Evolving an Ecosystem Approach to Science and Management Throughout NOAA and its Partners. Silver Spring, MD: National Marine Fisheries Service. 19 p.

National Marine Fisheries Service. 1987. Program Development Plan for Ecosystems Monitoring and Fisheries Management. Silver Spring, MD: National Marine Fisheries Service. 37 p.

National Marine Fisheries Service. 2016a. Ecosystem Based Fisheries Management Policy of the National Marine Fisheries Service, Policy 01-120. Silver Spring, MD: National Marine Fisheries Service. 8 p.

National Marine Fisheries Service. 2016b. NOAA Fisheries Ecosystem-Based Fisheries Management Road Map: Ecosystem-Based Fisheries Management Policy, 01-120. Silver Spring, MD: National Marine Fisheries Service. 50 p.

National Marine Fisheries Service. 2023a. Procedure for Addressing Climate Change in NMFS Essential Fish Habitat Consultations, Procedure 03-201-17. Silver Spring, MD: National Marine Fisheries Service. 20 p.

National Marine Fisheries Service. 2023b. Guidance for Treatment of climate Change in NMFS Endangered Species Act Decisions, Procedure 02-110-18. Silver Spring, MD: National Marine Fisheries Service. 8 p.

National Marine Fisheries Service. 2024. Ecosystem Based Fisheries Management Policy of the National Marine Fisheries Service, Policy 01-120. Silver Spring, MD: National Marine Fisheries Service. 11 p.

North Pacific Fishery Management Council (NPFMC). 2015. Bering Sea Fishery Ecosystem Plan. North Pacific Fishery Management Council, 1007 West 3rd Ave., Suite 400, L92 Building, 4th floor, Anchorage, Alaska 99501. 133 p.

Office of Science and Technology Policy (OSTP). 2023. Resilience Grand Pathways Framework: A Report by the Subcommittee on Resilience Science and Technology Committee on Homeland and National Security of the National Science and Technology Council. 18 p. <https://www.whitehouse.gov/wp-content/uploads/2023/03/Resilience-Science-and-Technology-Grand-Pathways-Framework.pdf>.

Pacific Fishery Management Council (PFMC). 2022. Pacific Coast Fishery Ecosystem Plan for the U.S. Portion of the California Current Large Marine Ecosystem (Revised and Updated). Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220-1384. 143 p.

Peters, R., A. R. Marshak, M. M. Brady, S. K. Brown, K. Osgood, C. Greene, V. Guida, M. Johnson, T. Kellison, R. McConnaughey, T. Noji, M. Parke, C. Rooper, W. Wakefield, and M. Yoklavich. 2018. Habitat Science is a Fundamental in an Ecosystem-Based Fisheries Management Framework: An Update to the Marine Fisheries Habitat Assessment Improvement Plan. U.S. Dept. of Commerce, NOAA. NOAA Technical Memorandum NMFS-F/SPO-181, 29 p.

Peterson C. D. and J. F. Walter III. 2023. Southeast Fisheries Science Center Management Strategy Evaluation Strategic Plan. NOAA Tech. Memo. NMFS-SEFSC-TM-766, 27 p. <https://doi.org/10.25923/khnf-vh41>.

Rankin, T. L., K. Frens, W. E. Morrison, S. K. Gaichas, S. G. Zador, C. Greene, K. Aydin, J. C. Reum, K. K. Holsman, and M. W. Dorn. 2023. Applications of Ecosystem Risk Assessment in

Federal Fisheries to Advance Ecosystem-Based Fisheries Management. NOAA Technical Memorandum NMFS-OHC-11, 22 p.

Schuurman, G. W., C. Hawkins Hoffman, D. N. Cole, D. J. Lawrence, J. M. Morton, D. R. Magness, A. E. Cravens, S. Covington, R. O'Malley, and N. A. Fisichelli. 2020. Resist-accept-direct (RAD)— a framework for the 21st-century natural resource manager. Natural Resource Report NPS/NRSS/CCRP/NRR—2020/ 2213. National Park Service, Fort Collins, Colorado. <https://doi.org/10.36967/nrr-2283597>.

Science Advisory Board (SAB). 2006. Evolving an Ecosystem Approach to Science and Management Throughout NOAA and its Partners: The External Review of NOAA's Ecosystem Research and Science Enterprise - A Report to the NOAA Science Advisory Board's External Ecosystem Task Team. Silver Spring, MD: National Marine Fisheries Service. 85 p. <https://sab.noaa.gov/wp-content/uploads/2021/08/eERRT-Final-Report-to-NOAA-Oct-06.pdf>.

