NOAA FISHERIES

NOAA Fisheries Climate Science Strategy

Highlights

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U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Office of Science & Technology

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FOREWORD

For some people, climate change is just a theoretical possibility. But ask fishermen, and many will tell you that climate-related changes in marine and coastal ecosystems are well underway.

Along the Atlantic Coast, many species of commercially valuable species of fish are moving north or deeper to stay within their preferred temperature range. In 2012, lobsters in the Gulf of Maine, spurred by high temperatures, started their summer migration a month early and grew to market size faster than usual. The result was a saturated market and a price collapse for Maine lobstermen. From shrinking Arctic sea ice to west coast droughts, bleaching corals and rising seas, our world is changing and we need to respond.

Similar changes are happening all along our coasts, and these changes could significantly impact people, businesses, communities and the nation. Many coastal communities depend on fishing and tourism, and climate-related changes are projected to affect jobs, impact economies and disrupt traditional ways of life.

The challenges aren't limited to sustaining the nation's fisheries. Climate change affects every aspect of the NOAA Fisheries mission. Climate change and the associated problem of ocean acidification are increasing the vulnerability of protected species, from seals and whales to sea turtles and salmon. These dual stressors are also impacting habitats from coastal rivers to estuaries and ocean waters. And nowhere is the challenge of simultaneously using and protecting marine ecosystems so starkly revealed as in the relatively pristine but fast-changing Arctic ecosystems.

The oceans are dynamic systems. That's why striking the right balance between use and protection of marine and coastal resources has always been a complicated process, whether its setting fishing levels, reducing by-catch, designating critical habitat, or considering permits for oil and gas exploration. Incorporating climate change into decision-making makes these efforts more challenging than ever before. Increased information, tools and action are essential to meeting these challenges.

This NOAA Fisheries Climate Science Strategy (Strategy) was developed to meet the growing demand for information to better prepare for and respond to climate-related impacts on the nation's living marine resources and resource-dependent communities. The Strategy is part of a proactive approach to increase the production, delivery and use of climate-related information to fulfill NOAA Fisheries mandates in a changing climate. Meeting these needs will help reduce impacts and increase the resilience of our valuable living marine resources, and the people, businesses and communities that depend on them.

Eileen Sobeck, Assistant Administrator
National Marine Fisheries Service

EXECUTIVE SUMMARY

Oceans and coasts are among the nation's most treasured and valuable resources. From fish and fisheries to whales, sea turtles, coral reefs and oysters, these living marine resources (LMRs) are at risk from a variety of impacts including a changing climate. Climate-related changes in ocean and coastal ecosystems such as warming oceans, rising seas, ocean acidification, and coastal droughts are impacting these resources and the many people, businesses and communities that depend on them.

These changes are expected to increase with continued changes in the planet's climate and ocean systems affecting jobs, impacting economies and disrupting traditional ways of life. There is much at risk. For example, ocean related fisheries generate approximately $200 billion in sales and support 1.7 million jobs nationally each year. Coastal habitats help defend coastal communities from storms and inundation, and provide the foundation for tourism and recreation in many coastal communities. These current and possible future climate-related changes also affect NOAA's ability to fulfill its stewardship mandates for marine resources and the communities that depend on them.

Given the pace and scope of climate-related changes in marine and coastal ecosystems, the National Marine Fisheries Service (NOAA Fisheries) needs additional information, tools and actions to fulfill its mission to sustain LMRs and their ecosystems for the benefit of the nation. NOAA Fisheries and other decision-makers need better information on what is changing, what is at risk and what actions to take to prepare for and respond to changing climate and ocean conditions. Addressing these needs will help NOAA Fisheries, partners and affected communities take action to reduce impacts and increase resilience.

