

Resiliency and Adaptation to Climate Change and Ocean Acidification Strategic Action Plan Full Content Outline

Objective: Strengthen resiliency of coastal communities and marine and Great Lakes environments and their abilities to adapt to climate change impacts and ocean acidification.

I. Overview of the Priority Objective

- Research, observations, and modeling needed to forecast regional and local scale climate change impacts and related vulnerabilities for natural resources, health, infrastructure, and livelihoods, including social and economic impacts.
- Better integration of ocean and coastal science into the broader climate dialogue and measures to improve understanding of the connections among land, water, air, ice, and human activities.
- Evaluation of potential social and economic costs related to sea-level rise, such as accelerating erosion, increased saltwater intrusion, and more severe coastal and inland flooding.
- Adaptive actions to identify climate change impacts and related vulnerabilities, such as ocean acidification, and the development of ecological and economic resilience strategies and priorities for research and monitoring to address these strategies.
- Changes to local and regional ocean and lake management systems that incorporate changing climate risks and elements of resilient systems.
- A comprehensive approach to understanding human health implications of policies for the ocean, our coasts, and Great Lakes, and for identifying opportunities for the protection and enhancement of human health.

II. Context and Continuity

- The National Ocean Policy calls for better understanding of the ocean, coastal and Great Lakes environments and the changes happening there.
- Strategies to act on this recommendation should be developed and implemented to reduce vulnerability, increase resilience, and improve the adaptation of systems to climate change impacts.
- This Strategic Action Plan includes a set of interdependent actions that will yield better understanding of, preparation for, and response to the impacts of climate change and ocean acidification impacts on communities and ecosystems. The Plan includes a coordinated approach of gathering observations, conducting foundational and interdisciplinary research to enhance understanding of the impacts of climate change and ocean acidification, developing improved models and forecasts at appropriate geographic and temporal scales, and conducting vulnerability assessments of human and natural systems. These advances will serve as a platform for the provision of accessible, timely, useful, and relevant science to inform and support the implementation of adaptation actions.
- This Strategic Action Plan outline was prepared in coordination with other strategies, plans, and assessments addressing climate change adaptation that are available, currently under preparation or nearing completion, including the National Fish, Wildlife, and Plants Climate Adaptation Strategy;

National Climate Assessment; the Freshwater National Action Plan called for by the Interagency Climate Change Adaptation Task Force; and U.S. Global Change Research Program Strategic Plan.

III. Body of the Plan

A. Action 1 – Improve understanding of the impacts of climate change and ocean acidification.

Advance scientific understanding of the impacts of climate change and ocean acidification on ocean, coastal and Great Lakes ecosystems and communities to provide an information basis for forecasting, vulnerability assessments, and adaptation efforts.

1. Why Do This

- Preparing for and responding to the impacts of climate change and ocean acidification requires improved understanding of the scale, scope and intensity of these impacts on the Nation's valuable ocean and coastal ecosystems and the communities that depend on them.
- This action will provide the information needed for improved forecasts of changes in ecological, economic, and social systems due to climate change and ocean acidification.
- An integrated research agenda, including physical, natural, and social sciences, will address critical gaps in understanding and build a foundation for the development of models, tools, and services that support the needs of decision makers at all levels.
- This action will also advance understanding and decrease the uncertainties surrounding the physical, chemical and biological impacts of climate change and ocean acidification and how humans would prepare for and respond to those changes.
- This action supports and extends Action 1 in the Inform Decisions and Improve Understanding SAP.

2. Timeframe – Long-term

3. Outcomes

- Improved scientific knowledge of the scale and scope of impacts from climate change and ocean acidification on coastal and ocean ecosystems to support the implementation of actions that strengthen resiliency of ocean and coastal ecosystems and communities.

4. Milestones

- Conduct strategic research on the response of key species to multiple stressors (e.g. pH, temperature, and nutrients) in ocean and coastal ecosystems.
- Improve understanding of how changes at the organismal level for key species will alter ecosystem structure and function using techniques such as evolutionary genetics, and laboratory, field, and mesocosm experiments on single and multi-species assemblages.
- Improve understanding and valuation of the impacts of climate change and ocean acidification on ecosystem services (e.g., fisheries, storm protection) and the communities/economies that depend on them.

