Climate-Related Needs Assessment Synthesis for Coastal Management

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Coastal Services Center

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Introduction

This document is a synthesis of climate-related needs of coastal and natural resource managers—gathered from 24 relevant sources—for internal use by the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center. The synthesis is merely a snapshot of climate-related needs identified in these sources and is not intended to be all-inclusive. Needs are categorized in bulleted lists.

Following are some of the criteria used in selecting, interpreting, and organizing these needs within this synthesis:

- Needs have not been prioritized or ranked in any way.
- Needs were not intentionally misconstrued, but some interpretation of context may have occurred to facilitate placement in subcategories.
- Many needs were identified in multiple regions, or perhaps a particular region was not associated with an identified need.
- Additional needs that appear to be more specific to a region appear later in the document.
- Some needs, because of the way they were identified in the documents, appear in multiple sections.
- Needs that relate to mitigation or reducing greenhouse gas emissions were not widely considered.

Bracketed numbers following listed needs correspond to the numbered sources in the "Resources" section. However, owing to the internal, informal nature of this document, a few needs are not directly linked to a reference, and sources range from formal published documents to notes from conferences and meetings. The categorized lists begin below.

Messaging and Outreach

- Consider messaging of climate change to address skepticism, urgency, and attribution issues of climate vs. weather. [2]
- Researchers should encourage outreach. [2]
- Show early success. [2]
- Development of consistent messages. [2]

- How to communicate reliable climate change science in a relevant way to the 50% of the population who are confused about whether they should be worried about global warming and its impacts. [2]
- Disseminate information on hazard mitigation to reduce vulnerability. [22]
- Project summaries to attract funds and collaborators. [7]
- Stories and narratives (experiences of change). [7]
- Need prepared presentations to take to the public and local and state officials to encourage change. [8]
- User focus groups to identify what people will respond to—how to convey message. [11]
- Journalists and communicators need training on climate change impacts. [11]
- Communicators (such as Sea Grant) should provide information addressing coastal impacts of climate change targeted to decision makers and processes. [11]
- Information addressing the adverse effects and consequences of future sea level rise must be communicated to all individuals who are or intend to live in the coastal zone, through printed material (brochures), websites, etc. Communication outlets include coastal zone management programs, local extension agents (Sea Grant or Land Grant), and local weather media. [11]
- Information addressing the coastal impacts of climate change should be targeted toward decision makers and decision-making processes. [11]
- Need a unified message. [5]
- Say what we know and what we don't know. [1]
- New ways to portray information in simple, easy-to-understand terminology. [1]
- Precise communication with public and managers: homeowners shouldn't be concerned about sea level rise directly but about the impeding impacts from related climate change (hurricanes, potential increase in storm activity, etc.). Be sure to relay the whole suite of issues, not just rising waters. [8]
- Discussion point—overusing sea level rise and climate change to influence public management decisions for coastal hazards. [8]
- Encourage scientists to put their work out there in a very useful and publicly available way. [14]
- Public must understand the implications of climate change and use that knowledge and their values to guide policy makers. [14]
- Participatory approach to decision making is needed. Public/stakeholders must be informed and involved. [14]
- Catastrophe modelers are a small community; three companies do most of the business. Outreach to these companies (AIR, RMS, and EQE) by scientists would be great. [14]
- Inclusion of climate change parameters in a number of current decisions that affect the longer term. [15]
- Initiate public outreach education effort on air quality and climate, including all impacts of alternative fuels. [18]
- Climate outreach by Sea Grant is needed because and only because climate is changing. It's slow and difficult for most people to detect, but the consequences are significant and, for some, life-altering. Programming needs to deal with minimizing, coping, and mitigating. [2]

Sense of Urgency

- We have enough information to begin making decisions now. Climate change is happening now throughout terrestrial and marine ecosystems. Recognition that climate change is happening has penetrated to the field level within the last 5 years. Need to take action. [14]
- Managers are limited to reacting to already-observed climate change effects on natural resources, which makes it difficult to plan for future changes. [16]
- Current planning time frames are too short for incorporating long-term climate change. [16]

Products and Services

- Develop adaptation guidebooks for agencies, realtors, and developers. [2]
- Develop tools and techniques to analyze, predict, or mitigate impacts of environmental and coastal hazards, including using geographic information systems (GIS). [22]
- Give concrete ideas of how this information can be incorporated into decision-making processes, including examples. [8]
- The federal Climate Change Science Program (CCSP) and the Union of Concerned Scientists (UCS) should synthesize Intergovernmental Panel on Climate Change (IPCC) information into more relevant format for regions. [11]
- Home buyers, homeowners, and renters should be given information about adverse effects and consequences of sea level rise and natural hazards through printed and Web resources. [11]
- All coastal management agencies should collaboratively work to translate hypothetical climate scenarios into specific management criteria for regulatory, engineering, planning, etc. purposes. [11]
- Coastal States Organization (CSO) and state programs should work in focused way on regional adaptation planning and share science with public and decision makers in that applied context (e.g., stakeholder consensus-building on plans). [11]
- Academic institutions, research entities, and state coastal zone management programs should evaluate land use planning more comprehensively in terms of climate change impacts to existing infrastructure and habitat and in terms of adaptation of land use planning. [11]
- Translate model results into GIS and animated presentations that all customers can understand. [6]
- Need recommendations on course of action to mitigate the effects of sea level rise and other climate change concerns. [5]
- NOAA should consider developing a “Climate Change Ready” program similar to “Tsunami Ready.” [1]
- Shoreline characterizations. [19]
- A guide on how to incorporate resilience in coastal restoration would be a useful tool in the Gulf region. [21]
- Continuity of information services (agriculture context). [14]
- User involvement in the production of information services (agriculture context). [14]