The goal of this NOAA Fisheries Climate Science Strategy (Strategy) is to increase the production, delivery, and use of climate-related information required to fulfill NOAA Fisheries mandates. Although the information needed to understand, prepare for, and respond to climate change impacts on LMRs is diverse, this Strategy identifies seven common objectives to efficiently and effectively meet these information requirements. The seven objectives are:

Objective 1: Identify appropriate, climate-informed reference points for managing LMRs.

Objective 2: Identify robust strategies for managing LMRs under changing climate conditions.

Objective 3: Design adaptive decision processes that can incorporate and respond to changing climate conditions.

Objective 4: Identify future states of marine, coastal, and freshwater ecosystems, LMRs, and LMR-dependent human communities in a changing climate.

Objective 5: Identify the mechanisms of climate impacts on ecosystems, LMRs, and LMR-dependent human communities.

Objective 6: Track trends in ecosystems, LMRs, and LMR-dependent human communities and provide early warning of change.

Objective 7: Build and maintain the science infrastructure needed to fulfill NOAA Fisheries mandates under changing climate conditions.

The Strategy provides a nationally consistent blue-print to guide efforts by NOAA Fisheries and partners to address the seven science objectives. The Strategy is designed to be customized and implemented through Regional Action Plans that focus on building regional capacity, partners, products and services to address the seven objectives listed above. In 2015-16, NOAA Fisheries and partners will develop Regional Action Plans that identify strengths, weaknesses, priorities and actions to implement the Strategy in each Region over the next 3-5 years.

The Strategy also identifies a series of immediate and near-term cross-cutting actions that address urgent common challenges across the objectives and that will produce high returns on investment across multiple regions and mandates. The immediate actions are:

1. Conduct climate vulnerability analyses in each region for all LMRs to better understand what is at risk and why.
2. Establish and strengthen ecosystem indicators and status reports in all regions to better track, prepare for and respond to climate-driven changes.
3. Develop capacity to conduct management strategy evaluations regarding climate change impacts on management targets, priorities, and goals.

The recommended near-term actions are:

1. Strengthen climate-related science capacity regionally and nationally to fulfill NOAA Fisheries information requirements in a changing climate.
2. Develop RAPs to customize and execute this Strategy in each region over the next 3 to 5 years, through NOAA Fisheries regional Science Centers, Regional Offices and many partners.
3. Ensure that adequate resources are dedicated to climate-related, process-oriented research to better understand how climate impacts LMRs, how to reduce impacts and how to increase resilience of LMRs and LMR-dependent communities.
4. Establish standard, climate-smart terms of reference to apply to all of NOAA Fisheries LMR management, environmental compliance requirements, and other processes that cross multiple mandates and core policy areas.

Implementing the Strategy is crucial for the effective fulfillment of NOAA Fisheries mission and mandates in a changing climate. By increasing the production, delivery, and use of climate-related information, NOAA Fisheries and partners will help reduce impacts and increase the resilience of the nation's valuable living marine resources and the communities that depend on them in a changing climate.