- Develop integrated (e.g., coupled natural and human system) research projects on regional ecosystem responses to climate change and ocean acidification impacts, including thermal and pH change, alterations in oceanic circulation patterns, variations in precipitation and freshwater input, and biogeographic range shifts.
- Integrate social, cultural, behavioral, and economic sciences into studies and models of climate change and ocean acidification impacts.
- Conduct research that assesses the roles and relative importance of coastal habitats in carbon storage and sequestration to increase the ability to incorporate these valuable ecological services into restoration, management, adaptation and mitigation efforts.

5. Gaps and Needs in Science and Technology

- Understanding of potential for physiological acclimation and evolutionary adaptation, with emphasis on ecologically and economically important organisms.
- Expanded implementation of alkalinity as a tracer and incorporation of particulate inorganic carbon (PIC) and remineralization formulations in the biogeochemistry ocean general circulation model (BOGCM).

B. Action 2 – Forecast the impacts of climate change and ocean acidification at decision-relevant scales.

Forecast the impacts of climate change and ocean acidification on ocean, coastal, and Great Lakes ecosystems and communities at temporal and spatial scales relevant for use in vulnerability assessments, adaptation planning, and decision-making.

1. Why Do This

- The planning and management communities have identified a need for valid points of reference when preparing for future conditions and decisions are often made at state to local levels.
- As current knowledge of climate change impacts is assimilated, and new knowledge is being produced, the ability to predict the future state of the ocean, our coasts, and the Great Lakes as they respond to the effects of climate change is becoming even more necessary to support planning and management
- Projections are urgently needed to plan and conduct vulnerability assessments, to inform adaptation efforts, and to avoid maladaptive activities.
- No single, reliable information broker is consistently meeting the demand, and the existing patchwork quilt of data, information, and services is inefficient and impedes a coordinated, ecosystem-based approach.
- The federal government can fill an urgent need by assembling the best science from federal agencies and the greater research community into best projections of what changes to expect at different spatial scales in the coming decades.
- These projections must be maintained through regular updates and recalibrated as new science and observations provide greater clarity; in addition, they must be disseminated to practitioners through an integrated framework of climate information and services.

2. Timeframe – Long-term

3. Outcomes

- For the upcoming 15, 30, 60 and 100 years, develop a “best” storyline for how the future will likely vary from historical/present conditions through projected impacts to:
 - Physical/chemical oceanography (e.g. temperature, salinity, and pH change, changes to currents and circulation patterns, wave climate, tidal range).
 - Geomorphology (e.g., shoreline erosion/progradation, tidal wetlands).
 - Hydroclimatology (e.g., variations in the timing of precipitation and freshwater input, storm frequency).
 - Biology and ecology (e.g. ocean and coastal biological resources, species composition, habitat shifts, potential for invasions).
 - Human and social systems (e.g. hazards, jobs, infrastructure, communities, cultural resources).
 - Coupled natural and human systems.
- Projected regional changes in relative sea-level and Great Lakes water levels.

4. Milestones

- Synthesize literature and compile existing data and models to provide the initial set of projections.
- Coordinate modeling and projections with the National Climate Assessment.
- Continue development of the Earth System Prediction Capability (NEON, IOOS, GEOSS, etc.) with respect to development of a fully coupled ocean observation, data assimilation, and modeling capability for the ocean, our coasts, and the Great Lakes.

5. Gaps and Needs in Science and Technology

- Better, more integrated scientific data and information to support the development of forecasts and projections.
- Federal capacity for maintaining, updating, disseminating and archiving model code and results to support management and decision making.

C. Action 3 – Strengthen and integrate observations from the Nation’s existing array of protected areas, research sites and observing systems into a coordinated framework of “sentinel sites and systems” to provide information critical for improved forecasts, vulnerability assessments, and adaptation strategies.

