



NOAA
FISHERIES

NOAA Fisheries Climate Science Strategy Headquarters Action Plan Through 2024

Roger Griffis, Jay Peterson, Dori Dick, Wendy Morrison, Susan Pultz, Michelle Rub, Melissa Karp, Stephanie Oakes, Doug Lipton, Patrick Lynch, Matthew Lettrich, Shannon Bettridge, Elizabeth Chilton, and Grace Roskar



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
NOAA Technical Memorandum NMFS-F/SPO-243
May 2023

NOAA Fisheries Climate Science Strategy Headquarters Action Plan Through 2024

Roger Griffis¹, Jay Peterson¹, Dori Dick², Wendy Morrison³, Susan Pultz⁴,
Michelle Rub⁵, Melissa Karp¹, Stephanie Oakes¹, Doug Lipton¹, Patrick Lynch¹,
Matthew Lettrich^{1,6}, Shannon Bettridge², Elizabeth Chilton¹, and Grace Roskar^{1,6}

¹NOAA Fisheries, Office of Science and Technology, Silver Spring, MD 20910

²NOAA Fisheries, Office of Protected Resources, Silver Spring, MD 20910

³NOAA Fisheries, Office of Sustainable Fisheries, Silver Spring, MD 20910

⁴NOAA Fisheries, Office of Habitat Conservation, Silver Spring, MD 20910

⁵NOAA Fisheries, Office of Aquaculture, Silver Spring, MD 20910

⁶ECS Federal, LLC, Fairfax, VA 22031

**NOAA Technical Memorandum NMFS-F/SPO-243
May 2023**



U.S. Department of Commerce
Gina M. Raimondo, Secretary

National Oceanic and Atmospheric Administration
Richard W. Spinrad, NOAA Administrator

National Marine Fisheries Service
Janet Coit, Assistant Administrator for Fisheries

Recommended citation:

Griffis, Roger, Jay Peterson, Dori Dick, Wendy Morrison, Susan Pultz, Michelle Rub, Melissa Karp, Stephanie Oakes, Doug Lipton, Patrick Lynch, Matthew Lettrich, Shannon Bettridge, Elizabeth Chilton, and Grace Roskar. 2023. NOAA Fisheries Climate Science Strategy Headquarters Action Plan Through 2024. NOAA Tech. Memo. NMFS-F/SPO-243, 21 p.

Available online at:

<https://spo.nmfs.noaa.gov/tech-memos/>

Table of Contents

| | |
|---|----|
| Executive Summary | iv |
| Introduction | 1 |
| Key Goals, Actions and Metrics | 2 |
| A. Building and Maintaining Science Infrastructure and Tracking Change (NCSS Objectives 6 & 7) | 4 |
| Table A. Actions and Metrics to address Building and Maintaining Science Infrastructure and Tracking Change | 6 |
| B. Understanding Mechanisms and Projecting Future Conditions (NCSS Objectives 4 & 5) | 9 |
| Table B: Actions and Metrics to address Understanding Mechanisms and Projecting Future Conditions | 10 |
| C. Informing and Supporting Management (NCSS Objectives 1 - 3) | 13 |
| Table C. Actions and Metrics to address Informing and Supporting Management | 14 |
| Conclusion | 20 |
| Acknowledgements | 20 |
| References | 21 |

Executive Summary

Changing climate and oceans are having significant impacts on the nation's valuable marine ecosystems and the many people, communities, and economies that depend upon them. Warming oceans, loss of sea ice, rising seas, extreme events, and acidification are impacting the structure of marine and coastal ecosystems, and the distribution and abundance of species in many regions. These socio-ecological impacts are expected to increase and there is much at risk.

To prepare for and respond to climate impacts on marine and coastal resources, the 2015 NOAA Fisheries Climate Science Strategy (NCSS) identified seven key objectives to increase the production, delivery, and use of climate-related information needed to fulfill the agency's mandates (e.g., fisheries management, protected resources conservation) in a changing climate.

NOAA Fisheries is working with many domestic and international partners to prepare for and respond to climate-related changes in marine and coastal ecosystems. This includes specific efforts at regional and local levels to increase the production, delivery, and use of climate-related information in living marine resource management as called for in the NCSS.

This Headquarters Action Plan identifies key goals and actions by NOAA Fisheries Headquarters Offices to implement the NCSS through 2024. The goals and actions support nationwide and regional efforts identified in Regional Action Plans (RAPs). These activities are part of NOAA's effort to build a climate ready nation.

The following is a summary of current or planned actions organized under the objectives of the NCSS.

Build and Maintain Science Infrastructure and Track Change (NCSS Objectives 6, 7)

- Maintain a nationally coordinated group of regional climate teams to provide cross-agency coordination, support, and execution of climate-related activities within and across regions.
- Monitor and track climate-related changes in the distribution, abundance, and productivity of key marine species and their habitats.
- Expand ecosystem indicator systems in all regions to track, communicate, and provide early warning of climate-related changes.
- Provide a modern data acquisition and management system to support the agency's requirements for easy discovery, access, and use of information on changing ecosystems.
- Expand engagement with international partners to increase the capacity to understand and track climate-related changes in marine and coastal ecosystems.

