

**Needs Assessment:
Climate-related Products and Services
for Sustainable Marine Ecosystems
in a Changing Climate**

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Sustainable Marine Ecosystems Team

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Executive Summary

NOAA's Next Generation Strategic Plan calls for development of timely and reliable climate services in four key areas: climate impacts on water resources, coasts and climate resilience, sustainability of marine ecosystems, and changes in the extremes of weather and climate. To identify priorities in these areas, the NOAA Climate Goal designed and conducted a series of needs assessments for each of the four focus areas

This needs assessment was designed to gather information from existing literature on the priority needs of audiences involved in understanding, management and use of marine ecosystems (e.g. decision makers and managers) for climate-related products and services. The purpose of the assessment was to help inform and guide NOAA's efforts to prioritize, resource and address these needs. The assessment was divided into two phases: 1) definition of the target audiences whose needs were being assessed (audience analysis) and 2) collection and synthesis of needs for climate-related products and services from existing literature (needs analysis).

The audience analysis was critical in bounding the scope of this needs assessment. The team categorized NOAA's ecosystem mandates (e.g., Magnuson-Stevens Act, National Marine Sanctuaries Act, Endangered Species Act, etc.) and associated stakeholder audiences into three broad categories: fisheries management, place-based ecosystem management, and protected species management. The priority audiences across these three categories spanned the areas of science, policy/management, and end-user/consumer (e.g. ocean resource users, including fishers). For purposes of this assessment, the analysis primarily focused on needs related to NOAA science, policy and management of marine ecosystems, recognizing that this analysis would also likely inform science and management needs of other organizations involved in marine resource management.

This assessment is based on information gleaned from a large volume of references and literature that primarily targeted the NOAA science community in recent years. The vast majority of this documentation focuses on the scientific needs to improve models, predictions, and projections of climate changes and their impacts on the physical characteristics of marine ecosystems. In general, the majority of existing reports and documents focused on the scientific needs to better understand past and future climate changes and impacts on marine ecosystems, rather than needs related to applying climate-related information in marine resource management. However, given the applicability of decision processes and risk management approaches across sectors, some needs information was drawn from reports on incorporating climate information into other decision-making processes such as the built environment, coastal areas or water resources.

The report is organized in three sections. Section 1 examines the needs of each of the three ecosystem management categories described above: fisheries management, place-based ecosystem management, and protected species conservation. Section 2 describes the major needs that cut across audiences including:

- baseline conditions and monitoring;
- predictions, projections, and models; and
- decision-support tools.

Section 3 provides case studies of how climate-related products and services are being successfully incorporated into marine resource management decision-making processes.

Overarching Needs

Through the needs assessment, a large diversity of needs were identified across the various audiences within the fisheries management, protected species and place-based sub-groups. While science-oriented audiences often wanted direct data and model products with minimal modification, management and stakeholders often desired more detailed, region-specific vulnerability and impacts assessments. Such products can require significant efforts to augment the value of standard climate products and observations. Meeting this diversity of needs is a key challenge for NOAA and requires careful consideration of how to continue to develop and deliver services that address specific climate information needs while interacting with other parts of NOAA's research and management capacity to efficiently deliver the highest-quality and most useful products.

The biggest gaps pertain, in part, to the scales at which climate scientists and marine ecosystem managers work. Climate science is best understood on global to continental scales, while marine resources are managed at regional or local scales. Bridging this scale difference through high-resolution climate models and observations and downscaling techniques is essential for enhancing the utility of climate models and observations for regional climate-ecosystem projections. Climate processes also occur over a range of temporal scales, from seasonal and interannual, to decadal and longer, adding further complexity to the application of climate information for management. Climate information must also be tailored to audiences that do not have a formal education in climate science. This is particularly true for some of the place-based systems that have a heavy outreach and engagement focus with the general public.

For all three ecosystem management communities (fisheries, protected species, and place-based), there is a universal need to characterize baseline conditions for a given ecosystem to compare past, current and future conditions and the effectiveness of management actions.

Data systems need to be more comprehensive, integrated, and interoperable, with common standards, protocols, and mechanisms for communicating information at scales relevant to decision makers.