Sherman, K. 1991. The Large Marine Ecosystem Concept: Research and Management Strategy for Living Marine Resources. *Ecological Applications*, 1(4): 350–360. <https://doi.org/10.2307/1941896>.

Slater, W. L., G. S. DePiper, J. M. Gove, C. J. Harvey, E. L. Hazen, S. M. Lucey, M. Karnauskas, S. D. Regan, E. C. Siddon, E. M. Yasumiishi, S. G. Zador, M. M. Brady, M. D. Ford, R. B. Griffis, R. L. Shuford, H. M. Townsend, T. D. O'Brien, J. O. Peterson, K. E. Osgood, and J. S. Link. 2017. Challenges, Opportunities and Future Directions to Advance NOAA Fisheries Ecosystem Status Reports (ESRs): Report of the National ESR Workshop. NOAA Technical Memorandum F/SPO-174. Washington, DC: National Oceanic and Atmospheric Administration, 66 p.

South Atlantic Fishery Management Council (SAFMC). 2009. Comprehensive Ecosystem-Based Amendment 1 for the South Atlantic Region. South Atlantic Fishery Management Council, 4055 Faber Place, Suite 201, North Charleston, South Carolina 29405. 286 p.

Spooner, E., M. Karnauskas, C. J. Harvey, C. Kelble, J. Rosellon-Druker, S. Kasperski, S. Lucey, K. Andrews, S. Gittings, J. Moss, J. Gove, J. Samhuri, R. Allee, S. Bograd, M. Monaco, P. Clay, L. Rogers, A. Marshak, S. Wongbusarakum, K. Broughton, and P. Lynch. 2021. Using integrated ecosystem assessments to build resilient ecosystems, communities, and economies. *Coastal Management*, 49(1): 26-45.

Szuwalski, C. S., K. Aydin, E. Fedewa, B. Garber-Yonts, and M. Litzow. 2023. The collapse of eastern Bering Sea snow crab. *Science* 382: 306–310.

Szymkowiak, M., and S. Kasperski. 2021. Sustaining an Alaska coastal community: integrating place based well-being indicators and fisheries participation. *Coastal Management* 49(1): 107-131.

Townsend, H., K. Aydin, S. Brodie, G. DePiper, Y. deReynier, C. Harvey, A. Haynie, E. Hazen, I Kaplan, S. Kasperski, K. Kearney, S. Large, S. Lucey, M. Masi, I. Ortiz, J. Reum, C. Stawitz, D. Tommasi, M. Weijerman, A. Whitehouse, P. Woodworth-Jefcoats, P. Lynch, K. Osgood, and J. Link (editors). 2020. Report of the 5th National Ecosystem Modeling Workshop (NEMoW 5): Progress in Ecosystem Modeling For Living Marine Resource Management. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-F/SPO-205, 72 p.

Townsend, H., C. J. Harvey, Y. deReynier, D. Davis, S. G. Zador, S. Gaichas, M. Weijerman, E. Hazen, and I. Kaplan. 2019. Progress on implementing ecosystem-based fisheries management in the United States through the use of ecosystem models and analysis. *Front. Mar. Sci.* 6: 641. doi: 10.3389/fmars.2019.00641.

Wilkinson, E. B and K. Abrams. 2015. Benchmarking the 1999 EPAP recommendations with existing Fishery Ecosystem Plans. U.S. Dept. of Commerce, NOAA. NOAA Technical Memorandum NMFS-OSF-5, 22 p.

Appendix A: EBFM Guidelines, Goals, and Action Items

This appendix lists the six Guidelines and each of their Goals provided within NOAA Fisheries' EBFM Policy, plus all of the implementing Action Items of this 2024 EBFM Road Map. These are the same Guidelines, Goals, and Action Items provided in the main body of this document, provided here for reading efficiency. In total, this Road Map contains six Guidelines, 18 Goals, and 38 Action Items in this Road Map.

Guideline 1 - Implement ecosystem-level planning

Goal 1.a: Support and provide guidance or assistance in the development and execution of FEPs, or other umbrella strategic planning documents, to describe and integrate ecosystem goals, objectives, and priorities for fisheries and ecosystem research (including climate-related), conservation, and management across multiple fisheries within an ecosystem.

Action Item 1.a.1: Assist living marine resource management partners in their development of new, or revised, ecosystem-level goals and objectives within FEPs or other ecosystem-wide strategic planning documents.

Goal 1.b: Incorporate EBFM goals and objectives, including anticipated climate impacts, into NOAA Fisheries operational and strategic planning and prioritization at all agency levels.

Action Item 1.b.1: Include and prioritize EBFM Road Map Action Items in key regional and national strategic and operational documents.

