ECOSYSTEM RESEARCH SCIENCE CHALLENGE WORKSHOP:

INFORMING NOAA'S ECOSYSTEM RESEARCH AGENDA

November 29 – December 1, 2011
Silver Spring, MD

Co-Chairpersons: Laura Letson and Bob Wood

Prepared by Ecosystem Research Science Challenge Workshop Organizing Committee
Edited by Mike Allen

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EXECUTIVE SUMMARY

An integrated, interdisciplinary ecosystem approach to research is critical to support and sustain the ecosystem services that are key elements of NOAA's mission and mandates.

The NOAA Research Council convened the **Ecosystem Research Science Challenge Workshop (ERSCW)** to further address two of NOAA's science challenges that were identified in the 2010 NOAA "Workshop on Strengthening NOAA Science." These were to:

- Assess and understand the roles of ecosystem processes and biodiversity in sustaining ecosystem services; and
- Develop and evaluate approaches to substantially reduce environmental degradation.

The NOAA Research Council also sought to use the ERSCW as a forum to solicit input on NOAA's forthcoming Ecosystem Research Agenda and the science necessary to support it. With that charge, the workshop organizing committee structured the workshop around a vision for ecosystem research at NOAA: a comprehensive Ecosystem Research Agenda would strategically align and integrate the agency's science assets, partnerships, and capabilities to facilitate the research needed to support the sustainable use, protection, and restoration of coastal and marine ecosystems, as well as the ecosystem services they provide.

The ERSCW was the first time that social and natural scientists from across NOAA and its partners (Federal agencies, academic institutions and non-governmental organizations) had met to discuss ecosystem research. Specifically, the ecosystem research needed to support the suite of ecosystem services that NOAA's mandates require the agency to address. As a result, this new perspective created a ground swell of support for an integrated, interdisciplinary ecosystem approach to research that meets the challenges identified above. The participants recommended:

> NOAA should develop and implement a comprehensive strategy for an ecosystem approach to research. NOAA's Ecosystem Research Agenda should build a greater understanding of the ecosystem processes and dynamics that support and sustain the ecosystem services that are key to meeting NOAA's mandates and mission. This approach should be structured around key questions about the environmental and societal factors that affect ecosystems, the responses of ecosystems to these factors, and the subsequent effects on ecosystem services, as well as questions about the ecosystem services that affect the human condition.

NOAA defines *ecosystem research* as the systematic study directed toward fuller scientific knowledge or understanding of geographically determined systems of organisms (including humans), the environment, and the processes that control the system dynamics.

Environment is the biological, chemical, physical, and social conditions that surround organisms.

- Adapted from Murawski & Matlock, 2006[1] and OMB, 2004[2]

To effectively address the issues raised in the workshop, NOAA must:

Advance the science

- Understand how critical ecosystem structure and processes are affected by natural and anthropogenic variability, stressors, and other external variables;
- Integrate the appropriate social science disciplines into NOAA's ecosystem research, from project design and implementation to translation of results, to better characterize and value ecosystem services, evaluate tradeoffs, and assess how ecosystem services influence ecosystems, including their socio-cultural, economic, political and institutional conditions; and
- Promote innovation in science, technology and methods that allows NOAA to better use existing ecosystem research capabilities, including advances in research, monitoring, modeling, and data management.

Transform NOAA's practices and approach to promote integrated research

- Leverage internal and external partners' resources and capabilities;
- Enable flexible budget and personnel mechanisms that promote new partnerships within and outside the agency; and
- Foster innovative ecosystem research approaches by training scientists in multidisciplinary methods and promoting collaboration that supports ecosystem research.

Motivate change

- Foster support and leadership for an integrative ecosystem research approach across all levels of NOAA;
- Develop and communicate compelling narratives to connect NOAA's ecosystem science with the ecosystem services that people value; and
- Establish and promote knowledge and communication networks to rapidly disseminate innovative ideas and approaches within and outside NOAA.