Models need to better represent climate-ecosystem linkages and characterize uncertainty. This entails an improved understanding of climate-ecosystem interactions, as well as improved representation of these interactions in climate and ecosystem models. Climate model output needs to be well-documented and available for marine ecosystem experts to apply to their own models to assess ecological responses.

Managers also need to be able to identify which resources are most vulnerable and why, in order to ensure their resilience. Perhaps the biggest need for managers is identifying mechanisms that build knowledge of a changing environment into their existing decision-making and communication processes.

As part of our assessment of existing literature, the team assumed there would be a well-documented need for climate-related training and capacity building across all audiences. However, few of the analyzed reports discuss the needs associated with incorporating climate information into decision processes associated specifically with *marine resource management*. A formal needs assessment process that includes user needs assessments survey or focus group data gathering would allow for more complete understanding of the climate-related needs specific to marine resource management.

Purpose, Design and Target Audiences

Background

The National Oceanic and Atmospheric Administration (NOAA) provides the nation with high-quality science and services to achieve its vision of healthy ecosystems, communities, and economies resilient in the face of change. Through its mission to understand and predict changes in climate, weather, oceans and coasts, share this knowledge with others, and conserve and manage coastal and marine ecosystems and resources, NOAA is responding to the nation's ever-increasing need for climate-related information.

Central to the success of its mission is NOAA's long-term goal to have *an informed society capable of anticipating and responding to climate change and its impacts*. Building on this, the NOAA Climate Goal in NOAA's Next Generation Strategic Plan has identified several focus areas related to the development of timely and reliable climate services: climate impacts on water resources, coasts and climate resilience, sustainability of marine ecosystems, and changes in the extremes of weather and climate. This document focuses on activities related to how a changing climate impacts marine ecosystem research and decision-making communities.

Purpose

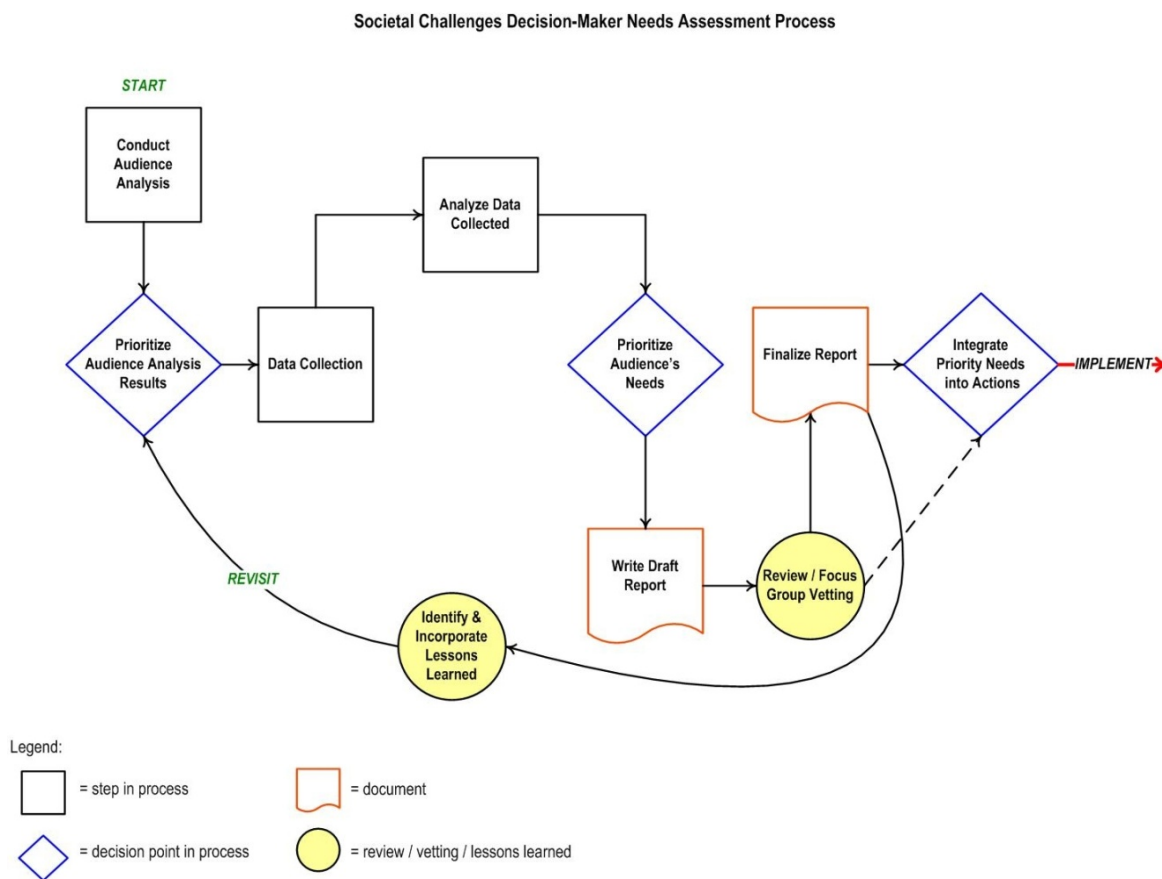
A needs assessment enables organizations to develop an effective program, product or service to address a specific community's needs and wants. A full needs assessment is defined as a systematic investigation of a specific audience to identify aspects of individual interest, knowledge, skill or attitude with regard to a particular issue, goal or objective. Within this framework, needs represent gaps between what currently exists and what should exist in a given environment. Wants represent proposed solutions to filling existing gaps. By engaging in a needs assessment, vital information is gathered on the priority needs of target audiences, which will allow the Climate Goal to prioritize resources to address those needs.