- Documentation of successful forecasting applications. [4]
- Insights into constraints and opportunities (scientific, technical, institutional, communications). [4]
- Research into new applications, as well as the need to view climate forecasts in a risk management context, understand the decision-making framework to identify opportunities, recognize experience and resilience of Pacific Islands. [4]
- Need current planning and decision making for interstate water management, coastal management, faunal adaptive management, and in-state water management. [15]
- Resource managers do not have sufficient site-specific information to plan for and manage the effects of climate change on the federal resources they manage. [16]
- Develop more relevant products—give people what they need. [18]

Risk and Vulnerability

- Risk assessments at all scales. [7]
- Risk and vulnerability assessments. [19]
- Congress should fund NOAA, Environmental Protection Agency (EPA), and Federal Emergency Management Agency (FEMA) to collectively issue a report that should be submitted December 31, 2009, ranking the vulnerabilities of U.S. major estuaries with respect to climate change. [11]

Comprehensive or Integrated Source of Resources

- Single source for the most up-to-date sea level rise and climate projects and information at the national level, including documented coastal and ocean changes that have occurred or are occurring because of climate change. [9]
- Regional information "clearinghouses." [9]
- NOAA should create a catalogue of best management practices for climate change (policy, adaptation strategies, vulnerability assessments, etc.) and update it annually. [11]

Sea Level Rise–Specific

- Develop realistic scenarios (sea level rise) for planning purposes. [2]
- Technical support to help determine how the ocean levels will change—which properties will be hit the most. [5]
- Federal guidance on best practices, case studies, trainings, workshops, and/or software tools focused on community-level and statewide vulnerability assessments and adaption planning for state coastal programs to address impacts of accelerated sea level rise. [9]
- Restoration projects need to plan for sea level rise and climate change; managers need to know how they can prioritize restoration and conservation and how to design restoration projects given sea level rise and climate change predictions. [10]
- Strategies for incorporation of sea level rise research and modeling into planning, policies, and regulations. [8]
- FEMA should develop a sea level rise module for its HAZUS risk assessment model that not only considers static changes in mean sea level rise, but also the resultant impacts on other hazards (e.g., erosion, wetlands loss, storm surge increase, increased intensity and/or frequency of storms). [11]

- Know sea level rise is occurring, but don't know options for mitigating and proactive policies. [8]
- Sea level rise—how will our transportation routes have to be adjusted? [8]
- Sea level rise—how will existing infrastructure, roads, wastewater treatment plants, residential development, be affected by sea level rise and when will effects occur? [8]

Tools

- Development of local-level tools. [2]
- There is a need not only to provide decision-making tools, but also to provide training and technical assistance at the local level in applying those tools. [21]
- Decision-support tools compiling historical shorelines, geomorphology, socioeconomic data, and model projections. [9]
- Sea level rise scenario planning tool. [10]
- Web-based tool on effects of sea level rise at the property level for public education and government decision making. [10]
- Tools for decision makers to easily see potential risk to people and development due to sea level rise, flooding, and related hazards. [8]
- Tools for sea level rise must be local and specific, show a range of scenarios, highlight loss of tax money from lost infrastructure, clearly present assumptions, indicate landmarks as examples to make relevant, and give concrete ideas of how this information can be incorporated into decision-making processes, including examples. [8]
- Visualization of sea level rise is needed. [6]
- Tools are not strong enough (need to include economic, social, institutional factors). Developing stronger tools to add additional parameters to give you more robust model. Need integrated approaches. [14]
- Predictive modeling tools for fisheries and coastal erosion management. [16]

Partnerships

- Effective partnerships are needed to address issues particularly on a regional basis. [2]
- Cooperate with private industry to develop products. [2]
- Interagency coordination on coastal adaptation to climate change and shoreline management issues, especially focusing on NOAA, state coastal management programs, FEMA, and state floodplain managers. [9]
- Need to connect planners, floodplain managers, land use planners, emergency managers, and coastal resource managers. [10]
- The Coastal States Organization and state coastal management programs should initiate regional adaptation planning. [11]
- Insurance industry and National Flood Insurance Program need to embrace and incorporate sea level rise science and address equity issues. [11]
- The National Science Foundation (NSF) should sponsor the creation of several (3-5) centers for coastal sustainable development, each led by an academic consortium, with

required local government and industry participation. Each center would be funded for five years and then aim to become self-sustaining. [11]
- Actively engage the public in designing/implementing community-based planning and research. [18]
- Encourage international cooperation for air quality with a focus on fine particles. [18]

Communication and Collaboration

- Target user groups/sectors for impacts and adaptation dialogue. [2]
- Need NOAA dialogue and coordination pertaining to climate services. [2]
- Establish sustained mechanisms for regional collaboration on climate change issues. [9]
- States should set up scientist and manager ("speed dating-like") interfaces to facilitate needs and research. [11]
- Researchers and managers should both have questions (so they have the data and the plan) before they do big projects. Federal agencies should facilitate (e.g., NOAA). [11]
- More interagency and interstate/regional coordination and exchange of information, including more funding to facilitate information exchange, more on-line resources and data portals for coastal managers, and more ways to get information out about what resources are available, what grants and funding are available. [11]
- Information addressing more specific data needs should be brought forth from stakeholders/coastal managers. [11]
- Federal and state agencies should foster regional coordination of strategies to use global information in local decisions. [11]
- U.S. organizations (federal/state) like NOAA should coordinate their work not only between states and other organizations similar to them, but also internationally. The Netherlands and England are working hard on coastal land protection for example. [11]
- Researchers should target meeting NOAA performance measures and formulate database. [11]
- State coastal zone management programs distribute performance measure data to academia/researchers. [11]
- Reduce "information gap" between providers and users of climate information. [13]
- Cooperative arrangements are necessary for resources managers because climate change will require managers to work beyond administrative border. Interagency coordination and collaboration are necessary as climate change transcends forest and agency boundaries. [16]
- Better collaboration and exchange of relevant information among all agencies at federal, state, and local levels in coastal management. [17]
- Regular exchange of information among coastal states, and among coastal communities about their management response to climate change-related impacts and risks. [17]
- Communication between educators, communications experts, and the media. [18]