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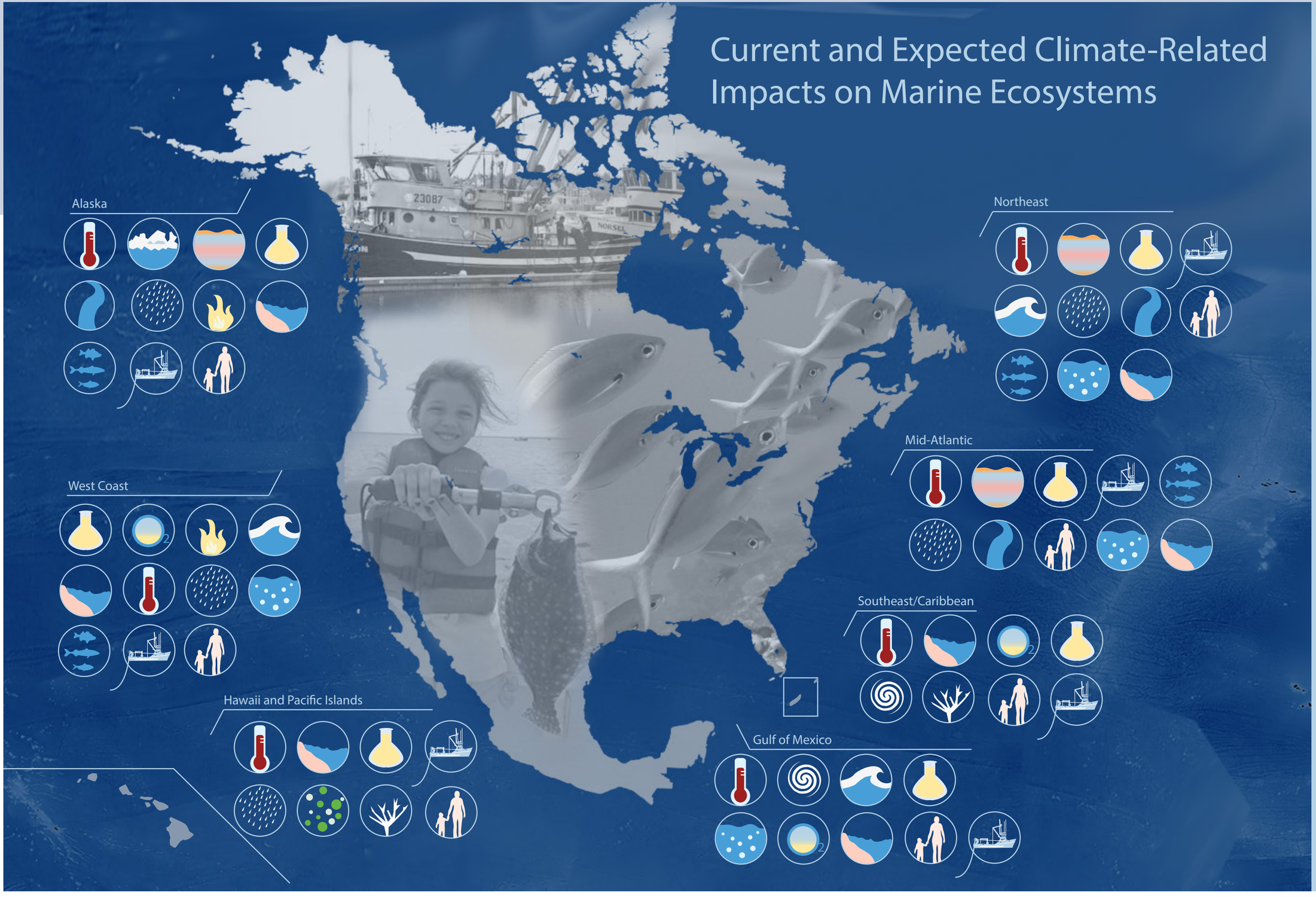
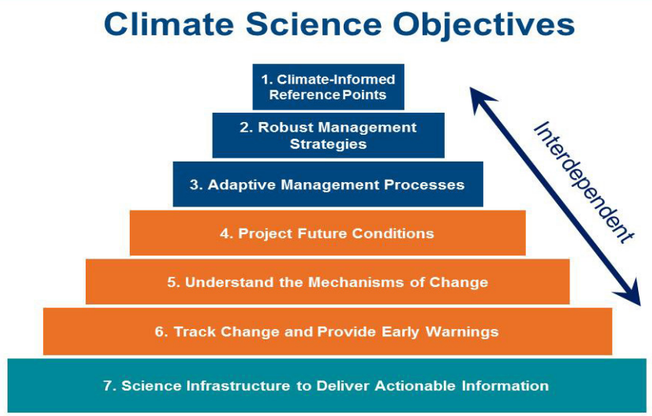
Current and Expected Climate-Related Impacts on Marine Ecosystems



NOAA FISHERIES CLIMATE SCIENCE STRATEGY

The NOAA Fisheries Climate Science Strategy (Strategy) is part of a proactive approach to increase the production, delivery, and use of climate-related information required to fulfill NOAA Fisheries mandates in a changing climate, including the Magnuson-Stevens Act, Endangered Species Act, Marine Mammal Protection Act, National Environmental Policy Act and others.