This report investigates the needs of researchers and decision-makers associated with managing and sustaining marine ecosystems in a changing climate. It describes the formal process used to identify the needs of these communities and the results of that process. Information obtained through this assessment will be used to inform the Climate Goal and other partners of the climate-related needs and information gaps of decision-making and research communities, in order to develop effective climate-related products and services to meet those needs. Implementation of the findings includes integrating the results internally into NOAA annual operating plans, and also coordinating with NOAA partners, such as state and Federal agencies, non-governmental organizations, etc.

Design/Methodology

Teams were established to conduct needs assessments for each of the Climate Goal’s four Societal Challenges. All of the needs assessment teams followed the same basic steps to conduct their assessments (see Figure 1). This report describes the phase 1 needs assessment conducted for the Climate Goal Societal Challenge: Sustainability of Marine Ecosystems (SME). The prescribed method used by the SME team followed the techniques outlined by the NOAA Coastal Services Center needs assessment training website (<http://www.csc.noaa.gov/needs/>), with additional effort spent on data collection design. This document includes a description of methods and summary of results analyzed from both an audience and needs perspective.

Figure 1. Climate Societal Challenge Needs Assessment Process



SME Team and Scope

In February of 2011, a cross-NOAA needs assessment team was established with existing staff from eleven NOAA Offices (see Appendix A for a listing of SME Needs Assessment team members). The members represent NOAA’s expertise in various ecosystem-related fields and connections to climate-related issues. The team met initially to establish the scope and boundaries of the assessment, which focused on internal NOAA stakeholders (e.g., science and

policy/manager entities), while including partners with external reach such as Sea Grant and Regional Integrated Sciences and Assessments (RISA) teams.

The assessment aims to identify the types of climate-related information needed by science and policy/management stakeholders to make informed decisions related to the impacts of climate variability and change on the sustainability of marine ecosystems. It was important to the team to make the distinction between the climate information a particular audience needed from the Climate Goal directly and what an audience would add to that climate information in order to serve their own needs and those of their constituents further down the information continuum. For example, climate model output a regional science center receives is different from the resultant information it develops by incorporating that output into their own ecosystem model to arrive at relevant information for policy-makers. This approach helped to structure the audience analysis and better organize the type and scope of perceived need for products and services needed from the Climate Goal.

Audience Analysis

A crucial initial step in any needs assessment is to identify target audiences and their specific traits. The SME team designed a structured audience data collection template in order to capture relevant components of the various audiences associated with the management of marine resources. The design of the template captures the maximum amount of relevant information and streamlined the effort spent prioritizing audiences. The template included traits such as sector affiliation, climate information uses, temporal and spatial scale of work, perceived need for climate information, products and services, vocation, and decision-making power or authority. The team then defined all the possible selections under each trait to keep the information collection manageable and within the bounds of the original needs question.