Strengthening and integrating observational and monitoring networks from the Nation’s existing array of protected areas (e.g., National Marine Sanctuaries, National Estuarine Research Reserves, National Estuary Program, coastal National Wildlife Refuges, coastal National Parks), research sites (e.g., coastal NEON, Long-Term Ecological Research sites, OceanSITES) and observing systems (e.g., IOOS, HAB and pathogen warning systems, NOAA fisheries and protected species stock assessments, NOAA Coral Reef Monitoring Network) into a coordinated set of “sentinel sites and systems” is a highly efficient and effective way to provide managers and communities with the information they need about how coastal and ocean conditions and resources are changing over time.

1. Why Do This

- To effectively prepare for and respond to increasing risks and impacts, managers and stakeholders need credible and consistent information on how ecosystems are being impacted now and are likely to be in the future in order to develop, implement, evaluate, and adjust management efforts over time.
- Linking and enhancing existing observations at protected areas and other key locations are efficient and effective ways to meet these needs.
- This action will advance a coordinated set of “sentinel sites and systems” that deliver information on past and current conditions, early warnings of changes to come, and improved forecasting and ability to track changes in coastal and ocean ecosystems in a changing climate.

2. Timeframe – Long-term

3. Outcomes

- A coordinated set of observations and monitoring in existing protected areas, research sites, and observation systems that allows for more comprehensive understanding of climate change and ocean acidification processes, impacts, and trends.
- A system of “sentinel sites” that provide the management community with the information needed to develop and implement adaptation actions.

4. Milestones

- Complete inventory and assessment of existing observations and monitoring capabilities in networks/systems of coastal and ocean protected areas, research sites, and observing systems.
- Based on the inventory (above), determine critical gaps in information/coverage and solutions for addressing these gaps.
- In collaboration with the National Climate Assessment, integrate existing observational and monitoring efforts into a suite of indicators of community and ecosystem impacts (physical, biological, chemical, cultural, social, economic) to track changes in vulnerability and resiliency through time.
- Create and implement an interagency plan for standardized monitoring of the impacts of climate change and ocean acidification through existing networks of protected areas using standardized and/or interoperable techniques, databases, and indicators (see above) when and wherever possible, to maximize integration of information across networks and agencies.
- Integrate relevant socioeconomic monitoring information (e.g., U.S. Census and Bureau of Labor Statistics data) with ecosystem monitoring information within regions to understand changes in coupled human-natural systems through time.
- Identify existing observations on changes in species phenology (i.e., the annual timing of major life cycle events such as migration, reproduction, flowering) in coastal and ocean

ecosystems, and develop a plan to provide for incorporating and accessing this information as part of the National Phenology Network.

- Deploy chemical sensors at existing coastal/ocean observing systems to monitor the variability and change at local to regional levels in biogeochemistry, particularly with regard to carbon system parameters (pH, DIC, TA, pCO₂), temperature, oxygen dynamics, and nutrients.
- Deploy biological sensors at existing coastal/ocean observing systems to monitor the seasonal measurements of calcification rates and other CO₂-sensitive processes not currently measured at time-series sites in order to assess the long-term response of ecosystems to ocean acidification.
- Disseminate and implement best practices, including guidance for relevant parameters that should be measured at each observing system, standardized chemical and biological monitoring protocols, and quality assurance and quality control procedures. This milestone should be coupled with appropriate training opportunities.

5. Gaps and Needs in Science and Technology

- Comprehensive monitoring in protected areas with appropriate instrumentation, methods, and quality control to provide an integrated, geographically-distributed database that can be used to estimate poorly understood spatial and temporal patterns of ocean acidification and sea level rise in estuaries and coastal zones.
- Advancements in the design of chemical and biological sensors that will allow for ready and accurate *in situ* measurements of multiple carbon system parameters (pH, DIC, TA, pCO₂) and biological responses, and automatic collection of metadata, where feasible.
- Strategies to eliminate or minimize biofouling of sensors so that they can be used in marine environments for extended periods.
- Incorporation of instrumentation for monitoring the impacts of climate change and ocean acidification into existing coastal and ocean observational and monitoring networks.
- Integration and coordination between existing social, behavioral, and economic monitoring efforts and ecosystem monitoring efforts.
- Management and delivery (access) of data and information.

D. Action 4 – Provide accessible, timely, and relevant climate change and ocean acidification information, tools, guidance, and services to support decision making at all scales.