[1] Murawski, S.A., and G.C. Matlock (editors). 2006. Ecosystem Science Capabilities Required to Support NOAA's Mission in the Year 2020. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-F/SPO-74, 97 p.
[2] OMB Circular A-21: Cost Principles for Educational Institutions (05/10/2004) (Section B.1.b)

Introduction

In April 2010, NOAA organized a "Workshop on Strengthening NOAA Science[3]", bringing together scientists and managers to identify the grand science challenges facing NOAA, as well as barriers to effectively conducting cutting-edge science at the agency. The 2010 Science Workshop Program Committee recommended follow-up workshops to explore specific science challenges in greater depth and to do so in collaboration with external partners. Four such workshops, including the Ecosystem Research Science Challenge Workshop (ERSCW), were held. The ERSCW sought to address two of the challenges posed by the 2010 committee:

- Assess and understand the roles of ecosystem processes and biodiversity in sustaining ecosystem services; and
- Develop and evaluate approaches to substantially reduce environmental degradation.

In December 2010, Dr. Jane Lubchenco challenged NOAA to develop a holistic Ecosystem Research Agenda that would coordinate the dispersed collection of ecosystem research activities across the agency. The NOAA Research Council thus sought to use the ERSCW as a forum to solicit input on the Ecosystem Research Agenda and the science necessary to support it. With that charge, the workshop organizing committee structured the workshop around a vision for ecosystem research at NOAA: a comprehensive Ecosystem Research Agenda would strategically align and integrate the agency's science assets, partnerships, and capabilities to facilitate the research needed to support the sustainable use, protection, and restoration of coastal and marine ecosystems, as well as the ecosystem services they provide.

To this end, the workshop was designed to encourage workshop participants to provide input about how NOAA could take an integrative and holistic approach to ecosystem research. Participants were drawn from across NOAA's Line Offices, other Federal agencies, academic institutions, and NGOs. They represented NOAA's diverse portfolio and geographic range with expertise ranging from economists to anthropologists in the social sciences and from marine biologists to climate scientists in the natural sciences with expertise in atmospheric, terrestrial, freshwater, and marine environments. The participants were assigned to small breakout groups that discussed one of four major ecosystem service themes central to NOAA's ecosystem mandates (Figure 1). Organizers recognized that the content of the themes overlapped and encouraged participants to highlight those interconnections and interdependencies. To ensure each group had a diversity of perspectives, some individuals were placed in groups addressing topics that were not necessarily the focus of their primary expertise. NOAA and non-NOAA participants were encouraged to forgo any potential Line Office and home organization allegiances and to think beyond their areas of expertise. Groups discussed the ecosystem services, key topics, and research

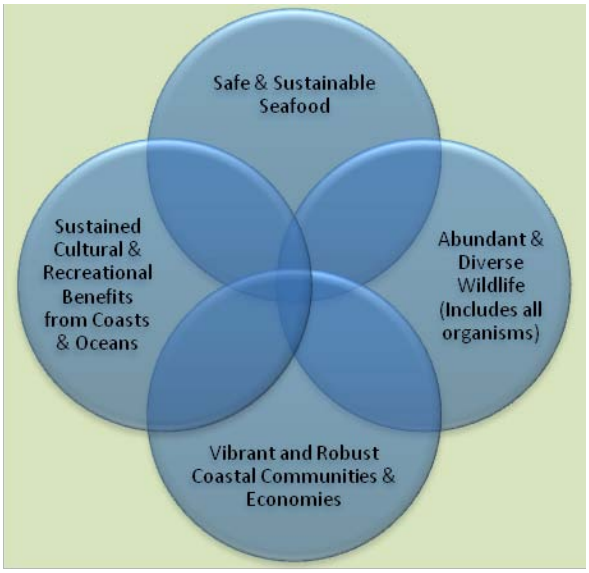

FIGURE 1: ECOSYSTEM RESEARCH THEMES

[3] Sandifer, P. and Dole, R. Strengthening NOAA Science: Findings from the NOAA Science Workshop. Report to the NOAA Research Council. 2010.

questions associated with their assigned theme. Additionally, participants provided some examples of research topics and questions that could be more fully developed and prioritized in subsequent efforts.