Data and Data Access

Traditional Data or Data Analysis

- Standardized method to measure and report sea level rise. [10]
- Need more surface elevation tables and water level stations in the GoMex to track relative sea level rise and subsidence. [10]
- Coastal states should engage students of all ages to collect basic coastal habitat and aversion data by making a part of the school science and social studies curriculum. [11]
- Need to track and show global, regional, and local changes in water and land levels (e.g., more surface elevation table work). [6]
- Expand research and utility of paleoclimatological data. [1]
- More observations are needed in the oceans and complex terrain of the West. [1]
- Improved data analysis tools for land- and water-based data. [1]
- Need access to the latest climate change data and how the (Oregon) coast may be affected. [5]
- Develop baseline information on current conditions and vulnerabilities. [13]
- Rainfall climatology based on radar and ground measures that focus on the impact of the sea breeze on coastal rainfall. [20]
- Monitor changes in sea level; periodically update inundation maps and planning assumptions. [13]
- Access to historical agricultural problems, observations, and remedies. [14]
- High-reliability observations. (agriculture context). [14]
- Better soils, precipitation, temp, pest, land use, crop information on fine and large scales. [14]
- Time varying data and model input/output. [14]
- There is an obvious need for climate data and models that are (1) high resolution and (2) diverse. Spatial resolution is important for planning and advocacy purposes, while temporal resolution is necessary to capture the role of storms, as well as the secular climate change (and sea level rise). [14]
- Local information on sea level rise: helpful as planning tool and as an advocacy tool. [14]
- Access to scientific data in a useful and publicly available format. [14]
- Need data about soil moisture (which is an important input in global disease modeling). [14]
- Need more accurate temperature data at regional, local level; water impacts, need more information about ability of soil to absorb water. [14]
- New data for prediction of “average year” for design. (15 years out of date). [14]
- Ocean observations are essential for more accurate, higher-resolution, reliable forecasting models. [4]
- Focus on observations of sea level rise, as well as analysis, to identify and understand trends of climate change. [4]
- Simplified scientific data to explain to the public the necessity to take action on this topic. [5]
- Wave and climate data that could be included in bluff retreat models. [17]
- Long-term observations and thresholds for understanding climate services and value. [18]
- Identify and fill gaps in observation sources. [18]

Remotely Sensed Data

- Provide accessible and timely data/metadata, including satellite/aerial, land use, land cover, shoreline, and demographics. [22]
- High-resolution topography and bathymetry (critical need in 7 states). [9]
    - Consistent temporal and spatial coverage of high-resolution topography and bathymetry data (lidar) to support shoreline changes (one state indicated the need for full coastal lidar coverage yearly).
- Congress should fund nationwide, high-resolution lidar, topographic, and bathymetric data for coastal watersheds. [11]
- Single framework for flying minimum high-resolution imagery regardless of agency/contractor flying, as well as standard for storing and sharing data. [11]
- Federal agencies should provide integrated and complete metadata with all geospatial data. Information addressing use limitation should be included. [11]
- NOAA needs to do lidar along the west coast including infrastructure. [1]
- Pursue opportunities for spaceborne observation platforms to support air quality climate issues, including NASA GEO-CAPE. [18]
- U.G. government should support JASON-3 satellite altimetry data (continued satellite measurements of sea level, wind speed, and wave height). [11]

Non-Traditional Data

- Baseline ecological indicators—vegetation maps/transects, hydrographs, meteorological data, phenology almanacs. [7]
- Status and trends reports from The Nature Conservancy's network. [7]
- Monitoring and mitigating impacts associated with ecological changes, such as wetlands migration. [9]
- Documented coastal and ocean changes that have occurred or are occurring because of climate change. [9]
- The diversity of data refers to the need for biological monitoring data sets, ocean acidification measurement, and social/economic data, in addition to the standard measurements of climate, water temperature, and sea level. [14]
- Economic analyses tied to local climate changes: insurance rates, infrastructure loss, fishing economy, etc. [14]
- Data gaps: chemical composition (carbon storage, N movement, chemical contaminants). This information is needed as a fine scale for farm management. [14]
- Beach profile surveys that help better predict climate change impacts on shoreline change. [17]
- The National Wetlands Inventory should transition from a static to a dynamic (across time) format. Information addressing climate change susceptibility should be incorporated. [11]
- Need "reference sites"—key areas with the variables of interest that can be tracked over time. Good to pick areas with available data/monitoring (e.g., National Estuarine Research Reserves), but those may not be sufficient to cover all variables of interest. [6]