Understand Mechanisms and Project Future Conditions (NCSS Objectives 4, 5)

- Conduct climate vulnerability assessments of living marine resources, habitats, and resource-dependent communities for use in decision-making.
- Better understand the response of ecosystems, living marine resources, and socio-economic systems to changing climate and ocean conditions.

- Provide robust forecasts and projections of future ocean, resource, and ecosystem conditions to support risk assessments and evaluation of effective management strategies for changing conditions.

Inform and Support Management (NCSS Objectives 1-3)

- Increase the use of scenario planning to describe multiple plausible future scenarios and identify strategies to prepare for and respond to climate-driven changes.
- Assess risks and evaluate effective management strategies for current and future conditions.
- Provide ideas and options for management approaches that are flexible and robust to changing conditions.
- Increase capacity to integrate climate change into management decisions.
- Increase consideration of ecosystem, environmental, and socioeconomic drivers in the stock assessment and management process.
- Develop information and tools to support fishing community adaptation planning in the face of changing climate and ocean conditions.

Introduction

Climate change is significantly impacting the Nation’s valuable marine ecosystems and the many people, communities, and economies that depend upon them (Pershing et al., 2018). Warming oceans, rising seas, decreasing ocean ice, changing currents, increasing ocean acidification and increasing extreme events (e.g., marine heatwaves, storms, precipitation) are affecting the distribution and productivity of marine and coastal species in many regions. These changes impact nearly every aspect of the National Oceanographic and Atmospheric Administration National Marine Fisheries Service (NOAA Fisheries) mission, from fisheries management and aquaculture to conservation of protected resources and vital habitats (Link et al., 2015). And there is much at risk. For example, fisheries support over 1.7 million jobs and \$350 billion in economic activity in the U.S. every year¹, fishing communities may be especially vulnerable to impacts of climate change², and coastal habitats provide vital services including protecting coastal communities from storms, floods and erosion. Action is needed now to reduce risks, increase resilience, and adapt to rapidly changing climate and ocean conditions.

Reducing the impacts of changing climate and ocean conditions on living marine resources and resource-dependent communities is contingent upon both mitigating the causes of climate change (e.g., reducing greenhouse gases) and adapting to the impacts of climate change (responding to effects of climate change)³. As part of NOAA’s efforts to support a climate ready nation⁴, NOAA Fisheries is working to: (1) mitigate climate change by reducing its carbon footprint including reducing emissions from facilities and ships (DOC, 2021) and (2) understand, prepare for, and adapt to current and anticipated impacts of changing climate and ocean conditions on living marine resources. This Headquarters Action Plan identifies some of the goals and actions proposed by NOAA Fisheries Headquarters Offices to help mitigate and adapt to climate change through implementation of the NOAA Fisheries Climate Science Strategy (NCSS).

The NCSS calls for increasing the production, delivery, and use of climate-related information to fulfill agency mandates (Link et al., 2015) and outlines seven integrated objectives to understand, prepare for, and respond to climate change impacts on the nation’s living marine resources

¹ Fisheries Economics of the United States. [Available at <https://www.fisheries.noaa.gov/national/sustainable-fisheries/fisheries-economics-united-states>]

² Social Indicators for Fishing Communities. [Available at <https://www.fisheries.noaa.gov/national/socioeconomics/social-indicators-coastal-communities>]

³ In this document we use the following definitions from the [US National Climate Assessment](#): Mitigation refers to actions that reduce the amount and speed of future climate change by reducing emissions of greenhouse gases (GHGs) or removing carbon dioxide from the atmosphere. Adaptation refers to adjustments in natural or human systems in response to a new or changing environment that exploit beneficial opportunities or moderate negative effects.

⁴ NOAA FY22-26 Strategic Plan: Building a Climate Ready Nation. [Available at <https://www.noaa.gov/organization/budget-finance-performance/value-to-society/noaa-fy22-26-strategic-plan>]

(Figure 1). Since 2016, the NCSS has been implemented through Regional Action Plans (RAPs)⁵ that identify specific actions from a variety of programs and in collaboration with many partners in each region. The RAPs are designed to account for region-specific needs and capabilities and increase collaboration, coordination and effectiveness of NOAA Fisheries efforts to advance resilience and adaptation to a changing climate.

In 2020, NOAA Fisheries assessed progress in implementation of the NCSS over the preceding five years. The resulting five-year progress report (Peterson et al., 2021) highlights accomplishments, gaps, and the continued need for improved science, advice, and decision support to respond effectively to changing climate and ocean conditions. While good progress has been made toward achieving some of the NCSS objectives, much remains to be done.

This Headquarters Action Plan (Plan) identifies key goals and actions proposed by NOAA Fisheries Headquarters Offices to help advance the NCSS. The Plan is not intended to be comprehensive, and highlights proposed actions of the Office of Science and Technology (ST), Office of Sustainable Fisheries (SF), Office of Protected Resources (PR), Office of Habitat Conservation (HC), Office of Aquaculture (AQ), and a variety of associated programs such as the NOAA Integrated Ecosystem Assessment Program and the Economics and Human Dimensions Research Program⁶ that help advance Ecosystem-Based Fisheries Management (EBFM). The Plan also identifies performance metrics for many of the actions to help track progress toward implementing the NCSS at regional and national levels, while recognizing that accomplishing the goals and actions is contingent upon availability of resources and agency priorities. The actions and metrics identified herein were developed through input from a variety of sources including the NCSS five-year progress report (Peterson et al., 2021) and public input received in 2021 on how to make fisheries and protected resources more resilient to climate change pursuant to Executive Order 14008, Section 216(c) (Cucuzza et al. 2021; see public input at footnoted link⁷). These activities are part of NOAA's effort to build a climate ready nation.