The Strategy responds to growing demands and directives to prepare for and respond to climate impacts on marine and coastal resources, such as the National Fish Wildlife and Plants Climate Adaptation Strategy (http://wildlifeadaptationstrategy.gov/), Executive Order 13653 (Preparing the Nation for the Impacts of Changing Climate), and the Priority Agenda For Enhancing the Climate Resilience of America's Natural Resources (https://www.whitehouse.gov/administration/eop/ceq/initiatives/resilience).

NOAA Fisheries and partners conduct a variety of science activities (e.g., monitoring, research, modeling and assessments) to inform and fulfill the agency's mission to sustain living marine resources and their ecosystems for the benefit of the nation. Up-to-date information is essential for effective management of living marine resources, especially with the pace, scale and scope of climate-related changes in marine and coastal ecosystems. The agency works with a wide variety of science partners to fulfill these needs, and these partners have critical roles to play in helping implement this Strategy.

This Strategy identifies seven priority science objectives needed to inform and fulfill NOAA Fisheries mandates in a changing climate. It provides a nationally consistent blueprint for building the science enterprise needed to support climate-ready fisheries management and protected species conservation. And while the information and tools needed to prepare for and respond to climate change impacts on marine resources and resource-dependent communities are diverse, the Strategy's seven objectives provide an efficient and effective way to address common information requirements across multiple NOAA Fisheries mandates.

The Strategy recommends specific actions and approaches to address each of the seven objectives. It also identifies a series of immediate and near-term cross-cutting actions that address urgent common challenges across the objectives (see next section). Implementing these actions will produce high returns on investment across multiple regions and mandates.

This Strategy is a key part of NOAA Fisheries efforts to increase the resilience of living marine resources and the people, businesses, communities and economies that depend on them in a changing climate.

SEVEN SCIENCE OBJECTIVES

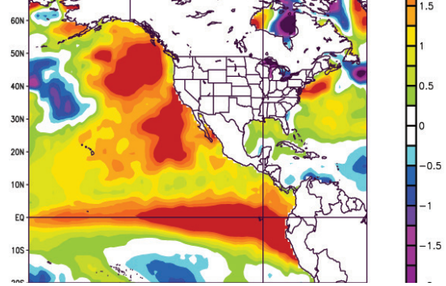
Objective 1: Identify appropriate, climate-informed reference points for managing living marine resources.

Reference points are the thresholds upon which living marine resource management decisions are made. Determining how climate-related effects should be incorporated into these reference points is critical to advancing climate-ready living marine resource management. As fish stocks, protected species, habitats, aquaculture, and ecosystems respond to climate change, the reference points for these species, systems, and human uses may need to change to reflect those different conditions. Existing efforts concerning these reference points has already indicated the need to bolster climate-related information in their development and use.

Most current assessments and reference points assume that future natural variability will reflect the range of conditions observed in the past. Such reference points often do not account for the fact that ecosystems and the living marine resources in them will change with the directional forcing of climate change, so that the past may not be a good predictor of future conditions. Stock assessments, biological reference points, and resource management plans based on these assessments may not adequately capture the future population dynamics in a changing ocean. Additional science is needed to ensure that reference points, assessments and living marine resource management plans (e.g., Fishery Management Plans, Fishery Ecosystem Plans, Species Recovery Plans, etc.) explicitly include climate-related considerations and consider the consequences of neglecting climate change in establishing biological reference points. Strategies to bolster and better deliver climate-smart reference points include identifying ecosystem-based reference points that incorporate climate change and ecosystem information and modifying existing biological reference points that do not.