The needs assessment team was then divided into three thematic audience sub-groupings: NOAA entities related to fisheries, place-based, and protected species management . Distribution of team members was based upon the members' affiliation and experience with the audiences represented by the sub-groups. Team members within each audience sub-group were asked to populate the template with known audiences and their respective traits.

Results of the completed template were then analyzed by perceived need and person-type to determine priority audiences, which would be further investigated. Initial prioritization of person type included science, policy/management and end-user/consumer.

Results were compiled into an audience analysis spreadsheet (Appendix B), which lists audiences sorted within each sub-group. Of note in the audience analysis is the consistent need for climate-related training and capacity building across science and policy/manager entities (all audiences). Additionally, there was a need for more technical climate information

(i.e., climatologies, model projections and predictions¹) needed by science audiences and more refined climate information (i.e. decision-support tools and training) from policy/management audiences. As a result of the analysis, we determined that Federal science and Federal policy/manager would be priority audiences in which to target the team's efforts, given the limitations in time and budget. It is also recognized that needs among these audiences may intersect or overlap with other audiences and Societal Challenges' needs assessment efforts.

Needs Assessment

After determining priority audiences, the team collected information on the existing documented needs of these audiences through an extensive literature search. A standard outreach message was used to solicit literature from key individuals within the Federal science and Federal policy/manager communities. Team members used the message to cast a wide request to individuals within their audience sub-group for existing climate needs resources. This effort, in combination with resources provided by team members themselves, generated 68 documents, comprising reports, strategic plans, management documents, etc. The references list provides a listing of documents and resources used during this needs assessment. A data collection spreadsheet was designed to capture needs information from the resources. Each team member reviewed the documents returned to them to glean relevant climate needs and entered the data into the collection spreadsheet.

The results of the data collection were organized by the three audience sub-groups, as well as by cross-cutting need. The team was charged with analyzing the data and summarizing the results by audience and by need. Where relevant, cross-cutting needs were identified, as well as audiences for which needs information is lacking. In addition, case studies were included to serve as examples of the role climate information plays in the management of marine resources. These summaries are included in the subsequent sections of this report. Once reviewed by the team, the report was vetted both internally and with key audiences to validate the team's findings and fill any gaps based upon existing literature.

¹ The terms climate projection and climate prediction are used according to the IPCC AR4 glossary of terms (Baede, 2007). Climate projection describes simulations of the response of the climate system to an emission or greenhouse gas/aerosol concentration scenario. These scenarios are generally used for century-scale climate simulations and rely on socioeconomic and technological assumptions subject to substantial uncertainty. Climate prediction or climate forecast describes an attempt to produce a most likely description of the future evolution of the climate system and do not rely on emissions scenarios. Such configurations are generally used for seasonal to decadal-scale predictions.

Needs Assessment

Summary of Major Needs (across thematic audiences)

Fisheries Management

Climate change will greatly impact the ability of decision-makers to adequately manage U.S. fish stocks, marine ecosystems and the fisheries (ie., fishing communities, business and related economies) that depend on them. For example, as temperatures change, species' geographic distributions will shift due to temperature tolerances of the fish and changing circulation patterns that affect larval dispersal patterns. The shift in geography, however, will likely occur at different rates (Meuter and Litzow 2008, Nye et al. 2009, Cheung et al. 2009, Overholtz et al. 2011) among species, creating new combinations of species that will interact in novel ways. Similarly, altered patterns of atmosphere-ocean heat fluxes and wind and water circulation from climate change will influence the vertical movement of ocean waters (Doney 2006, Bakun, 1990), changing the availability of essential nutrients and oxygen to marine organisms throughout the water column. These changes in ocean productivity could have significant impacts on the productivity of fish stocks and how the populations will react to fishing pressure.

Based on review of the literature on climate-related needs of NOAA and related fisheries scientists and managers(e.g., Regional Fishery Management Councils and Interstate Fisheries Management Commissions), this group has five major categories of needs:

1. Projections of regional-scale patterns in physical or biogeochemical variables resolved and skillfully captured by climate models.
2. Multiple model projections linking changes in climate, oceans and marine resources.
3. Assessment of past and current impacts on marine resources and the communities that depend on them.
4. Vulnerability assessments of how climate variability and change impact key assets in the fisheries community.
5. Decision-support tools and processes for developing and evaluating management options

These general categories are broken down into more detailed needs for individual Fisheries-related audiences in Table 1. A general description of these audiences is below.