Goal 1.c: Facilitate EBFM coordination across all elements of NOAA and its partners.

Action Item 1.c.1: Establish and maintain joint staff EBFM and/or climate teams for each major U.S. management region to ensure planning and coordination across headquarters Offices, Regional Offices, and Science Centers.

Action Item 1.c.2: Develop, coordinate, and disseminate a national EBFM communication plan, including regular national reporting on progress towards EBFM Road Map Action Items.

Action Item 1.c.3: Ensure and actively facilitate ongoing dialog between NOAA Fisheries Science Centers, Regional Offices, and management partners to ensure coordinated efforts to advance EBFM.

Guideline 2 – Advance our understanding of ecosystem processes

Goal 2.a: Conduct science under a diverse suite of disciplines to understand ecosystem processes, drivers, and threats, including work from the Climate, Ecosystems, and Fisheries Initiative and other, ongoing and anticipated science innovations.

Action Item 2.a.1: Advance resources and build capacity to conduct science in support of EBFM, including through collaborative research and citizen science.

Action Item 2.a.2: Expand, develop, and maintain data streams and the production of information, and review archived data to update it where appropriate.

Action Item 2.a.3: Conduct biennial EBFM science and management workgroups and conferences.

Goal 2.b: Provide and update regular ecosystem status report updates and similar reports to ensure they inform regional decision-making processes.

Action Item 2.b.1: Provide support and information for development and review of new or updated ESRs.

Action Item 2.b.2: Include ESR support duties as a significant percentage of personnel performance plans, for a sufficient number of personnel in each Financial Management Center.

Action Item 2.b.3: Expand and coordinate regional and national efforts to develop and disseminate ecosystem indicators that support multiple decision support products and reach across Councils and other management partners.

Goal 2.c: Prioritize science in alignment with priority ecological, economic, and social objectives identified in Guideline 1 above so that a deeper understanding can better inform management advice.

Action Item 2.c.1: Identify, prioritize, research, and address key ecosystem and climate questions, as defined by EBFM and climate staff teams working internally (see Goal 1.c.1) and with external management partners and stakeholders.

Action Item 2.c.2: Assess the science needs, assets, and gaps associated with management on-ramps for bringing ecosystem science into key decision-making processes, as noted in Goals 1.a and 5.b.

Guideline 3 - Prioritize vulnerabilities and risks to ecosystems and their components

Goal 3.a: 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 changing conditions, including from biophysical and human pressures.

Action Item 3.a.1: Conduct climate vulnerability assessments (CVAs) for living marine resources, habitats, and coastal communities, identify gaps or needed updates in existing CVAs, and identify new and existing on-ramps for use in management.

Action Item 3.a.2: Conduct ecosystem-level risk assessments to identify existing and emerging stressors, opportunities, vulnerabilities, and cumulative impacts most likely to hinder our ability to meet management goals and objectives.

Goal 3.b: Identify the individual, cumulative, nonlinear, and nonstationary pressures and potential “black swan” events that pose the most risk to those vulnerable resources and dependent communities.

Action Item 3.b.1: Research and apply methodologies for identifying or predicting significant and disproportionately impactful pressures and events within managed marine ecosystems.

Action Item 3.b.2: Identify those habitats, species, and human communities that are most vulnerable to pressures and events and evaluate management mitigation measures.

Goal 3.c: Prioritize management options for mitigating risk, enhancing resilience, and improving adaptive capacity within existing decision-making processes.

Action Item 3.c.1: Identify potential improvements for existing regulatory responses to rapid within-year changes in catch rates of target species and bycatch rates of non-target and protected resources to mitigate risks.

Action Item 3.c.2: Identify where outreach to partnering agencies and affected communities with interacting authorities and interests can be initiated or strengthened and assist management partners in developing policies that address risk and uncertainty from climate and other ecosystem drivers.

Action Item 3.c.3: Develop and test management strategies, recovery strategies, and habitat restoration approaches that are robust to rapid environmental change, extreme conditions, and data uncertainties.

Guideline 4 – Explore and address trade-offs within an ecosystem

Goal 4.a: Include climate considerations explicitly in the evaluation of the dynamics and trade-offs of living marine resource management in a regional ecosystem.

Action Item 4.a.1: Conduct scenario planning to explore living marine resource and coastal community dynamics under current and future ocean conditions and to consider multiple objectives across fisheries and ocean uses.

Action Item 4.a.2: Develop and expand capacity of fisheries, habitat, protected resources, and integrated ecosystem assessments to explore ecosystem dynamics under extreme events and changing ocean conditions.