STRATEGIC VISION FOR ECOSYSTEM RESEARCH AT NOAA

The purpose of this document is to provide initial input to inform the development of a comprehensive NOAA Ecosystem Research Agenda that strategically aligns and integrates the agency's science assets, partnerships, and capabilities to facilitate the research needed to support decisions about the sustainable use, protection, and restoration of coastal and marine ecosystems, as well as the valuable ecosystem goods and services that they provide. NOAA will more effectively fulfill its mandates and accomplish its mission by *transforming* the agency's current approach to ecosystem science, while *maintaining* and *enhancing* the exceptionally high value of existing research and monitoring programs.

Participants at the ERSCW provided an overarching recommendation to achieve this agenda:

> NOAA should develop and implement a comprehensive strategy for an ecosystem approach to research. NOAA's Ecosystem Research Agenda should build a greater understanding of the ecosystem processes and dynamics that support and sustain the ecosystem services that are key to meeting NOAA's mandates and mission. This approach should be structured around key questions about the environmental and societal factors that affect ecosystems, the responses of ecosystems to these factors, and the consequent effects on ecosystem services, as well as questions about the ecosystem services that affect the human condition.

Participants quickly agreed that a focus on optimizing the value of ecosystem services delivered to society provides a useful framework for discussing ecosystem research at NOAA. The construct framed by ecosystem services requires that NOAA's applied science is directed to understand what benefits society wants from ecosystems and what science is necessary to inform NOAA's management actions and policies. The vision for this transformative approach to ecosystem research includes: advancements in interdisciplinary, cross-agency ecosystem science; improved understanding of the fundamental dynamics of ecosystems; and incorporation of relevant natural and social science disciplines into NOAA's Ecosystem Research Agenda. To enhance the effectiveness of research, NOAA must work to enhance integration and communication across these disciplines throughout the planning and implementation phases of ecosystem research endeavors. By doing so, NOAA will dramatically increase its capacity to inform the management of coastal and marine ecosystems and resources.

Transformation begins with action.

A comprehensive and effective Ecosystem Research Agenda will require NOAA to:

- Integrate across programs, partners, approaches, mandated activities, and social and natural science disciplines, and effectively build synergy across NOAA's complementary ecosystem research programs;
- Identify and address gaps in NOAA's Ecosystem Research Portfolio;
- Encourage internal and external partnerships that build ecosystem research capacity;
- Support research into key factors that impact valuable ecosystem services; and
- Ensure sustained support for existing long-term observation and monitoring systems, modeling/forecasting capabilities, and core research strengths.

To accomplish this, a framework should be established that will organize NOAA's ecosystem research in a way that enables and encourages integration across disciplines and offices, providing a multi-scale understanding of:

- Human activities and natural variability that affect ecosystem processes, and consequently, the provision of ecosystem services;
- Institutional and cultural contexts for interactions between human communities, healthy and sustainable ecosystems, and the production, delivery, and valuation of ecosystem services; and
- The links between ecosystem services and ecosystem management goals, including the effects of management strategies on ecosystem services and the value of these services to society.

This framework will inform an implementation strategy to create a mechanism for NOAA to identify complementary relationships among individual ecosystem research efforts; assess current research resources and investments both within NOAA and with the agency's external partners; and set research priorities based on complementarities, synergies, and gaps.

TOWARD A STRENGTHENED ECOSYSTEM RESEARCH PORTFOLIO

NOAA should adopt, pursue and provide resources for an integrative approach to ecosystem research, particularly by incorporating the relevant social and natural science expertise at the inception of the research, and by working to maintain integration throughout the development and implementation of projects and the Agenda. Implementing the workshop recommendations will require all levels of NOAA to support fundamental transformation of NOAA's approach to ecosystem research. This transformation, which builds off NOAA's previous successes and strong science portfolio, will involve *advancing the science, transforming NOAA's practices and approach to promote integrated research,* and *motivating change*. Workshop participants recommended the following strategies be incorporated into NOAA's Ecosystem Research Agenda:

Advance the science

- Understand how critical ecosystem structure and processes are affected by natural and anthropogenic variability, stressors, and other external variables;
- Integrate the appropriate social science disciplines into NOAA's ecosystem research, from project design and implementation to translation of results, to better characterize and value ecosystem services, to evaluate tradeoffs, and to assess how ecosystem-services influence ecosystems, including their socio-cultural, economic, political and institutional conditions; and
- Promote innovation in science, technology and methods that allows NOAA to better use existing ecosystem research capabilities, including advances in research, monitoring, modeling, and data management.