NOAA Fisheries Service Scientists

Scientists involved in assessing fish stocks, fisheries and impacts/interactions between living marine resources and their habitats, human uses, climate change and other stressors that provide the scientific foundation for management decisions by NOAA and others.

Commission and Council Fisheries Scientists

Scientists involved in assessing fish stocks, fisheries and impacts/interactions between living marine resources and their habitats, human uses, climate change and other stressors that provide the scientific foundation for management decisions by NOAA and others.

NOAA Fisheries Service Managers

Key decision makers concerning marine and coastal fisheries and their habitats.

Commission and Council Fisheries Managers

Key decision makers concerning marine and coastal living marine resources.

Table 1. Needs by Fisheries Management Audiences.

Perceived Need (by audience)	NMFS Fisheries Scientists	Commission and Council Fisheries Scientists	NMFS Managers	Commission and Council Fisheries Managers
Monitoring and assessment of baseline conditions and trends	✓	✓		
Climatologies	✓	✓		
Physical, chemical or biological variables skillfully captured by climate models	✓	✓		
Physical, chemical or biological variables not yet resolved by global climate models	✓	✓		
Multiple model projections linking changes in /climate, oceans and marine resources	✓	✓	✓	✓
Assessment of climate impacts on living marine resources and the communities that depend on them.	✓	✓	✓	✓
Vulnerability/impact assessments (biological and habitat/water quality)	✓	✓	✓	✓
Vulnerability/impact assessments (social and economic impacts)	✓	✓	✓	✓
Decision support tools and processes for Development and evaluation of management options			✓	✓

Projections of patterns in physical chemical or biological variables

NOAA-Fisheries has evaluated its science needs for addressing climate change (Osgood 2008). Climate observations and predictions are necessary for NOAA-Fisheries to identify climate-induced ecosystem factors and to incorporate climate into the living marine resource management process. Both historical and current climate observations are needed to document how climate has and is changing in particular regions and for comparisons to local ecosystem changes.

The necessary climate observations include both the physical parameters generally associated with a region's climate (e.g. air and ocean temperature, wind, and precipitation) and the ocean's chemical parameters (e.g. salinity, oxygen, nutrients, and carbonate system parameters). These observations are required on scales that are pertinent to ecosystems. Specifically, sea surface and water column profiles of these parameters are necessary, and measurements are needed on spatial and temporal scales that capture the variability experienced by organisms. Indices of climate variability and change are useful to quantify the state and tendency of climate forcing and environmental conditions (Osgood 2008).

Regional climate projections are essential for including climate in scenarios of living marine resource status. Regional projections of how the climate will change and how present climate variations will be affected are needed. Climate projections should be developed for different climate forcing scenarios and include a measure of uncertainty.

The development of coupled atmosphere-ocean models is necessary for projections of climate impacts on ocean physical properties, such as temperature, salinity, currents, meso-scale features, stratification, and upwelling, which are important controlling factors on when and where living marine resources can successfully persist. Projections of stream flow and changing water levels are also important for anadromous fish and coastal habitat concerns (Osgood 2008).

Multiple model projections linking changes in climate, oceans and marine resources

One of the critical needs is development and application of couple models that link climate, ocean physical and chemical characteristics, and the biological components from lower to higher trophic levels. This is an active and emerging field of modeling that allows development of scenarios of how different climate changes may ripple through the physical, chemical, and biological components of marine ecosystems including impacts on fisheries.

Vulnerability assessments of climate impacts

Decision-makers who manage fisheries and marine ecosystems are in need of vulnerability assessments that describe how climate change will impact the habitat and biological components of their management area (i.e., large marine ecosystems). We use the term vulnerability assessments in the general sense here, because the gamut of assessments includes such diverse efforts as resource scenario assessments (10 to 100 year outlooks of the resources and habitat), socio-economic impacts to fishing fleets due to climate change, to more simplistic assessments that identify at-risk resources that should be managed to increase resiliency to climate change. Regarding habitat, specifically, climate change has the potential to significantly influence how decision-makers go about planning and executing habitat protection and restoration projects (ACFHP 2011). Without vulnerability assessments, decision-makers may not realize the full extent and timeline of how climate change can impact their management area. Vulnerability assessment provides decision-makers with a forward-looking approach so that climate can be integrated into planning and actions can be implemented to reduce future risks.