Action Item 4.a.3: Develop a framework for identifying and assessing fishing fleet behavior, including fishing location choices and changes in shoreside support sectors, to support fisheries management planning and planning for other ocean uses under climate change.

Goal 4.b: Analyze trade-offs with respect to optimizing benefits from all fisheries within each ecosystem or jurisdiction, including protected resources and habitat considerations, acknowledging all objectives may not be achievable simultaneously, by accounting for all ecosystem-specific policy goals and objectives.

Action Item 4.b.1: Develop procedures and fora to identify, evaluate, and minimize conflict within and across fisheries, habitats, protected resources recovery, and human well-being priorities at near-term and long-term time scales.

Action Item 4.b.2: Expand capacity of fisheries, habitat, protected resources, and ecosystem assessments to explore multi-species harvest, conservation, and recovery policies and guidance on setting multi-species annual catch limits.

Goal 4.c: Conduct management strategy evaluations that include ecosystem-level analyses that provide ecosystem-wide management advice and that inform harvest control rule and other management decisions, consistent with statutory requirements.

Action Item 4.c.1: Develop MSEs to assess management options to mitigate and prepare for the risks and vulnerabilities identified under Guideline 3 to meet the ecosystem goals and objectives identified under Guideline 1.

Action Item 4.c.2: Develop MSEs in collaboration with management partners that address manager and stakeholder needs and leverage existing public engagement processes.

Action Item 4.c.3: Develop and maintain capacity to conduct whole-ecosystem MSEs to test the robustness of living marine resource management plans and policies to ecosystem-scale changes.

Guideline 5 – Implement ecosystem considerations into management

Goal 5.a: Develop and monitor ecosystem-level reference points.

Action Item 5.a.1: Develop and implement best practices for identifying and estimating ELRPs for ecosystem-level biodiversity, resilience, and persistence, taking into account the potential effects of climate variability and change on marine ecosystems.

Goal 5.b: Incorporate ecosystem considerations, climate uncertainties, and an understanding of consequences and trade-offs into appropriate living marine resource management decisions as well as explore and test regulatory options to incorporate climate change, ecosystem considerations, and other related features into management decisions, advice, and options.

Action Item 5.b.1: Develop ecosystem- and climate-ready terms of reference for fish and protected resources stock assessments, habitat assessments, and ecosystem assessment analyses, reviews, and decision-making processes.

Action Item 5.b.2: Update regulatory language that provides guidance on MSA national standards, MSA and MMPA bycatch mitigation, ESA recovery planning and implementation, and EFH refinements and consultations to ensure that language addresses EBFM principles and supports climate-ready fisheries, species, and habitats.

Goal 5.c: Provide integrated advice across multiple habitats and species (both targeted and protected) within an ecosystem.

Action Item 5.c.1: Provide guidance for and examples of dynamic and flexible fisheries management measures that can respond to shifts in species' distribution and availability for all living marine resource taxa in an ecosystem.

Action Item 5.c.2: Build habitat (EFH and critical habitat) mapping and designation capacity to address the potential effects of climate change and to site, design, and implement habitat protection and priority restoration across all regions, with the goal of enhancing fish productivity and recovering protected resources.

Guideline 6 – Support ecosystem resilience via monitoring and adjusting of management actions

Goal 6.a: Evaluate ecosystem-level measures of resilience to maintain core ecosystem structure, biodiversity, production, energy flow, and functioning.

Action Item 6.a.1: Develop operational definitions, measures, and thresholds of resilience that can be used across NOAA Fisheries' range of mandates (MSA, MMPA, ESA, NEPA, Executive Orders, and others) and that can be applied to our ecosystems under a future of climate variability and change.

Goal 6.b: Evaluate coastal fishing community well-being.

Action Item 6.b.1: Develop and report on metrics for human well-being in fishing communities that address fishery benefits to the nation.

Action Item 6.b.2: Develop a framework for identifying seafood systems and seafood supplies that have been affected by fisheries and natural disasters, market forces, and more general ecosystem change, particularly identifying and including traditional seafoods and culturally important fish species and stocks.

Goal 6.c: Identify and track NOAA Fisheries-wide performance and success metrics for tracking progress toward meeting EBFM goals and objectives.

Action Item 6.c.1: Establish and report on EBFM performance measures.

Action Item 6.c.2: Review and track Action Items accomplished across NOAA Fisheries.