1. Why Do This

- Federal agencies must work together to provide decision makers at all levels with pertinent, comprehensive, accessible, and timely information for understanding, planning for, and responding to the impacts of climate change and ocean acidification.
- This action will support efforts to build resilience across ocean, coastal, and Great Lakes ecosystems and communities.

2. Timeframe – Mid-Term

3. Outcomes

- Enhanced ability of individuals, communities, and governments at all scales to identify their needs, and ultimately, to implement forward-looking, adaptive actions that build ecosystem, societal, and economic resilience.

4. Milestones

- Make geospatial data, especially information on relative locations of water and land surfaces, shallow bathymetry, and cardinal habitat and ecological characteristics, available to ocean, coastal, and Great Lakes communities as a basis for adaptation planning.
- Develop an interagency plan for LiDAR mapping, to acquire and maintain more precise shallow bathymetry and terrestrial elevation data in order to ensure comprehensive and accurate topographic information for coastlines, enabling response to and planning for changing landforms, water levels, and other effects of coastal inundation.
- Provide accessible, standardized guidance for incorporating climate change and ocean acidification information into ecosystem management and coastal and marine spatial planning activities.
- Support economic and non-economic valuation of ecosystem services.
- Integrate information, tools, and services on coasts and oceans into the emerging online interagency climate information clearinghouse/portal, which will include:
 - Best-available scientific data and information.
 - User-friendly projections.
 - Transferable decision-support tools.
 - Best practices.
 - Relevant contacts from adaptation activities across the Nation.
 - An active support mechanism to facilitate dialogue among users.
- Foster a “community of practice” by bringing together coastal climate change adaptation practitioners to share strategies and lessons learned.
- Coordinate Federal climate services (e.g. data, guidance, tools, etc.) to maximize utility of information for decision-makers at all scales.
- Develop a strategic plan for continuously identifying information needs of decision makers and addressing them through a use-inspired, integrated research agenda.
- Provide a standard suite of regional and decadal climate projections at the scale appropriate for decision-making.
- Provide guidance on the effective use of best-available regional and decadal climate projections, including associated uncertainties.

5. Gaps and Needs in Science and Technology

- Geopositioning (LiDAR, shallow bathymetry, etc.) products, data and derived elevation products to support a wide range of operational needs and to establish a consistent baseline for planning assumptions, regulatory decision making, and scientific research.

- Expanded availability of geopositioning information and a unified portal for access to the data to support work to conduct robust national assessments of natural resource and landform response to sea-level change and of the vulnerability of infrastructure and human communities.

E. Action 5 – Assess vulnerability of the built and natural environments and their interactions in a changing climate.

1. Why Do This

- Addressing the inherent links between the impacts of climate change on the natural environment and the consequences for human communities and infrastructure is fundamental to improving the resiliency of ecosystems, communities, and economies.
- This action will support decision-makers with information they need to develop actions that reduce vulnerability and strengthen resiliency and adaptation of ocean and coastal ecosystems and communities in a changing climate.

2. Timeframe – Mid-Term

3. Outcomes

- Strategically assessing the vulnerability of ocean and coastal ecosystems and coastal communities in a changing climate.

4. Milestones

- Establish methods, best practices, and standards for vulnerability assessments, including the consequences of climate change and ocean acidification for economic, ecological, cultural, and social systems, infrastructure, and technology.
- Conduct coupled vulnerability assessments that address the interactions of the built and natural environments in the face of a changing climate.
- Complete comprehensive climate change vulnerability assessments for federally funded and/or managed coastal facilities, infrastructure, cultural resources, and ecosystems.
- Identify the most vulnerable areas, as well as areas most likely to be resistant/resilient to climate change impacts, to help decision-makers design effective adaptation plans.
- Develop partnerships, guidance, tools, and best practices to help support vulnerability assessments at local, state, tribal, and regional scales (See Action 4).

5. Gaps and Needs in Science and Technology

- Pathways for incorporating improved knowledge about sensitivity, exposure, and adaptive capacity, as well as future environmental changes and impacts, into vulnerability assessments (See Actions 1, 2 and 3).

F. Action 6 – Design, implement and evaluate adaptation strategies in order to reduce vulnerabilities and promote risk-wise decisions.