Objective 2: Identify robust strategies for managing living marine resources under changing climate conditions.

There is an urgent need to identify and evaluate alternative management strategies under different climate and ocean scenarios to assist managers with choosing the best possible actions for meeting management goals in a changing climate. The best management practices for living marine resources today may not be the best management practices in the future with changing climate and ocean conditions.



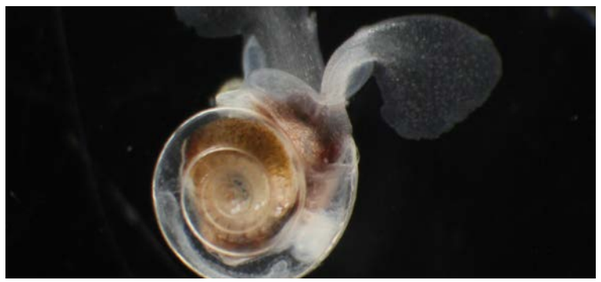
Various ecosystem, socio-economic, and living marine resource models can be coupled with scenarios of climate change to test the performance of current and alternate management practices under future conditions. These Management Strategy Evaluations are key tools to help design and evaluate management options and adaptive management strategies for living marine resources. Management Strategy Evaluations can help identify management options that are robust to a wide range of predicted future conditions. They can also identify protection and mitigation measures, harvest control rules, and related management options to more effectively meet management goals across a suite of living marine resources or systems.

Objective 3: Design adaptive decision processes that can incorporate and respond to changing climate conditions.

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. Adaptive decision processes that can incorporate, track and respond to climate-related information and as well as the

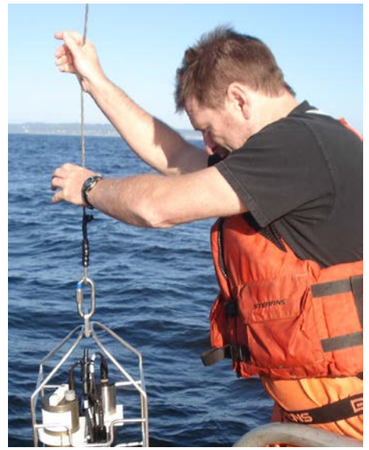
results of management actions will be essential for meeting management goals for fisheries and protected species. Effective production, delivery and use of scientific advice for management decisions can be as important as the management advice itself. Integration of climate science into the management process may necessitate some changes on both the delivery and receiving ends to ensure effective receipt and use of the information. For example, robust strategies for managing living marine resources under climate change may require both regular updates in the short term based on performance tracking, and the periodic evaluation against rigorous management strategy evaluations that employ fully coupled sets of system models. The primary output of this objective will be enhanced scientific support and management processes that use information in adaptive, responsive and flexible ways over near and longer time-frames. A key step is adoption of climate-smart science and management processes that identify where best to incorporate climate-related information in the management process, use climate-related information to assess risks and best management options, and effectively evaluate and respond to changing conditions.

Objective 4: Identify future states of marine, coastal, and freshwater ecosystems, living marine resources, and resource-dependent human communities in a changing climate.



There is a tremendous need for improved near-term forecasts and longer-term projections of future ecosystem states to help living marine resource managers and users prepare for and respond to changing conditions. How will changing climate affect marine and coastal ecosystems in each region? How will these changes affect the abundance and distribution of living marine resources? And how will these changes affect resource-dependent businesses, communities and economies? Forward-looking management of living marine resources depends on robust estimates of future conditions over seasonal, inter-annual and multi-decadal time-scales. Modeling the impacts of changing climate thru physical, chemical, and biological parts of marine and coastal ecosystems is a major challenge. Projecting the impacts on of these changes on people, businesses and communities is a second major challenge. Investment in robust, model-based projections of the effects of climate change on marine and coastal ecosystems from physics and chemistry thru biological resources and human communities can provide useful scenarios to help identify what's at risk and possible solutions to reduce impacts and increase resilience in a changing climate. An essential foundation for these efforts is development of operational forecasts and projections of climate impacts on regional ocean conditions.