Appendix B: Focus Areas for EBFM Science and Management Conferences

Under this Road Map’s Action Item 2.a.3, NOAA Fisheries will continue its practice of organizing biennial EBFM science and management staff workgroups and conferences. Past NOAA Fisheries EBFM science and management conferences have addressed Moving EBFM Forward (2020) and ecosystem status reports (2021, Morrison et al. 2022). NOAA Fisheries staff also regularly work together across regions in [National Ecosystem Modeling Workshops](#). Future focus areas for EBFM science and management conferences or workgroups that could help develop ideas and actions in this Road Map include:

- Convening a working team of stock assessors and ecosystem scientists to explore relationships between environmental indices and stock abundance.
- Sharing methods for evaluating degraded habitat for its restoration needs and costs, taking into account the potential effects of climate variability and change on that habitat.
- Developing models to assess the combined effects of climate variability and long-term social and economic impacts of fishery resource depletion and recovery and protected species recovery, on ocean resource management.
- Assessing availability and developing long-term planning for food habits data collection and publication, and for using that data to update ecosystem food web models.
- Discussing how to revise stock assessment terms of reference to consider ecosystem information in keeping with the Stock Assessment Improvement Plan at Section III (Lynch et al. 2018).
- Explore ecosystem-scale and cross-regional MSEs.
- Develop a national framework for understanding potential ELRPs for ecosystem-level biodiversity, resilience, and persistence.
- Explore and report on three to five nationally applicable indicators of human well-being in fishing communities that address fishery benefits to the nation, and which can be supplemented as needed with regionally appropriate indicators of human well-being.
- Explore ecosystem “resilience,” or alternative frameworks like “persistence,” under climate change and for different regions of the country, drafting metrics of ecosystem resilience, and assessing the regional and national utility and applicability of resilience concepts under major mandates.
- A workshop to discuss the development and content of Fishery Ecosystem Plans and other strategic planning documents to provide standards and examples for integrating science products (i.e., MSEs, ELRPs, IEAs, ESRs, ESPs) into management documents.
- Some meeting(s) on shifting stocks/implications on management/tools. Information about this is changing all the time and we will continuously benefit from new examples and approaches (e.g., would be good to see changes in ocean circulation integrated in workshop about shifting stocks).
- “EBFM Toolkit” short Pop-up Workshops (e.g., half-day or one day) sharing examples of a featured science-based tool(s) that are or could be used to inform management (e.g.,

spatial-temporal models of shifting species distributions in a changing environment; climate vulnerability assessments (NE Habitat CVA (how do other regions get started?); and building community input into CVAs (how do we do this meaningfully?)). How can we use Habitat CVAs to identify those habitats that should be protected given their vulnerability? Or integrating/interpreting information from different types of CVAs (species, habitats, communities).

- Workshop focusing on ways to enhance social science within EBFM.
- A workshop in the next year that is focused on the Road Map as a whole and is basically about how we ensure it doesn't immediately start to collect dust. Matching people and assets and capabilities to particular Action Items, identifying where additional support is needed for high-value near-term Action Items, etc. This could even be focused intensively on Guideline 1; perhaps that's where impact would be greatest.
- A workshop on defining and operationalizing "flexibility," from multiple perspectives (managers, fishery participants, governance, data providers/analysts, others). Perhaps an outcome could be development of some flexibility scenarios that could be tested with a relatively simple or shovel-ready MSE framework.
- A workshop on benefits of/progress made through/getting the most out of scenario planning
- A workshop on trade-offs, based on RM Action Item 4.b.1 supporting text: "NOAA Fisheries will bring together different scientific disciplines to better identify the trade-offs made for marine ecosystems and managed resources, potentially building off of possible future trade-offs identified in the scenario planning in Action Item 4.a.1."
- On-ramps to integrate habitat and protected species information into fisheries management decisions.

Appendix C: List of Acronyms and Abbreviations

BIL	Bipartisan Infrastructure Law, or Infrastructure, Investment and Jobs Act
CEFI	Climate, Ecosystems, and Fisheries Initiative, a group of NOAA science projects managed under Inflation Reduction Act funding, see “IRA”
Council	Fishery Management Council of the United States
CVA	Climate vulnerability assessment
EBFM	Ecosystem-based fisheries management
EBM	Ecosystem-based management
EFH	Essential fish habitat
ELRP	Ecosystem-level reference point
ESA	Endangered Species Act
ESR	Ecosystem status report
FEP	Fishery ecosystem plan
FMP	Fishery management plan
FSC	Fishery Science Center (of NOAA Fisheries)
IEA	Integrated ecosystem assessment
IRA	Inflation Reduction Act, which includes temporary funds for NOAA, some of which are being used for CEFI projects
MMPA	Marine Mammal Protection Act
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSE	Management strategy evaluation
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	National Marine Fisheries Service (of NOAA)
RO	Regional Office (of NOAA Fisheries)