Key Goals, Actions, and Metrics

NOAA Fisheries is responsible for stewardship of the nation's valuable living marine resources through science-based decision-making focused on fisheries management, protected resources conservation, and habitat protection. There is high and growing demand for climate-related information in fulfilling these mandates, and the NCSS and other recent documents (e.g., Karp et

⁵ Climate Science Strategy Regional Action Plans. [Available at <https://www.fisheries.noaa.gov/national/climate/climate-science-strategy-regional-action-plans>]

⁶ The Human Integrated Ecosystem Based Fishery Management Strategy 2021-2025 calls for many of the climate actions identified in this document.

⁷ Give Us Your Input on Making Fisheries and Protected Resources More Resilient to Climate Change. [Available at <https://www.fisheries.noaa.gov/feature-story/give-us-your-input-making-fisheries-and-protected-resources-more-resilient-climate>]

al., 2018; Lynch et al., 2018) identify objectives and actions to address needs across the science to management process.

This Plan identifies goals and actions of NOAA Fisheries Headquarters Offices to address the seven objectives of the NCSS. The seven NCSS objectives are grouped into the three categories listed below and in Figure 1:

- A. Building and Maintaining Science Infrastructure and Tracking Change (NCSS Objectives 6 & 7).
- B. Understanding Mechanisms and Projecting Future Conditions (NCSS Objectives 4 & 5).
- C. Informing and Supporting Management (NCSS Objectives 1-3)

The proposed goals and actions to address each category are listed below in the following tables and include performance metrics to assess progress towards achieving the goals. For planning purposes, the actions were identified using funding levels in the FY23 NOAA budget request, but implementation of this Plan is contingent upon available resources and agency priorities.

For each category, Offices also identified areas of particular need where further progress could be made if additional resources were available. Those actions are listed below each table and will be considered in the planning process contingent on resource availability.

Climate Science Objectives

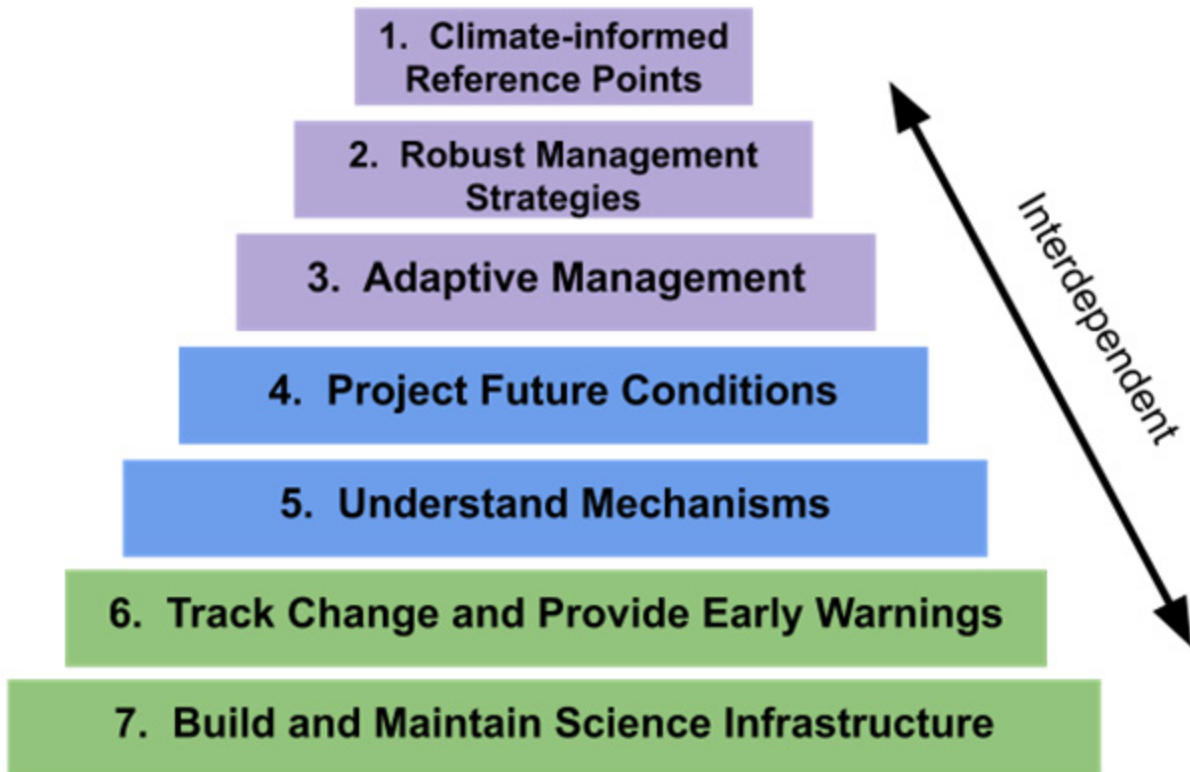


Figure 1. The seven main objectives of the NOAA Fisheries Climate Science Strategy (Link et al. 2015). The colors indicate the grouping of objectives into the three categories described in this document: (A) Building and Maintaining Science Infrastructure and Tracking Change, (B) Understanding Mechanisms and Projecting Future Conditions, and (C) Informing and Supporting Management.