Accessibility/Data Coordination/Standards

- Inventory and integration of existing and additionally developed information into common formats (e.g., geographic information system). [17]
- Development of an integrated database accessible by managers at different levels of governance; data ideally would be aggregated or disaggregated to various levels of spatial resolution and for different temporal resolutions. [17]
- Detailed inventories and monitoring systems for an adequate baseline understanding of existing local species. [16]
- Accessibility, usefulness, and usability of data and science. [18]
- Prepare infrastructure necessary for archival access and reanalysis for climate data sets from many sources. [18]
- Time series photos—ground, aerial/satellite. [7]
- Invasive species occurrences/locations. [7]
- States and federal agencies should collaborate with regional associations/regionally to create data inventory to identify data gaps and strategies to fill gaps and disseminate data through a portal. [11]
- National Climatic Data Center (NCDC) should more effectively coordinate use of climate change data with the states. [11]
- Coastal states and stakeholders should convey need for data in a systemwide/regional effort. [11]
- Federal and state agencies should coordinate (prioritize and demo multiple objectives of data) data collection and data access to avoid duplication and ease of use (similar to Integrated Ocean and Coastal Mapping clearinghouse, use regional ocean governing organizations, incentives for private clients to share data). [11]
- Congress should appropriate funds to support systemwide or regional data collection/ dissemination efforts such as the Integrated Ocean Observing System (IOOS), national coastal databank, etc. to foster effective and efficient coastal data collection & management. [11]
- NOAA, U.S. Geological Survey (USGS), U.S. Army Corps of Engineers (USACE) should coordinate lidar mapping efforts on a regional scale. [11]
- Data management/coordination should be an a priori step—Gulf of Mexico Alliance (GOMA), Gulf of Mexico Coastal Ocean Observing System (GCOOS), and Northern Gulf Institute (NGI) should foster coordination of relevant data for the region before researchers/modelers get started with sea level rise efforts. [6]
- Strengthening support for research and observing systems for meteorological, atmospheric, oceanographic, and terrestrial variables in Pacific Islands, including the engagement of local observers and practitioners in the design and operation of climate observing systems. [13]
- High-reliability observations, distributed in a consistent format that is user-friendly and accessible to diverse user groups. [14]
- Continuity of information services: observation networks and model-based analyses must be provided on a consistent basis. [14]
- Observation and analysis initiatives must be developed in coordination with the users of agriculture information. [14]

- Information exchange must be facilitated by standardized data formats and access interfaces. [14]
- Free exchange of information. [14]
- Must be high-quality data, ease of access, validated data sets or model output, with developed standards and formats. [14]
- One-stop access to needed multidisciplinary data sets. [14]
- Make air quality data available in a standardized format using NOAAPORT dissemination system. [18]
- NOAA should set standard on "climate quality" observations and maintain integrity, including modernizing the Historical Climatology Network (HCN) and participating in Global Atmosphere Watch Program (World Meteorological Organization) with at least one site in the U.S. [1]
- Ease of access to observations; user-friendly formats and distribution (agriculture context). [14]

Mapping and Accessibility

- Lidar maps need to be more accessible. [2]
- Products for mapping shoreline change, habitat change, hazard vulnerability, and coastal erosion and inundation. [9]
- Inundation mapping vs. shoreline change mapping (critical need in 5 states). [9]
    - Guidance for monitoring changes along "sheltered" or estuarine coastlines.
    - Combined models of inundation and shoreline erosion that also incorporate changes in coastal geomorphology, hydrological conditions, and human alterations and response (seawalls, sand replenishment, etc.) to assess social, environmental, and economic vulnerabilities.
- Map and model sea level rise with lidar. [10]
- Map and zone high-risk areas (based on wave run-up, storm surge, and erosion potential). [10]
- FEMA maps that indicate erosion potential and likely inland migration of V-zones. [10]
- Updated mean high-water shoreline maps. [10]
- Natural resource mapping and identification of high-priority areas and the impacts of sea level rise. [8]
- 1-2 foot contour maps for the coastal floodplain. [12]
- Develop capability for the National Weather Service to provide GIS maps of inundation. These flood simulations/maps need to get down to street-level to be useful. [14]
- Remapping of flood zones under different sea level rise projections. [17]
- Coordination among federal, state, and local agencies, and academic and research organizations on coastal mapping. [9]
- Map and model sea level rise with lidar. [10]

Social Science

- Social scientists at university level should be included. [2]
- Priority topic: understanding risk (to people and development) and related hazards (flooding, surge). [8]
- Assessments of social, legal, and economic issues related to sea level rise and shoreline "retreat," armoring, renourishment, and "no action" alternatives across developed and urbanized coastlines. [9]
- Sea level rise transportation impacts and planning. [8]
- Sea level rise infrastructure impacts and planning. [8]
- Socioeconomic analysis of ecological values is needed. [6]
- Improve economic and marketing tools to manage risk at acceptable levels, and improve information regarding global competition (include production and marketing implications of climate change in competitive countries). That is, integrate market/economic information into climate assessments. [14]
- Improve information regarding global competition (include production and marketing implications of climate change in competitive countries). [14]
- Either the public sector needs to develop its own risk prediction models or get access to the company models, or both. Methods used by the insurance industry to set prices are based on historical models and on predictions of future risk. The core regulatory problem is that the models are expensive, too expensive for all but a few states (or independent insurance companies) to run on their own. [14]
- Loss prevention continues to be an effective business model. There's a need to clarify the role of climate change in natural disaster losses. There's an opportunity for collaboration to advance the risk management solutions. [14]
- Enhance efforts to integrate traditional knowledge and practices into discussions of climate and health, including the engagement of traditional leaders and teachers. [13]
- Increased participation by tribal governments would be useful. Emphasizing cultural/spiritual impact of climate change on native people will make climate change more relevant to native people. Native people's traditional knowledge when coupled with scientists' research can yield insights. [14]

Economics

- Outreach efforts are needed to identify the connections to growth and development, as well as what long-term costs may be of sea level rise (armoring or retreating). [21]
- Demonstrate importance of weather, climate, and ocean information in business models. [22]
- Information on the costs of response options to accelerated sea level rise impacts such as migration and/or vertical accretion of coastal wetlands and beaches and the consequences of taking no action. [9]
- Economic impacts of phase shifts. [10]
- Need to quantify economic impacts by region. [15]