Objective 5: Identify the mechanisms of climate effects on ecosystems, living marine resources, and resource-dependent human communities.



Information on how and why a changing climate is likely to affect living marine resources and resource-dependent human communities provides the foundation for better forecasts and projections of future impacts, and better strategies to reduce impacts and increase resilience. There is an urgent need for research to provide this information on how and why marine and coastal resources, and resource-dependent communities, are affected by changing climate and ocean conditions. This includes information on what species may be most vulnerable to climate change and what actions may be most effective in reducing impacts and increasing resilience of living marine resources and the communities that depend on them.

Objective 6: Track trends in ecosystems, living marine resources, and resource-dependent human communities and provide early warning of change.

Tracking the status and trends climate-impacts on marine and coastal ecosystems is essential to providing early warnings and developing effective responses. NOAA Fisheries has excelled at producing data-based assessments of the status and trends of living marine resources for science-based management. Some of these assessments

explicitly incorporate climate-related information, but many gaps remain in the agency's ability to track and provide early warnings of changes in marine and coastal ecosystem conditions. Significant improvements in tracking and reporting on ecosystem conditions (e.g., ecosystem status reports and outlooks) are needed to provide resource managers and users with the information they need to prepare for and respond to climate-related changes. Significant efforts are also needed to develop and provide early warnings of rapid change in these systems. Development of physical, biological, and socio-economic indicators for tracking trends and providing early warnings is a key step.

Ecosystem status reports, warnings and outlooks should be implemented in all regions to ensure regular delivery and use of this information by managers and stakeholders.

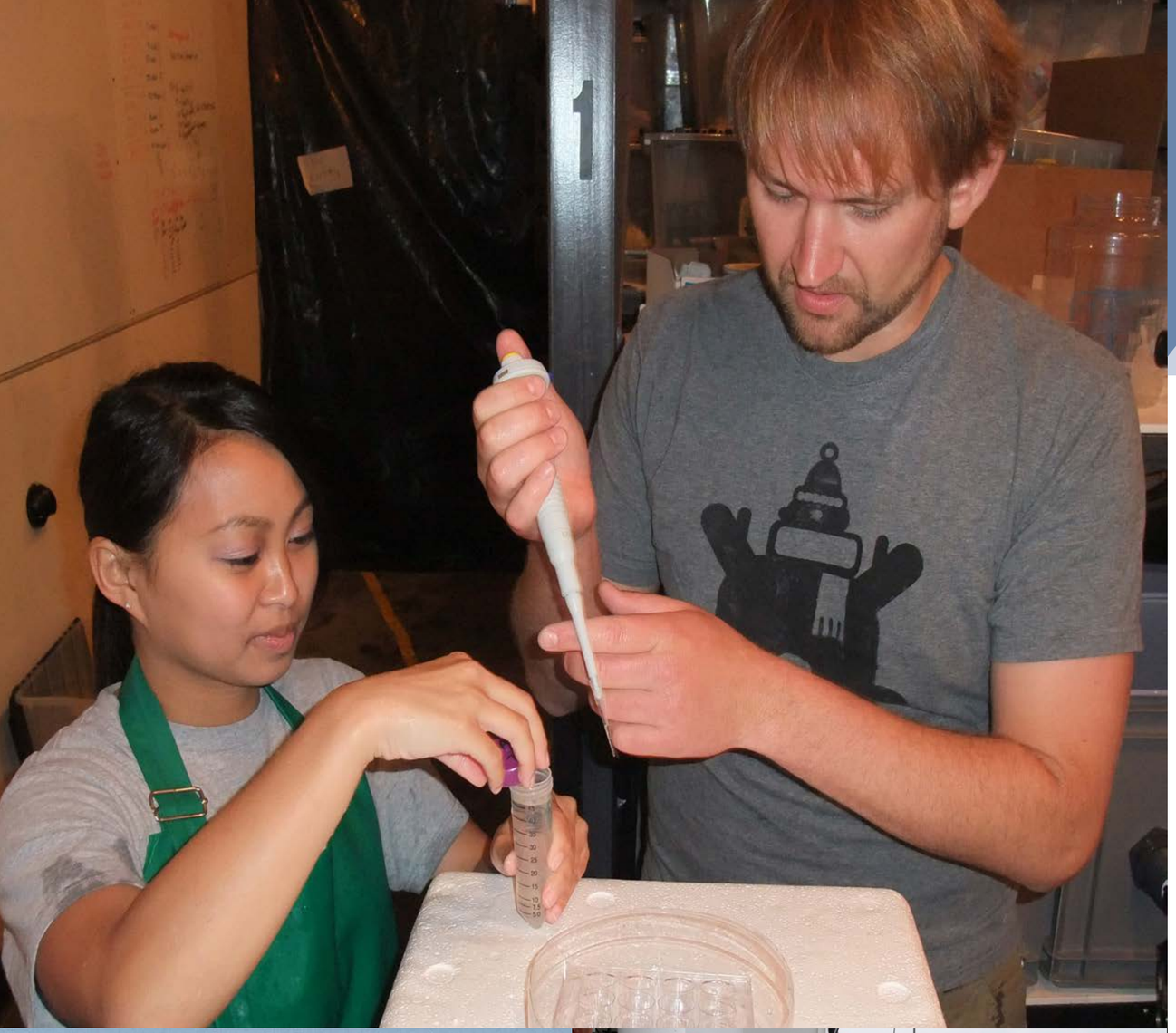
Objective 7: Build and maintain the science infrastructure needed to fulfill NOAA Fisheries mandates under changing climate conditions.