1. Why Do This

- The Nation’s coastal and ocean resources are already being impacted by climate change and ocean acidification, and these impacts are expected to increase in the future.
- Coordinated action is needed at all levels to reduce vulnerability and impacts to the built and natural environments.
- There is an opportunity to make significant progress in this area through building on current efforts at local, state, tribal, and regional levels.
- There is an urgent need for immediate and prolonged investment now in adaptation plans and actions for repair, replacement or expansion of existing critical infrastructure (e.g., water and waste water treatment plants, hospitals, coastal highways, etc.) to address current and future impacts as well as reduce future losses.
- This action will help to reduce current and future vulnerabilities and impacts to climate change and ocean acidification by enhancing and increasing the design, implementation, and evaluation of adaptation plans for built and natural environments.
- Accomplishing this action will directly advance the nation’s ability to be “climate ready.”

2. Timeframe – Long-term

3. Outcomes

- Reduced vulnerability and improved resilience of communities, ecosystems, and infrastructure through actions that lead to “climate smart” siting and design, restoration and protection of ecosystem services, improved public health and safety, reductions in the loss of life and property, and decreased costs of responding to disasters.

4. Milestones

- Promote, build on and incentivize design, implementation, and evaluation of adaptation strategies in local, state, regional, tribal, and federal decision making.
- Develop tools, capacity, and best practices for adaptation planning at local, state, tribal, regional, and national scales.
- Identify, protect, connect, and restore key areas needed to promote resilience, sustain biodiversity, ecosystem function and ecosystem services, and maintain plant, fish, and wildlife corridors along coasts and lakeshores.
- Incorporate species migration patterns and ecosystem protection measures into all publicly funded infrastructure projects.
- Promote regional frameworks (e.g., Interagency Climate Change Adaptation Task Force regional adaptation consortia, Landscape Conservation Cooperatives, CMSP Regional Planning Bodies) for coordinated adaptation planning, implementation, and evaluation across geographic scales and organizations.

- Promote ecosystem-based approaches to adaptation to use the adaptive services of natural systems to help reduce vulnerabilities and risks to people and the built environment.
- Achieve a no-net increase in the amount of property and infrastructure in high-hazard areas.
- Mitigate vulnerability of coastal communities to the effects of climate change and ocean acidification. Develop plans for fortification, retreat, or other strategies that ensure continuity of critical services and reduced exposure to hazards. Consider ecosystem-based approaches (as opposed to gray infrastructure) when feasible.
- Implement pre-disaster mitigation planning and recovery to prepare for climate change. Revise Federal guidelines and programs to encourage more resilient and sustainable forms of rebuilding or retreat.
- Reduce the impacts of stressors over which we have more direct control (e.g., pollution, habitat destruction and resource extraction) to enhance the resiliency of coastal, ocean, and Great Lakes ecosystems to climate change and ocean acidification.
- Modify policies, practices, programs or projects that promote maladaptation (increased vulnerability and risks to communities or natural environments).
- Expand the interpretation, and where necessary, issue proposals to strengthen the Coastal Zone Management Act and the Stafford Act to include and better support climate change adaptation efforts.
- Develop strategies to address the unique needs for adaptation of cultural resources on shores and under water, including consultation with tribes and State Historic Preservation Offices.
- Ensure that coastal and ocean ecosystems and coastal communities are included, where relevant, in Federal agency adaptation planning efforts under Executive Order 13514.
- Complete development of the National Fish Wildlife and Plant Climate Adaptation Strategy to safeguard the nation's valuable natural resources and the communities that depend on them in a changing climate.
- Include consideration of climate change and ocean acidification impacts and costs in all federal financing (grants, loans) programs that support the maintenance or construction of public infrastructure in coastal areas.

5. Gaps and Needs in Science and Technology

- Feasible alternative scenarios for the future operations, maintenance, and relocation of built infrastructure (e.g., coastal roads, port facilities, dam operation) to mitigate the effects of climate change on ecosystems.
- Evaluation and prediction of new coastal migration corridors and potential new habitat for ecosystems.
- Methods and standards for evaluation of resilience and adaptation that include economic, ecological, cultural, and technological consequences of climate change and ocean acidification.