Climate Science Issues and Questions

- Science needs to be improved. [2]
- Scientific consensus. [8]
- Service agencies (i.e., climate modelers) should work to reduce uncertainty related to thermosteric effects generated from climate models and applicability of model outputs for coastal managers' use for sea level rise projections. [11]
- Short vs. long-term coastal hazards: what is the hazard to be mitigated on the ocean front—immediate threat of storms (shore erosion, wind and flood damage), or eventual threat of sea level rise (inches per decade)? [8]

Uncertainty/Probability

- Uncertainties in impacts of sea temperature, acidification, and sea level rise on the marine environment. [7]
- Uncertainty ranges for climate change impact projections to indicate scientific confidence. [17]
- Well-founded distinctions between more and less likely impacts (e.g., at-least vs. maybe as much as). [17]
- Scientific basis for uncertainty buffers (e.g., additional setbacks, extra capacity for storm water runoff). [17]
- Basic understanding of the reasons for the uncertainty (e.g., lack of data, lack of complexity in the models, unpredictability of future state of the world, insufficient understanding of natural processes) [17]
- Probability of impacts. [8]
- Probabilistic climate change projections with measurable indicators of change over various time horizons. [17]
- Clearly presented assumptions of sea level rise models. Disagreement leads to indifference. [8]

Research

- Requests for proposals should be tailored to applications of the science. [2]
- Better understanding of the science of climate change. [2]
- Impacts (and potential impacts) of invasive species on targets. [7]
- Saltwater intrusion. [8]
- Congress should fund academic/agency research on coastal consequences of extreme events. [11]
- Climate change impacts on wildlife habitats (i.e., coastal habitats, marine, estuarine, beach) and what adaptation and mitigation is needed or will be needed. [11]
- Congress should fund academic and agency (NOAA, USGS) research to examine the likely coastal consequences of extreme events resulting from climate change (rising sea level, storm intensity, flooding, surge). [11]

- State coastal zone management programs should develop databases with information on the performance of the state coastal zone management program and share this information with academic institutions, in order for research to be targeted toward filling policy and scientific gaps in these programs. [11]
- NOAA to support climate research and proposals that are interdisciplinary. [1]
- Specific information on changes in ocean temperature and impacts of climate change on sea level, flood elevations, coastal erosion, water resources, energy resources, weather, and ocean. [5]
- Possible scenarios that could result from climate change. [1, 5]
- Regional, down-scaled climate change information for local use. [1]
- Information needed about the effects of climate change at the community or watershed scale. [5]
- There is a need to understand the different causes of sea level rise. [21]
- The effects of sea level rise on beach erosion, back bay flooding, and storm damage from intensified storms are incorporated into the message given to municipalities, coastal residents, agencies, etc. during individual meetings, workshops, and seminars. [8]
- Enhancing efforts to monitor, document, understand, and model climate processes and consequences at local, island, national, and regional levels. [13]
- Time scales: processes operate on timescales from seasonal to millennial. [14]
- Biological components: species response to climate, invasives. [14]
- Analyze effect of climate change on factors that influence fruit set (by crop). [14]
- Study varietal and rootstock adaptability to climate variability. [14]
- Increased information and technology to manage changing pest populations. [14]
- Need to understand the interactions between the physical climate system and the fisheries. [14]
- Fisheries science faces a complicated task, in that basic studies of climate have only begun in the past 10-15 years, during a time when climate change is already active. It is a challenge to build foundational understanding of climate impacts on fisheries when the climate system is in flux. [14]
- Information about polar areas. [14]
- Ecosystem's role as a mitigation tool such as in carbon sequestration needs to be better researched and emphasized. [14]
- Better understanding of cloud processes. [4]
- Climate change in context of multiple stresses. [4]
- Improved information of weather- and climate-related extreme event impacts on local ecosystems, resources, and hazards. [4]
- Improved understanding of coastal sea level, waves, and swell is a critical need. [4]
- Translation of sea level rise into shoreline retreat, beach erosion, and bluff retreat rates, presented for planning-relevant time horizons. [17]
- Better understanding of littoral sand budgets and beach profile response to long-term sea level rise. [17]
- Ensure air quality results are included in global warming discussions and actions. [18]

Ecosystem Science/Impacts/Adaptation

- Priority topic: habitat changes, including wetlands and marshes. [8]
- Translate any ecological changes predicted by model not only on geologic timescale, but also human time scales. [8]
- Monitoring and mitigating impacts associated with ecological changes, such as wetlands migration. [9]
- Information, research, and guidance on environmental/habitat changes associated with sea level rise (e.g., coastal wetlands, salt wedge migration, invasive species, ocean acidification, ecosystem/species migration, freshwater resources, and improved storm surge models). [9]
- Better understanding is needed of natural erosion and deposition cycles in tidal marshes to improve our ability to predict the effects of accelerated rates of sea level rise. [9]
- Research on anticipated role of sea level rise in beach nourishment frequency and volumetric requirements, as well as the potential use of artificial sediment supplies to "nourish" coastal wetlands. [9]
- Research to understand the potential for latitudinal habitat changes as climates shift. [9]
- Understanding and predicting ecological impacts of climate change. [10]
- Environmental impacts of phase shifts. [10]
- Impacts of warming water and hypoxia on nearshore waters. [10]
- Landscape response to sea level rise and salinity changes. [10]
- Improved understanding of the potential loss of habitats important for ecological services. [8]
- More research is needed on climate change impacts on ecosystem adaptation, mitigation. [11]
- There was interest in trying to model how sea level rise and surge will change nutrient dynamics in coastal waters, as well as ground water/aquifers. [6]
- Need to know longevity of restoration projects to know whether to invest. Should be evaluating restoration success based on multiple variables, including sea level rise. [6]
- Need to know effects of shoreline armoring in regard to sea level rise. [5]
- There is a lack of understanding of the connection between protection and restoration of natural areas and reduced hurricane damage. [21]
- Address consequences (of climate change) for natural systems. [13]
- Information needed on how, and how quickly, ecosystems adjust to changing climate. [14]
- We need localized climate change information to restore and protect ecosystems. What types of forest do we want in the future? Will this forest be possible given the future climate? Restricted range species often most vulnerable to climate change. [14]
- Need to recognize regional differences (including within the state of Florida, for example) when planning for the impacts of climate change because of ecological variability in a small change in latitude. [15]
- Expected temperature and precipitation changes and the effects these changes will have on management areas. [16]
- Climate/ecosystem impacts—moving from documenting change to identifying impacts and adaptations. [18]