A. Building and Maintaining Science Infrastructure and Tracking Change (NCSS Objectives 6 & 7)

The capacity to understand and respond to changing climate and ocean conditions depends on having a strong science infrastructure that can effectively collect, analyze, model, and deliver the products and services needed for climate-informed decision-making. This includes having sufficient observational capabilities to consistently collect and analyze ecosystem data and deliver information on ecosystem status and trends to decision-makers. This section identifies key goals, proposed actions, and performance metrics for strengthening the agency's climate-related science enterprise and improving the detection, tracking, and reporting of climate-related changes in marine and coastal ecosystems.

Key Goals

- Maintain a nationally coordinated group of regional climate teams to provide cross-agency coordination, support, and execution of climate-related activities within and across regions.
- Monitor and track climate-related changes in the distribution, abundance, and productivity of key marine species and their habitats.
- Expand ecosystem indicator systems in all regions to track, communicate, and provide early warning of climate-related changes.
- Provide a modern data acquisition and management system to support the agency's requirements for easy discovery, access, and use of information on changing ecosystems.
- Expand engagement with international partners to increase the capacity to understand and track climate-related changes in marine and coastal ecosystems.

Table A. Actions and Metrics to address Building and Maintaining Science Infrastructure and Tracking Change (NCSS Objectives 6 & 7)

| NCSS Objective | Key Goal | Proposed Actions | NOAA Fisheries office(s) (leads) | Metric |
|----------------|---|---|----------------------------------|---|
| 6, 7 | Maintain a nationally coordinated group of regional climate teams to provide cross-agency coordination, support, and execution of climate-related activities within and across regions. | Conduct quarterly meetings with regional climate teams to discuss climate-related activities, strengthen cross-regional communication and collaboration, and provide a forum to discuss challenges and solutions. | ST | Quarterly meetings are conducted throughout 2022-2024. |
| 6, 7 | Monitor and track climate-related changes in the distribution, abundance, and productivity of key marine species and their habitats. | Maintain fishery-independent surveys and fishery dependent sources of information on living marine resources and their habitats to track changes in distribution and abundance. | ST, PR | Data are made available to NMFS scientists for use in tracking change. |
| | | Complete observations of coral reef fish, habitat, and climate parameters in American Samoa, the Pacific Remote Island Areas, Puerto Rico, and U.S. Virgin Islands to assess health and track shifts related to climate change. | HC | Fish, benthic, and climate data are collected in 2023 and archived no later than 2024. |
| | | Continue collecting and processing, with the NOS-OCM Coastal Change Analysis Program, more detailed (1 m pixel vs 30 m pixel) maps of land cover change in areas undergoing rapid change | HC | Maps of Puget Sound and Tampa Bay are completed by 2024. |
| | | Coordinate effort to collect and collate data regarding fish health for wild marine species. | AQ | Data available to inform forecasting tools for potential exposure to disease outbreaks in cultured species. |

| NCSS Objective | Key Goal | Proposed Actions | NOAA Fisheries office(s) (leads) | Metric |
|----------------|---|--|----------------------------------|---|
| | | Coordinate efforts to collect and collate environmental and biological data on aquaculture farms in real time, for use in informing future siting, species selection, farm practices, and forecasting tools (disease, extreme events, etc.) for cultured species. | AQ | Establish data collection system |
| 6, 7 | Expand ecosystem indicator systems in all regions to track, communicate, and provide early warning of climate-related changes. | Support the development of stock-specific indicators and status reports - Support regional development of Ecosystem and Socioeconomic Profiles (ESPs) or similar products that provide information on the performance and outlook of specific stocks using ecosystem status and other information. | ST, SF, HC | Facilitate regional engagement and capacity to develop ESPs through workshops or other instructional venues. |
| | | Maintain and improve Ecosystem Status Reports (ESRs) - Provide support for the development, maintenance, and delivery of regularly updated ESRs in each of the regions. Promote communication of ESR information to Councils and other stakeholders in each region on a regular basis. | ST, SF, PR, HC | Ecosystem Status Reports and are completed in all regions by 2023 and presented to Councils or primary stakeholders. |
| 6, 7 | Provide a modern data acquisition and management system to support the agency's requirements for easy discovery, access, and use of information on changing ecosystems. | Develop and apply modern data management services to integrate and deliver climate information for science and decision-making. | ST | Number of climate data sets collected, integrated, or disseminated via Fisheries applications, tools, or data dissemination outlets to better serve scientists and decision makers by 2024. |
| | | Complete a NMFS Data Acquisition Plan for next generation observation and data management system. | ST | Initial draft is developed and delivered to NMFS for review and consideration by 2024. |