Transform NOAA's practices and approach to promote integrated research

- Leverage internal and external partners' resources and capabilities;
- Enable flexible budget and personnel mechanisms that promote new partnerships within and outside the agency; and
- Foster innovative ecosystem research approaches by training scientists in multidisciplinary methods and promoting collaboration that supports ecosystem research.

Motivate change

- Foster support and leadership for an integrative ecosystem research approach across all levels of NOAA;
- Develop and communicate compelling narratives to connect NOAA's ecosystem science with the ecosystem services that people value; and
- Establish and promote knowledge and communication networks to rapidly disseminate innovative ideas and approaches within and outside NOAA.

Workshop participants discussed a variety of options for fostering ecosystem research innovation and implementation at NOAA. These ideas, in conjunction with examples of successful ecosystem research activities at NOAA, can provide a starting point for internal discussions on how to implement a new ecosystem research framework across the agency.

Advance the Science

NOAA's ecosystem research currently emphasizes characterizing and monitoring critical ecosystem components to provide a robust understanding of the status and trends of ecosystems and the services they provide. However, research that provides an understanding of the mechanisms controlling ecosystem function and resilience is incomplete. Reliably predicting ecosystem changes caused by diverse human and natural perturbations, and subsequent impacts on the delivery of ecosystem services, requires more research focused on ecosystem responses.

Understanding the connections between ecosystem functions and their associated drivers of change, and the natural and social impacts that result from these connections, is also critical to this Ecosystem Research Agenda. Traditionally, NOAA has focused on priority elements associated with activities that have significant economic value (such as commercial fishing). NOAA's current efforts include elements of these relationships, but there are significant gaps, both in terms of the breadth of the social, cultural, economic, political and institutional/governance elements that are studied, and in quantification of how changes in ecosystem conditions affect these elements. To more fully incorporate these elements, NOAA must engage social scientists in ecosystem research, from project design and implementation to translation of results. This approach must also include more research into how best to value ecosystem services, how to assess tradeoffs between services, and the importance that different sectors of society attach to various services.

National Estuarine Research Reserve Climate Sensitivity Analysis Project: A Synthesis of Ecological and Socio-demographic Data to Understand Reserve Sensitivity to Climate Change

NOAA's Estuarine Reserves Division and Climate Program Office are taking a multidisciplinary approach to identify stressors that impact critical habitat and ecosystem processes in National Estuarine Research Reserves. Currently, the NOAA partners (NCCOS Oxford Lab and University of Wisconsin) are synthesizing data that describe the physical, ecological, and sociological attributes of the Reserves and categorizing Reserves based on their key attributes and sensitivities to natural and anthropogenically induced stressors. Preliminary results suggest key indicators of habitat condition (e.g., salinity, dissolved oxygen) are sensitive to environmental stressors (e.g., increased precipitation) in some Reserves, while the impact of the stressor is less pronounced elsewhere. This approach will incorporate both the natural and social attributes of Reserves, providing foundational information to guide management decisions and future vulnerability assessments that consider climate impacts on the diverse suite of ecosystems services provided to natural and human communities.

As ecosystems are a complex set of interactions and feedbacks, there is often a tendency to oversimplify and focus on single-issue science. While discipline-specific inquiry is important and necessary, more complete knowledge of ecosystem structure and function must integrate multiple perspectives. Multidisciplinary teams are critical to assess the impacts of multiple stressors acting simultaneously on systems. NOAA can use its place-based management programs to ensure a holistic ecosystem perspective is applied: where routine monitoring and examinations of key processes are integrated to explain observed changes and to develop insight, diagnostic ecological indicators, forecasting capabilities, and management options.