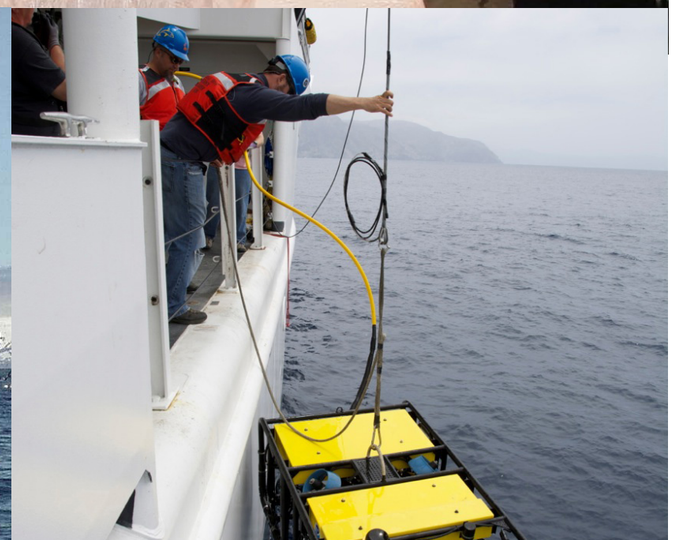
Development and implementation of the science enterprise described in this Strategy will require a robust science infrastructure including ships, bouys and satellites to track conditions and provide early warnings, mega-computers to forecast impacts of changing climate marine ecosystems and fisheries, laboratories to study the impacts of climate change and ocean acidification and scientists to produce and deliver the needed information. To succeed in implementing the Strategy, NOAA Fisheries will need to maximize and expand on its existing science infrastructure. The developing next generation observation technologies to help track and provide early warnings of climate impacts on marine and coastal ecosystems is a key step in fulfilling this objective.