| NCSS Objective | Key Goal | Proposed Actions | NOAA Fisheries office(s) (leads) | Metric |
|----------------|--|--|----------------------------------|---|
| | | Develop a Distribution Mapping and Analysis Portal (DisMAP) to provide users with the ability to dynamically track and understand past and projected future distributions of marine species. | ST, SF | An initial Version 1.0 of DisMAP is completed for public release in early calendar year 2022. |
| 6, 7 | Expand engagement with international partners to increase the capacity to understand and track climate-related changes in marine and coastal ecosystems. | Continue partnership with Fisheries and Oceans Canada (DFO) to share and make available as part of DisMAP information on the distribution of marine species in Canadian waters for use in understanding and tracking changes in species distributions across shared marine ecosystems. | ST | Incorporation of species distribution information from DFO into DisMAP. |
| | | Produce Climate-Aware Advice for fisheries and aquaculture in collaboration with international partners. | AQ | Develop a report from the ICES WKCLIMAD workshop by December 2022. |
| | | | AQ | Convene a session at the 5th Effects of Climate Change on the World's Oceans Symposium in 2023. |

Additional actions as resources become available

Offices identified areas of particular need where additional progress could be made if resources were available. A selection of actions are listed below for consideration during resource utilization planning processes.

- Support development and implementation of new and existing products that build off of Ecosystem Status Reports and advance the implementation of Ecosystem-Based Fisheries Management. [ST, SF]
- Expand surveys/observations of protected species to assess shifting distributions and abundances and changes to critical habitat. [PR]
- Expand fishery-independent surveys to assess causes and impacts of shifting distributions and productivity. [ST]
- Implement long-term monitoring of protected species to better understand climate change-related impacts and effectiveness of our actions. [PR]
- Identify potential protected species and other living marine resources indicators/triggers and thresholds (tipping points). [PR, ST]
- Utilize electronic technologies to expand monitoring capabilities, including better detection of shifting distributions and changing productivity. [ST, PR]

B. Understanding Mechanisms and Projecting Future Conditions (NCSS Objectives 4 & 5)

Understanding “why,” “how,” and “when” changing climate and ocean conditions affect living marine resources and resource dependent communities provides the basis for assessing future vulnerabilities, evaluating risks, and identifying adaptation options. Understanding mechanisms of climate impacts is also critical to developing robust near-term forecasts and longer-term projections of future ocean ecosystem conditions, and to evaluating effective management strategies for future conditions.

Key Goals

- Conduct climate vulnerability assessments of living marine resources, habitats, and resource-dependent communities for use in decision-making.
- Better understand the response of ecosystems, living marine resources, and socio-economic systems to changing climate and ocean conditions.
- Provide robust forecasts and projections of future ocean, resource, and ecosystem conditions to support risk assessments and evaluation of effective management strategies for changing conditions.

Table B: Actions and Metrics to address Understanding Mechanisms and Projecting Future Conditions (NCSS Objectives 4 & 5)

| NCSS Objective | Key Goal | Proposed Action(s) | NOAA Fisheries office(s) (leads) | Metric |
|----------------|---|--|----------------------------------|---|
| 4, 5 | Conduct climate vulnerability assessments (CVAs) of living marine resources, habitats, and resource-dependent communities for use in decision-making. | Support completion and publication of fish and invertebrate CVAs. | SF, ST | Atlantic HMS CVA is launched in FY23. |
| | | Complete marine mammal CVAs for Atlantic/Gulf of Mexico/Caribbean and Pacific/Arctic. | ST, PR | Marine mammal CVAs for the Atlantic/Gulf of Mexico/Caribbean and the Pacific/Arctic are completed and submitted for publication in 2022. |
| | | Complete a sea turtle CVA. | ST, PR | Sea turtle CVA is completed and submitted for publication in 2022. |
| | | Complete habitat CVAs. | ST, HC | Northeast Habitat CVA is completed and published in 2022. Plan for at least one additional regional Habitat CVA. |
| | | Complete community CVAs. | ST | Initiate a community CVA by 2024. |
| 4, 5 | Better understand the response of ecosystems, living marine resources, and socio-economic systems to changing climate and ocean conditions. | Support external competitive research through the NOAA Climate and Fisheries Adaptation (CAFA) Program, in collaboration with the NOAA Climate Program Office, to promote sustainable management, adaptation, and resilience of the nation's valuable fish stocks and fisheries-dependent communities in a changing climate. | ST | New CAFA Program projects for 2023-2025 are launched, and Communities of Practice are developed to connect investigator teams and provide a mechanism to share information, lessons learned, and solutions developed across the regions and projects. |
| | | Support external competitive research to advance forecasts and projections of changing ocean ecosystems for use in living marine resource management (collaboration with the NOAA Climate Program Office). | ST | New joint OAR-NMFS research projects are launched in 2022-2024 to advance marine forecasts and projections to inform living marine resource management. |