Decision-support products and processes for developing and evaluating management options

Decision-makers who manage fisheries and marine ecosystems are also in need of decision-support processes and products that provide relevant and timely information on how a resource reacts to certain management actions on an iterative basis (Lemos and Rood 2010). Decision-support products and processes will need to be developed with the cooperation of the agency's scientists who provide the analytical models for projections (as noted earlier). For example, managers who are trying to increase the resiliency of a highly vulnerable stock want to know the effectiveness of management alternatives that are influenced by various climate, ecological, and human responses (Hartmann 2011). Because these responses may sometimes change in unpredictable ways, they require iterative evaluation of projected conditions, as well as thresholds. This process, supported by information, tools, and various forms of assessment, allows decision makers to avoid, minimize, and respond to negative economic or social impacts in the near- and long-term by preparing for different response options.

Although there are a growing number of research efforts to understand the impacts of climate change on living marine resources, , there are relatively few efforts to incorporate this knowledge into management action. Given the challenges of managing for climate change, decision-makers are interested in learning more about what type of management actions could be taken to address climate change impacts. Thus, managers would be interested in having inter-agency or intra-agency meetings to compare management strategies and to further research new methods, so as to develop a list of best management practices for addressing climate change.

Protected Species

Climate change is already impacting marine species, habitats and ecosystems, and these impacts are expected to increase over time. Protected species are some of the most vulnerable species in a changing climate because they are already in a degraded or at-risk state, and the conditions that led to their protected status (e.g., reduced population sizes, and destruction of habitats, etc.) are likely to affect their ability to withstand and respond to impacts of a changing climate. In addition, climate change may also impact non-protected species to the point where they are proposed or listed for protected status, potentially increasing the number of species under NOAA's protected species responsibilities.

NOAA is responsible for protection and conservation of a variety of species under the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973. Species under NOAA's authority include most marine mammals, sea turtles while in the marine environment, salmonids and other anadromous and marine fish, corals, abalone, and marine plants. Fulfilling these mandates requires a range of activities, most of which involve consideration of environmental information, including changing climate conditions. In general, NOAA's protected species activities fall into six major areas:

- Monitoring and assessment of populations and habitat conditions
- Science and projections to foster recovery and protect critical habitat
- Development and implementation of recovery plans
- Review and consultations on federal and other actions impacting protected species
- Permitting actions that may impact protected species
- Regulating actions that may impact protected species
- Increasing awareness and compliance with laws and regulations concerning marine-related protected species.

This needs assessment identified needs for climate products and services of key audiences involved in NOAA's protected species mission area by reviewing existing sources of information. The key audiences were divided into the following six groups and needs for each group identified based on existing information:

1. Protected species scientists
NOAA and academic partners who are involved in conducting and providing data and information on protected species to federal government managers and other entities.
2. Protected species managers (NOAA)
Include Federal, state and tribal protected species managers.
3. Federal agencies whose activities may impact NOAA protected species.
These include federal agencies responsible for evaluation, consultation and action regarding impacts of their actions on federally protected species.

4. State and local governments whose activities may impact NOAA protected species
5. Non-governmental organizations and private sector activities that may impact NOAA protected species
6. Private land owners whose activities may impact NOAA protected species

The survey results are summarized in Table 2. In general, the majority of the NOAA protected species audiences have broad needs for climate information, products and services spanning from regional climatologies to training and capacity building. The scientific audiences appear to have the greatest need for regional climatologies and projections to be able to provide the management and decision-maker audiences with information on vulnerability and decision scenarios.

One of the important observations is that the information needed by managers and other decision makers can differ dramatically in scale and scope depending on the species and type of activity/decision at hand. Decisions regarding if and how to list a species under the Endangered Species Act may require regional climatologies and projections across longer timeframes and geographic scales, compared to the scale required in consultations to determine the potential impacts of a small project on protected species critical habitat. Decision-support tools, training and capacity building are common needs across the audiences, although the specific type of training and capacity building may differ among audiences.