Transform NOAA's practices and approach to promote integrated research

Conducting problem-driven science within an ecosystem approach to research requires integrating the social and natural sciences (including atmospheric, terrestrial, and marine sciences). Such a holistic perspective is too large for any agency to do alone. NOAA must continue to leverage the diversity of mandates under which it does its research, as well as work with and better integrate the capabilities of its external partners — academic institutions, Federal and state agencies, NGOs, and industry, both domestic and international — to promote innovation. This will help to avoid duplication and improve efficiency and effectiveness of the research portfolio.

The participants recognized the importance of the discipline-specific mission of each line office, but emphasized a holistic ecosystem approach to research is a powerful a tool for providing the best available science to meet the diversity of NOAA's mandates. They suggested NOAA would conduct more effective ecosystem research if the research is planned and executed in an integrated, cross-cutting manner. Successful integration will require: identification and facilitation of new, transformative, and innovative ideas; testing of new models of coordination; creative mechanisms for fostering connectivity and exchange of ideas between groups; and collective investment of staff and other resources to a common goal.

Currently, funding is administered and allocated within each line office, and this mechanism does not readily support the integrated nature of ecosystem research as discussed in this report. Learning from successful, cross-line office efforts to develop integrative research[4], a variety of models could be considered. One option is to develop an "Innovation Fund" that would support a multidisciplinary and multi-line office research framework. Such a fund could be administered as a competitive research program for scientists within and outside of NOAA, and would encourage teams to creatively tackle elements of an ecosystem research plan (such as those described in this report). The ultimate goal would be for a majority, if not all, of this innovation fund to be used for sustained, integrative research that would incorporate the knowledge gained from NOAA's excellent ongoing disciplinary work.

Another suggestion was for NOAA to develop an integrated and interdisciplinary ecosystem research plan that incorporates natural and social science components at the fundamental working level. A small team of scientists (5-10), reporting directly to the Administrator, could be detailed and funded for an extended period of time (e.g., 1-2 years) to facilitate the creation of this plan and promote interdisciplinary ecosystem research activities. Actively communicating with both internal and external (domestic and international) scientific colleagues, this team would identify and communicate compelling ideas and approaches (both incremental and transformative). The plan should also consider issue of scales, particularly those most relevant to conservation, management, and provisioning of ecosystem services, recognizing that ecosystem

[4] Appendix 4: Initial List of Ideas of Where to Look for Best Practices

research is often conducted at local-to-regional scales, with some work being done on a global scale. As such, NOAA regional entities should be closely consulted, as they will be the primary implementers of the research plan.

To enable scientists to work more collaboratively on this portfolio, participants noted that many NOAA scientists have not had opportunities to develop their skills and experience in integrative, multidisciplinary science. Providing such opportunities, as well as occasions to connect with partners from other disciplines, would speed an organizational transformation. This workshop, for example, provided a forum for participants to explore new collaborations and improved their understanding of the other science disciplines that are contributing to NOAA's ecosystem research portfolio. Future workshops and other fora that foster innovation (e.g., Gordon Research Conferences or the like) would be useful. An integrated science conference, including representation from the natural and social sciences necessary to solve complex problems, would provide informal development and collaboration opportunities to think creatively on key interdisciplinary issues.

NOAA should also consider bringing in fresh perspectives through internal staff scientist rotations or details and visitation programs with other agencies and academia. A formal mechanism for internal scientists to rotate among NOAA laboratories and science centers would broaden scientists' exposure to different approaches and ideas. Scientists should also have opportunities to act as science managers through rotations or details to improve their understanding of and skill at scientific administration and to bring alternate perspectives to management challenges.