| NCSS Objective | Key Goal | Proposed Action(s) | NOAA Fisheries office(s) (leads) | Metric |
|----------------|---|--|----------------------------------|---|
| | | Lead planning and implementation of the Sustainability, Predictability, and Resilience of Marine Ecosystems (SUPREME) Program to help advance climate-ready ecosystem management under the UN Decade of Ocean Science. | ST | The SUPREME collaboration network is established by 2023. |
| | | Develop the Fisheries Integrated Modeling System (FIMS) to better connect stock assessments with ecosystem, climate, and socioeconomic data and models. | ST | A pilot study application of FIMS to a single population in each region will be complete by 2024. |
| | | Complete report on how projected climate change is likely to impact marine aquaculture and how industry can adapt to these changes and help mitigate the causes of climate change. | AQ | Final report titled “Climate Smart Approach to Aquaculture: Risks and Opportunities for US Aquaculture Management in a Changing Climate” is released to the public in 2022 or early 2023. |
| | | Participate in the NOAA-wide task force on carbon dioxide removal to prepare an agency-wide research strategy that examines how carbon dioxide removal intersects with NOAA’s mission and consider how to address knowledge gaps within these methods. | AQ | A final research strategy is anticipated to be available to the public for comment in the fall of 2022. |
| 4,5 | Provide robust forecasts and projections of future ocean, resource, and ecosystem ocean conditions to support risk assessments and evaluation of effective management strategies for changing conditions. | Develop regional Decision Support Systems that work with existing programs to deliver climate informed science and management advice as part of the NOAA Climate, Ecosystems, and Fisheries Initiative (CEFI). | ST | Decision Support Teams are established and operational by 2024 as part of the CEFI. |

Additional actions as resources become available

Offices also identified areas of particular need where additional progress could be made if resources were available. A selection of actions are listed below for consideration during resource utilization planning processes.

- Support development of a marine heatwave early warning system. [ST]
- Expand and enhance ocean modeling and decision support systems. [ST]
- Support development of initial forecasts and projections for changes (e.g. in distribution, abundance, productivity) in protected species populations and fish stocks due to changing ecosystems. [PR, ST]
- Assess the effects of vessel strikes on climate vulnerable protected species, particularly where shipping traffic is likely to increase due to loss of sea ice or as a result of species shifting into new areas due to climate-related changes. [PR]
- Assess the effects of changing fishing patterns and prey availability for climate vulnerable overfished and protected species. [PR, SF]
- Understand causes of, and develop early warning system(s) for, protected species major health events such as disease, strandings, die offs, etc., and improve our ability to attribute mortality to climate-related changes when applicable. [PR]
- Support development of an early warning system for disease, invasive species migrations, HABs, heat waves, acidification, extreme coastal storm events, etc. for aquaculture seed and production operations [AQ]

C. Informing and Supporting Management (NCSS Objectives 1-3)

Ultimately, the NOAA Fisheries science enterprise generates data, tools, information, and advice that resource managers and other decision-makers rely on for effective decision-making. Effective management of living marine resources in a changing climate will require increased coordination and responsiveness of both science and management to changing (and perhaps unexpected) conditions. Integration of climate science into the management process may necessitate some changes on both the delivery and receiving ends to ensure the effectiveness of the information. For example, robust strategies for managing living marine resources under climate change may require regular short-term updates based on indicator and performance tracking, as well as more rigorous management strategy evaluations that employ fully coupled sets of system models. The goals and actions listed below are focused on developing, delivering, and using information and advice for climate-informed living marine resource management.

Key Goals

- Increase the use of scenario planning to describe multiple plausible future scenarios and identify strategies to prepare for and respond to climate-driven changes.
- Assess risks and evaluate effective management strategies for current and future conditions.
- Provide ideas and options for management approaches that are flexible and robust to changing conditions.
- Increase capacity to integrate climate change into management decisions.
- Increase consideration of ecosystem, environmental, and socioeconomic drivers in the stock assessment and management process (see Lynch et al., 2018).
- Develop information and tools to support fishing community adaptation planning in the face of changing climate and ocean conditions.

Table C. Actions and Metrics to address Informing and Supporting Management (NCSS Objectives 1-3)

| NCSS Objective | Key Goal | Proposed Action(s) | NOAA Fisheries office(s) involved | Metric |
|----------------|--|--|-----------------------------------|---|
| 1, 3 | Increase the use of scenario planning to describe multiple plausible future scenarios and identify ways to prepare for and respond to potential ecosystem changes. | Support efforts to conduct regional scenario planning related to fisheries management and habitat conservation. | ST, SF, HC | Scenario planning efforts for fisheries management are completed in two regions by 2023. |
| | | Conduct scenario planning efforts for protected species vulnerable to climate change. | PR | Two climate scenario planning efforts for protected species that are vulnerable to climate change are completed by 2024. |
| | | Assess needs and options to increase NMFS capacity to use scenario planning. | ST, PR, SF | Conduct needs assessment and identify options including training. |
| | | Track and support follow-on projects identified in Council-led scenario planning initiatives. | SF, ST, PR | Prioritize follow-on projects from scenario planning initiatives for funding by 2022. |
| 1, 3 | Assess risks and evaluate effective management strategies for current and future conditions. | Develop Decision Support Systems in each region to assess risks and evaluate performance of different management strategies under changing conditions. | ST | Pilot Decision Support Systems established in at least 2 regions by 2024. |
| | | Include risk assessments in a “science to advice” process for aquaculture-related NEPA documents. | AQ | Science teams deliver a first round of advice products by March 2023. Primary objective is to provide support for expansion of marine aquaculture within the context of climate change. |
| | | Develop capacity to conduct aquaculture risk assessments. | AQ | Aquaculture risk assessment specialist position filled at the NE Fisheries Science Center and an annotated bibliography of risk methods and applications delivered by March 2023. |