Climate Variability and Extreme Events

- Improving information on the nature and consequences of climate conditions such as temperature, rainfall, tropical storms, and trade winds, as well as patterns of natural variability (including El Niño Southern Oscillation and Pacific Decadal Oscillation) and how they might change. [13]
- Improving understanding of extreme events, from the frequency and severity of tropical cyclones and El Niño Southern Oscillation events to trends in heavy precipitation, including current patterns of frequency and severity and improved projections of how those patterns might change. [13]
- Better understanding of changes in patterns of variability. [4]
- Better understanding of implications for extreme events. [4]
- Better understanding of the linkage between climate change, sea level rise, and wave climatology (i.e., the effects on storm frequency and intensity). [17]
- More reliable forecasting of El Niño events, and any changes in the frequency or severity of such events under climate change, including impacts on shoreline retreat rates. [17]
- Better estimates of frequency and intensity of severe storms. [14]

Modeling and Predictions

Ecosystem Modeling

- Computational models for local projections of expected changes on managed resources. [16]
- High-resolution data and models must address the challenge of separating land management effects from the effects of soils/climate on agricultural productivity. [14]
- Models that predict migration and/or vertical accretion of coastal wetlands and beaches in response to accelerated sea level rise and the consequences of taking no action. [9]
- Need to model ecological migration (of habitats and species) and impediments to that migration (e.g., dams, development)—use information to prioritize pathways for conservation. [6]
- Predict impacts of storm events on estuaries. [6]
- Modeling how the tidal hydrology in the Long Island Sound will change under the best available climate-change sea level rise forecast scenarios. [12]
- Tools that forecast expected habitat changes, especially potential loss of habitats important for ecological services. [8]
- Predicted spread of invasive species under different climate change scenarios. [7]

Integrated Modeling

- Biological information must be integrated with climate analyses to provide information and predictions on pests. [14]
- Modeling complex integrated human systems. [14]
- Predictive models showing the ecological and socioeconomic impacts of sea level rise are needed. [21]
- NOAA, USGS, Army Corps of Engineers, FEMA and other federal agencies should partner to develop integrated models that link climate to ocean and coastal processes and

the impacts to the shore (including bluffs, dunes, and barriers) ecosystem and its development (i.e., flooding). [11]
- Integrated chemical models (C, N, and pollutants) must be included in climate analyses. [14]

Regional or Subregional Scale Modeling
- Local and regional scale modeling of specific ecosystems. [16]
- Eco-region or site-specific scale projections. [16]
- Need the tie between global and regional models and feedbacks. [14]
- More work needs to be done on developing sub-models for Florida. [15]
- Can the climate prediction models for sea level rise show what private property and public infrastructure are already at risk (say in the next 10-100 years)? [8]
- In both the wine industry and the fruit industry, information that is specific to microclimate and to species/variety is required. This depends on both improved models and field trials. [14]
- Federal guidance for modeling local- and subregional-scale shoreline changes associated with varying sea level rise projections. [9]

Modeling Advancements
- Need more robust class of modeling and simulation. [14]
- More reliable models and projections (for issues such as sea level rise, coastal erosion, the Pacific Decadal Oscillation). [4]
- There is an obvious need for climate data and models that are (1) high resolution and (2) diverse. Spatial resolution is important for planning and advocacy purposes, while temporal resolution is necessary to capture the role of storms, as well as the secular climate change (and sea level rise). [14]
- Modelers, IPCC, and NOAA should develop models to decrease uncertainty for sea level rise. [11]
- Improve climate monitoring and prediction; integrate climate information (e.g., ENSO). [13]

Modeling of Climate Variability and Extreme Events
- Develop/improve crop-specific models that predict effect of temperatures on winter hardiness. [14]
- Develop winter climate models. [14]
- El Niño Southern Oscillation–related seasonal precipitation forecasts. [20]
- Seasonal drought prediction and monitoring. [20]
- Federal guidance for modeling local- and regional-scale effects of storm events, coupled with rainfall, river flooding, and sea level rise projections. [9]
- Short-term freeze prediction for crops. [20]
- The IPCC or NOAA should come up with a more reliable sea level rise number. [11]
- Models need to be dynamic—need to be able to add new data as become available. [6]
- Developing reliable projections of climate change and predictions of climate variability on various timescales. [13]