PRIORITY ACTIONS:

The NOAA Fisheries Climate Science Strategy identifies a series of priority near-term actions that address urgent common needs across the seven science objectives. These actions will produce high returns on investment and meet urgent needs across mandates and regions. These actions are listed below:

1. Conduct climate vulnerability assessments on major living marine resources in each region.
2. Produce ecosystem and socio-economic indicators and status reports to track climate-related impacts in all regions.
3. Increase the capacity to conduct management strategy evaluations that incorporate climate-related information.
4. Strengthen climate-related science capacity within each region and nationwide.
5. Develop Regional Action Plans to customize and implement the Strategy in each region over the next 3 – 5 years.
6. Increase resources for process research to better understand the mechanisms of climate impacts on living marine resources.
7. Establish climate-smart terms of reference to increase the delivery and use of climate-related information in all NOAA Fisheries mission areas.





TAKING ACTION - REGIONAL ACTION PLANS

The Strategy provides a national framework designed to be customized and implemented in each region through NOAA Fisheries Science Centers, Regional Offices, programs and their partners. While some impacts of climate change on LMRs are shared across regions, each region has a unique combination of climate-related challenges, capabilities, and information needs that will need to be addressed in implementing the Strategy.

To meet these needs, NOAA Fisheries will continue existing efforts and work with partners to develop Regional Action Plans (RAPs) to identify strengths, weaknesses, priorities, and actions to implement the Strategy in each Region over the next 5 years.

The RAPs will focus on building regional capacity, products, and services to address the seven Objectives. They will be based on regional information needs and existing strengths, weaknesses, opportunities, and challenges to address them. The RAPs are designed to efficiently harness existing work, identify information gaps and tangible solutions to address them, and increase the capacity of the NOAA Fisheries regional science enterprise (including partners) to produce and deliver the information called for in the Strategy.

While budget realities and other factors will affect overall implementation of the Strategy, RAPS are expected to identify and guide implementation efforts in each region through a variety of means, including adjustments to existing programs/budgets and initiation of additional efforts with new resources.

For more information on NOAA Fisheries existing climate science activities, partnership opportunities, implementation of the Strategy and the RAPs please visit http://www.st.nmfs.noaa.gov/ecosystems/climate/.

SUMMARY

Climate-related changes in ocean and coastal ecosystems such as warming oceans, rising seas, ocean acidification, and coastal droughts are impacting the nation's valuable living marine resources and the many people, businesses and communities that depend on them. These changes are expected to increase with continued changes in the planet's climate system affecting jobs, impacting economies and disrupting traditional ways of life.

There is much at risk. Marine and coastal fisheries generate approximately $200 billion in sales and support 1.7 million jobs nationally each year. Coastal habitats help defend coastal communities from storms and inundation, and provide the foundation for tourism and recreation in many coastal communities.

NOAA Fisheries and other decision-makers need better information on what is changing, what is at risk and what actions will help reduce impacts and increase resilience in a changing climate. The Strategy responds to high and growing demands and directives to prepare for and respond to climate impacts on marine and coastal resources.

The NOAA Fisheries Climate Science Strategy (Strategy) is part of a proactive approach to increase the production, delivery, and use of climate-related information required to fulfill NOAA Fisheries mandates. The Strategy identifies seven common objectives to efficiently and effectively meet these information requirements and support climate-ready conservation and management of living marine resources.

The Strategy is designed to be customized and implemented through Regional Action Plans that focus on building regional capacity, partners, products and services to address the seven objectives. In 2015-16, NOAA Fisheries and partners will develop Regional Action Plans that identify strengths, weaknesses, priorities and actions to implement the Strategy in each Region over the next 3-5 years.

Implementing the Strategy is crucial for the effective fulfillment of NOAA Fisheries mission and mandates in a changing climate. By increasing the production, delivery, and use of climate-related information, NOAA Fisheries and partners will help reduce impacts and increase the resilience of the nation's valuable living marine resources and the communities that depend on them.

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For more information as well as the entire document, please visit
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