| NCSS Objective | Key Goal | Proposed Action(s) | NOAA Fisheries office(s) involved | Metric |
|--|---|---|-----------------------------------|---|
| 1, 3 | Provide ideas and options for creating management approaches that are flexible and robust to changing conditions. | Communicate climate work being done by Councils and NMFS via national-level webpage that highlights national and regional NMFS climate actions and success stories. | SF, ST | Develop a webpage to communicate examples of approaches. |
| | | Illustrate the utility of ecological risk assessments (ERA) and how Councils can systematically approach ERA to help address current challenges and advance EBFM. | HC, SF | Publish report outlining regional case studies of ERAs and how to apply in the council process. |
| | | Explore the development and implementation of ecosystem level reference points (ELRPs) in fisheries management. | SF, ST | Publish paper on the development and implementation of ELRPs in fisheries management. |
| | | Develop policy outlining criteria and process for updating governance of federally managed fisheries. | SF | Policy on adapting governance to a changing climate completed by 2024. |
| | | Support science, intervention, and restoration actions to enhance coastal habitat and species resilience to climate change. | HC | Fund annual Ruth Gates restoration grant competition to encourage innovative techniques to enhance climate resilience of coral reefs. |
| Fund Transformational Habitat Restoration and Coastal Resilience Grants and Coastal Habitat Restoration and Resilience Grants for Underserved Communities under the Bipartisan Infrastructure Law. | | | | |
| Support large-scale oyster restoration in Chesapeake Bay with the seeding of reef in the Manokin River (MD) and construction of reef in Mobjack Bay (VA). | | | | |

| NCSS Objective | Key Goal | Proposed Action(s) | NOAA Fisheries office(s) involved | Metric |
|----------------|--|--|-----------------------------------|---|
| | | Investigate how restoration aquaculture can be used to enhance coastal resilience and carbon sequestration. | AQ | Inform managers and stakeholders on practices and strategies for adapting to and improving future conditions. |
| 1, 3 | Build capacity to integrate climate-related information into management decisions. | Complete Procedure for addressing Climate Change in NMFS EFH Consultations. | HC | Procedure is completed by 2023. |
| | | Conduct a workshop on compensatory mitigation in dynamic environments and develop a best practices manual. | HC | Workshop is completed in 2023, and a Best Practices manual is drafted following the workshop. |
| | | Conduct training for hydropower biologists and engineers that incorporates scenario planning and other climate change considerations as an element. | HC | In-person training for hydropower specialists is completed in 2023. |
| | | Identify and develop new training materials to improve consistent inclusion of climate-related information and impacts in Endangered Species Act (ESA) and Marine Mammal Protection Act related actions. | PR | Review existing materials and identify gaps and needs by 2024. |
| | | Implement marine and coastal climate-smart conservation training. | PR | Conduct 2 training sessions in 2023. |
| | | Assessing Review and update, if needed, existing climate-smart conservation training for target audiences. | ST, SF, HC, PR, AQ | Complete needs assessment and make recommendations. |
| | | Develop climate-relevant guidance(s) for inclusion of climate change in PR management. | PR | Complete revision of National ESA Climate Guidance, Section 7 Climate Change Framework, and Recovery Planning Climate Change Framework by 2024. |
| | | Produce a resource guide that describes management challenges and implications of adjusting biological reference points to account for a productivity shift. | SF, ST | A draft resource guide for updating reference points in a changing climate is completed by 2024. |
| | | Implement Recovery Planning Climate Change Framework. | PR | Climate-related information is incorporated into new recovery plans. |

| NCSS Objective | Key Goal | Proposed Action(s) | NOAA Fisheries office(s) involved | Metric |
|-----------------------|---|--|--|---|
| 1, 3 | Increase consideration of ecosystem, environmental, and socioeconomic drivers in the stock assessment and resource management process (see Lynch et al., 2018). | Implement a new tab in the Fisheries Species Information System to collect and track information related to how ecosystem variability and climate impacts are considered and taken into account in NOAA Fisheries stock assessments. | ST | Number or proportion of stock assessments that account for ecosystem/environmental variability by 2024. |
| 1, 3 | Promote fishing community adaptation in the face of changing climate and ocean conditions. | Develop information and tools to support fishing community adaptation planning in the face of changing climate and ocean conditions. | ST | Hold at least one expert workshop on developing information and tools to support fishing community adaptation planning. |

Additional actions as resources become available

Offices also identified areas of particular need where additional progress could be made if resources were available. A selection of actions are listed below for consideration during resource utilization planning processes.