Education

- Education brought down from global to local issues. [2]
- Establish open dialogue with stakeholders for education. [2]
- Climate experts to speak to the public to explain the science and show how they are addressing climate change, putting it all in context of what is already happening. [2]
- There is a need to understand the different causes of sea level rise. [21]
- Improved local government education/translation. Translation to decision making. [8]
- Public education/translation. [8]
- Improve public understanding of environmental effects of shoreline change. [22]
- There is a need to raise awareness in coastal communities that sea level rise is occurring. [21]
- Educate public communities on climatic patterns (storm and non-storm), including global warming. [22]
- Congress should fund education programs supporting integrated natural science and public policy curriculums (specifically climate change impacts to region, state curriculum K-12 and higher education; also for university to re-evaluate curriculum.) [11]
- To connect science to decision makers and the public, coastal program managers should team with universities in their states to host massive educational campaigns aimed at a) coastal residents, b) college students, and c) elected officials to build shared awareness of climate change basics, including science, range of potential impacts to that state's coastline, variables that will affect those outcomes, and where choices lie (decisions that will have to be made). [11]
- NOAA should package climate information for teachers. [1]
- NOAA should develop COMET quality training modules on basis and impacts of climate change for e-learning. [1]
- Educational component in school system. [5]
- An informational brochure for the public and educational information for decision makers to inform communities about effects of climate change. [5]
- Education and climate literacy are at the heart of all these efforts (students, public, and decision makers). [18]

Training

- Learning to translate models. [2]
- Needed training topic: climate forecasting. [23]
- Training on planning for climate change. [23]
- Priority topic: local government education/translation. Translation to decision making. [8]
- Demonstrate technologies to help managers quantify risks of hazards and select effective mitigation measures. [22]
- Train coastal managers on GIS/remote sensing and data retrieval and use. [22]

- There is a need not only to provide decision-making tools, but also to provide training and technical assistance at the local level in applying those tools. [21]
- Training for sea level rise, shoreline change models, and adaption strategies for coastal communities. [9]
- Training on local and regional perspectives on climate change impacts. [9]
- Technical training for coastal program managers in shoreline delineation, mapping, vertical and horizontal reference datums, mapping errors and error quantification, and legal definitions. [9]
- There needs to be information on training opportunities; if there are no opportunities, there needs to be more awareness of the issue. [11]
- Coastal managers need to tell nongovernmental organizations, feds, etc. what training they need. [11]
- Training opportunities should be provided to coastal managers by appropriate agencies. [11]
- There is a need to provide training modules for specific user groups (e.g., Future Farmers of America, tobacco farmers, Hispanic migrant workers). Training for nonpoint source pollution, for example, might include the use of irrigation schedules for water consumption and optimal conditions for pesticide applications. Training levels should be geared to a user group's level of knowledge and complexity of integration. [20]

Integrated Solutions/Adaptation Strategies/Adaptive Management/EBM

- Improve ability of local governments to identify and address hazards. [22]
- National Science Foundation or other group should combine uncertainties of social, physical, and biological science for comprehensive risk management. [11]
- Integrate existing climate information (e.g., El Niño Southern Oscillation forecasts) into healthcare and emergency-services planning regularly. [13]
- Integrate information on climate variability and change into planning and decision making in key sectors, most notably water resource management and agriculture. [13]
- Integrated Coastal Zone Management. [13]
- Integrated information and comprehensive data, management tools and ability to proactively undergo restoration/preservation, increased funding for monitoring and technology to better communicate results. [14]
- Integrated approach to tackling climate change needed. [14]
- Science and information to support coping with a changing climate, including adaptation and mitigation, proactive planning, short-term needs and long-term planning, place-based and problem- and solution-focused, sustained user engagement throughout, as well as mechanism for continuous evaluation of products/services. [18]
- Links to other NOAA themes and resource management responsibilities. [18]
- Integration, from observations to users and back again. [18]

Water Resources

- Having organized approach to dealing with impacts of climate change, such as flooding from rain and saltwater intrusion (dykes, pumps) [8]
- Aquifer problems—saltwater intrusion, increased cost of water. [8]
- Drought is a big issue in the Southeast right now and a drought workshop will be held in Atlanta in April. More importantly, a National Integrated Drought Information System (NIDIS) pilot is being proposed in the Southeast. The purpose is to provide better drought risk information to the states by developing and demonstrating a variety of early warning and drought-risk-reduction tools, information, and strategies in partnership with users and federal, state, regional, and local agencies. Having early warning systems sensitive to extremes from seasons to years to decades is essential to meeting the regional demand for climate impacts and adaptation information. [10]
- Water resource management needs monthly seasonal climate forecasts for the service area, as well as adjacent regions. [20]
- Integrate climate information in drought mitigation plans (mentioned in an agricultural context). [13]
- Incorporate sea level rise considerations in water management infrastructure refurbishing. [15].
- Information about potential changes in runoff, pollutant loads, salinity, and nearshore coastal and estuarine water temperatures, and exploration of the implications of such changes for water quality, water availability, and aquatic ecology. [17]
- Provide GIS compatible data feeds. [18]
- Increase availability of probabilistic forecasts for decision makers. [18]
- Expand inundation-mapping services with GIS overlay. [18]
- Provide drought data and forecasts: long- and short-term water resource information and projections. [18]

NOAA/Federal Role

- Supports legislation that encourages NOAA and other agencies to assist states via technical assistance, mapping, modeling, data, and forecasting products, and intergovernmental coordination. Federal activities related to coastal adaptation should also be coordinated with coastal programs early in the planning process. [9]
- Interagency coordination on coastal adaptation to climate change and shoreline management issues, especially focusing on NOAA, state coastal management programs, FEMA, and state floodplain managers. [9]
- Recognition by Congress and the administration that the Coastal Zone Management Act is a primary statute that can foster climate change adaptation at state and local levels. [9]
- Federal support of state and local policy analyses to increase awareness among state coastal program managers of adaptation strategies and policy options, along with their potential implications. [9]
- NOAA needs an “Integrated Climate Information System” including a clearer vision of its role. [1]