- Support the development of management strategy evaluations. [ST, SF]
- Implement recovery and conservation actions for climate vulnerable protected species to reduce the impacts of bycatch, vessel strikes, prey availability or quality, and habitat destruction or modification. [PR]
- Investigate existing fisheries permit systems and options for making them more flexible and responsive to changes in species targeted and locations caught and landed. [SF]
- Publish white paper outlining actions Councils can take to manage emerging fisheries under the existing MSA. [SF]
- Conduct an analysis of how existing tools (such as scenario planning and climate vulnerability assessments) can be used to support climate informed management. Includes clarifying when, where and how the tools can be used individually or in combination to support living marine resource management. [SF, others?].
- Implement a climate summit (similar to recreational summit) to get new ideas from stakeholders on addressing climate challenges across science, fisheries, habitat, protected resources, aquaculture, and wind.
- Expand funding and technical support for new scenario planning efforts nation-wide and develop targeted training to fulfill capacity needs.

Conclusion

NOAA Fisheries is committed to increasing the production, delivery, and use of climate-related information to help sustain the Nation’s valuable marine resources and the diverse people, businesses, and communities that depend on them. NOAA Fisheries Headquarters Offices play a key role in supporting nation-wide and regional efforts. This Plan identifies some key actions for NOAA Fisheries Headquarters Offices and partners to undertake through 2024 to help fulfill that commitment by addressing the objectives of the NCSS. This includes both the continuation of existing efforts, such as utilizing Ecosystem Status Reports to track ecosystem conditions, and the development of important new efforts such as the NOAA Climate, Ecosystems, and Fisheries Initiative that will provide an end-to-end modeling and decision support system to increase delivery and use of climate-informed management advice. Many of these actions also include working with internal and/or external partners who are critical to the success of these efforts.

While these proposed actions are important steps toward fulfilling the objectives of the NCSS, we recognize that additional efforts will be needed to ensure climate-informed living marine resource management in the face of changing climate and ocean conditions.

Acknowledgements

This document was made possible by the NOAA Fisheries staff and partners working to understand, prepare for and respond to the impacts of climate change on the agency’s mission. Special thanks to Marina Cucuzza, Frank Schwing, Rita Curtis, and Alan Haynie for their input and guidance. This document further benefited from the leadership, review, and input from many others at NOAA Fisheries Headquarters Offices including Kenric Osgood, Karen Abrams, and other members of the NOAA Fisheries Inter-office Climate Action Team (NICAT).

References

Cucuzza, M. L., H. L. Sagar, and R. B. Griffis. 2021. Synthesis of Public Comments to NOAA on Executive Order 14008, Tackling the Climate Crisis at Home and Abroad, Section 216(c): Recommendations on How to Make Fisheries and Protected Resources, Including Aquaculture, More Resilient to Climate Change. NOAA Tech. Memo. NMFS-F/SPO-218, 79 p. Available at <https://spo.nmfs.noaa.gov/sites/default/files/TM218.pdf>

DOC. 2021. Department of Commerce 2021 Climate Action Plan for Adaptation and Resilience. Office of the Federal Chief Sustainability Officer. 20 p. Available at <https://www.sustainability.gov/pdfs/doc-2021-cap.pdf>

Karp, M. A., J. O. Peterson, P. D. Lynch, and R. B. Griffis (eds.). 2018. Accounting for Shifting Distributions and Changing Productivity in the Fishery Management Process: From Detection to Management Action. NOAA Tech. Memo. NMFS-F/SPO-188, 37 p. Available at <https://spo.nmfs.noaa.gov/sites/default/files/TMSPO188.pdf>

Link, J. S., R. Griffis, and S. Busch (eds.). 2015. NOAA Fisheries Climate Science Strategy. NOAA Tech. Memo. NMFS-F/SPO-155, 70 p. Available at <https://spo.nmfs.noaa.gov/sites/default/files/TM155.pdf>

Lynch, P. D., R. D. Methot Jr., and J. S. Link (eds.). 2018. Implementing a Next Generation Stock Assessment Enterprise. An update to the NOAA Fisheries Stock Assessment Improvement Plan. NOAA Tech. Memo. NMFS-F/SPO-183, 127 p. Available at <https://spo.nmfs.noaa.gov/sites/default/files/TMSPO183.pdf>

Pershing, A.J., R. B. Griffis, E. B. Jewett, C. T. Armstrong, J. F. Bruno, D. S. Busch, A. C. Haynie, S. A. Siedlecki, and D. Tommasi. 2018. Oceans and Marine Resources. *In* Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II (D. R. Reidmiller, C. W. Avery, D. R. Easterling, K. E. Kunkel, K. L. M. Lewis, T. K. Maycock, and B.C. Stewart, eds.), p. 353–390. U.S. Global Change Research Program, Washington, DC. <https://doi.org/10.7930/NCA4.2018.CH9>

Peterson, J., R. Griffis, P. Woodworth-Jefcoats, A. Jacobs, A. Hollowed, E. Farley, J. Duffy-Anderson, M. Dorn, T. Hurst, J. Moss, L. Rogers, K. Shotwell, T. Garfield, R. Zabel, Y. deReynier, E. Shott, L. Crozier, S. Bograd, N. Mantua, J. Samhouri, J. Quinlan, K. Gore, R. Muñoz, J. Leo, L. Waters, M. Burton, V. Saba, D. Borggaard, M. Ferguson, and W. Morrison. 2021. NOAA Fisheries Climate Science Strategy Five Year Progress Report. NOAA Tech. Memo. NMFS-F/SPO-228, 157 p. Available at https://spo.nmfs.noaa.gov/sites/default/files/TMSPO228_0.pdf