- NOAA should be positioned to quickly respond to expected opportunities, including planning and budgeting strategies related to climate change. [1]
- NOAA needs a referral system so customers can be passed along to a qualified individual for response to inquiries. [1]
- NOAA leadership/facilitation is essential. [18]
- Recognition of NOAA as a provider of climate services with evolution from individual efforts to a coordinated enterprise learning from good models (National Integrated Drought Information System, Regional Integrated Sciences and Assessments) [18]
- Shared commitment to and responsibility for a National Climate Service that is international and multiagency, including government at all levels, business, nongovernmental organizations, the scientific community, educators, and public and private-sector partners. [18]
- Want NOAA to be a steward, referee, facilitator of place-based climate trends. [18]
- NOAA should focus and define efforts and capabilities, not compete with or duplicate efforts of other agencies. The agency could provide more leadership for key National Response Plan responsibilities. [18]

Funding

- Project summaries to attract funds and collaborators. [7]
- Additional financial support to better address climate change, including research and data acquisition, expansion of permitting and enforcement/compliance activities, and increase in technical and planning staff members to build capacity. [9]
- Congress and state governments should increase coastal habitat restoration funding and address the long-term sustainability of restoration projects. [11]
- Request for proposal (RFP) process should include applied models that respond to planners' needs, address uncertainties, and avoid duplication of effort. [11]
- Federal agencies should do a better job of issuing RFPs (have actual application, relevant to managers, make sense to the scientific process) and coordinating among themselves, given limited funds, in order to limit redundancy. [11]
- Congress should dramatically increase coastal habitat restoration funding. Information addressing long-term sustainability against sea level rise should be included (greenway planning acquisitions allow for migration, private partnerships encouraged). [11]
- Extrapolate/extend the North Carolina National Centers for Coastal Ocean Science-funded ecosystem impacts or sea level rise work to the Panhandle region as much as possible. [6]
- Financial assistance to local governments to prepare and implement plans to reduce greenhouse gasses. [5]
- Funding to do local assessments of vulnerability of infrastructure, especially sewer. [5]

Legislation

- Congress should amend the Coastal Zone Management Act to include a provision for coastal states to develop an adaptation plan and funding to provide relevant information. [11]
- State and local agencies should be encouraged/incentivized to have long-term climate change (such as sea level rise) be a required component of enhanced state and local mitigation plans required by the Disaster Mitigation Act of 2000. [11]
- Congress should enact a law requiring FEMA to consider sea level rise in identification of coastal flood hazards; flood insurance and minimum floodplain management criteria through the National Flood Insurance Program (NFIP) should be modified appropriately. [11]
- Congress should mandate that all coastal states address how sea level rise will impact their coastal communities through local schools up to state regulatory agency level. [11]
- Priority topic: strategies for incorporating this information into planning, policies, and regulations (at appropriate scale). [8]
- Routine integration of climate information into planning and regulatory regimes. [13]

Ocean Observation Applications

- More accurate, higher-resolution, reliable forecasting models—ocean observations essential. [4]
- Documentation of successful forecasting applications. [4]
- Insights into constraints and opportunities (scientific, technical, institutional, communications). [4]
- Recognize experience and resilience of Pacific Islands. [4]
- Better understanding of cloud processes, patterns of variability, and implications for extreme events. [4]
- Need to understand climate change in the context of multiple stresses. [4]
- Need for improved information on weather and climate-related extreme events. [4]

Storm Surge (Modeling and Mapping of Storm Surge Included)

- More floodplain and surge/inundation mapping was identified as a key need, along with improved surge predictions and hurricane intensity and track forecasting. [21]
- There is a need for a standardization of both surge modeling and mapping. [21]
- Run the SLOSH model more often, including having runs 48-hours out to inform the local decision making. [21]
- There is a need (from the public perspective) to understand the Saffir-Simpson scale, and many citizens are not familiar with their evacuation procedures. [21]
- New outreach and education materials need to be developed (storm surge), and new visualization techniques are again highlighted. [21]

- Need a study on how to combine joint probability of event occurrence such as storms and high wave energy and high tide. [11]
- Congress should fund academic and agency (NOAA, USGS) research to examine the likely coastal consequences of extreme events resulting from climate change (rising sea level, storm intensity, flooding, surge). [11]
- Army Corps of Engineers should provide study on how to combine joint probability data of event occurrence—storm and wave energy. [11]
- Develop new storm surge models and develop the real-time surge network similar to Carolina Ocean Observing System. [12]
- Users need storm surge community-level risk and vulnerability information. [8]
- NOAA could support the development of alternative storm surge models or improve upon SLOSH. [18]

Additional Pacific Region Needs

- Ocean Climate Information System. [4]:
  An ocean climate information system would comprise a consolidation of historical and contemporary ocean in-situ and satellite data (including wave climatology), arranged either for individual Pacific Island countries and territories or for the region as a whole. Synergies with other projects, programs, and observing systems include the following:

  - Access to relevant integrated products (including waves, water level, marine conditions, storm surge [also return periods, second moments]), with the Community Risk and Community Lifelines project.
  - Develop and maintain an inventory of available data and products (metadata level information), with the Pacific Islands Global Climate Observing System (PI-GCOS), and perhaps the Global Observing Systems Information Center (GOSIC).
  - Develop a Pacific Island climate information service with PI-GCOS and interested regional groups, a viable assumption being that the clearinghouse function for climate would be coordinated through the PI-GCOS project, since it is able to coordinate with National Meteorological and Hydrological Services and other regional climate interests.

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