Setting Ecosystem-based Management Goals for South Florida

NOAA has taken a fresh approach for using science to affect management actions that improve the state of South Florida's coastal marine ecosystems. This approach brought together both natural and socioeconomic scientists, managers, and non-governmental organizations to reach consensus on a set of ecosystem-based management goals for South Florida's coastal waters that were specific and measurable. To build consensus and synthesize science in a manner useful for managers, Marine & Estuarine Goal Setting for South Florida (MARES) revised the DPSIR (Driver-Pressures-State-Impacts-Response) model, which describes the interactions between society and the environment, by replacing the "I for Impacts" with an "E for Ecosystem Services." The use of the DPSER model has allowed resource managers and scientists to focus on determining how human activities alter the production of ecosystem services. Thus, they will be able to propose responses that will sustain and/or maximize the production of a diverse set of ecosystem services, which is the goal of ecosystem-based management.

In the longer-term, NOAA should develop a mechanism for recruiting and deploying scientists to carry out an ecosystem research program. This must include the correct mix of disciplines, experience, and hiring authorities (FTE, term, post-docs, and visiting scientists). Scientific career tracks also need to be redefined and implemented such that scientists can advance in their careers within NOAA and be promoted to the highest levels without having to become line, program or project managers. This issue has been previously

identified[5,6] and hopefully will be addressed at the earliest opportunity so as to recognize and adequately value the important contributions being made by "working-level" career scientists at NOAA.

Motivate Change

While NOAA's culture is open to innovation, both the competing requirements of different groups working within their respective mandates, and integration across organization-, discipline- and mission-related boundaries, present significant challenges. To make progress on these challenges, NOAA leadership must champion a process that includes specific goals for integration. This could include redefining performance measures to foster an atmosphere that better supports integrative ecosystem service science. More broadly though, this process should encourage innovative, interdisciplinary ideas that result in an atmosphere of scientific creativity founded on integration and a commitment to filling key ecosystem research knowledge gaps.

NOAA cannot accomplish a truly integrated Ecosystem Research Agenda without substantial engagement and collaboration both across the agency and with external partners[7]. It is important that NOAA includes partners' input in the development and implementation of an ecosystem research framework. Creating lasting organizational change will only occur if scientists and partners collaborating on the research are actively engaged in promoting ecosystem research at the same time that leadership, at all levels of the organization, are also championing the changes from above. All engaged parties must see progress to build trust and long-term success.

To more effectively communicate the value and potential of integrated ecosystem research to support and sustain the ecosystem services that are key elements of NOAA's mission and mandates, both within and beyond NOAA, NOAA should engage communication experts (internal NOAA experts as well as external partners such as COMPASS) to provide expertise and assistance. NOAA should develop compelling narratives and a collection of success stories (such as the ones highlighted in boxes in this report) demonstrating the value of this integrative approach, within NOAA, among our partners, and to Congress and the public. This white paper lays the foundation for these communications efforts, and as such, has broader utility beyond the Research Council (RC). The RC should lead the way as a strong champion for changing the way that NOAA conducts ecosystem research, identifying actions for implementation, and helping to spread the message that such changes will help NOAA better meet its mission and mandates.

Workshop participants suggested two additional options for motivating change. First, a comprehensive knowledge management system with advanced IT solutions is needed for information sharing, communication, networking and meetings, and other hard and soft knowledge management strategies to proactively identify and connect communities of practice, clusters of expertise and knowledge, and enable opportunities for collaboration and innovation. For example, social networking tools could be used to: reach out and educate people about the issues; rally for action; and collect data on people's perceptions of hot topics, management actions and values. Wikis or blogs[8] can ensure that there is interactive follow up to the ERSCW and this report, allowing individuals within and external to NOAA to share ideas, exchange and assess best practices, etc. Second, where productive

[5] Sandifer, P. and Dole, R. Strengthening NOAA Science: Findings from the NOAA Science Workshop. Report to the NOAA Research Council. 2010.
[6] Integrating Social Science into NOAA Planning, Evaluation and Decision Making: A Review of Implementation to Date and Recommendations for Improving Effectiveness. A Report from the NOAA Science Advisory Board. 2009.
[7] Engaging NOAA's Constituents: Putting the pieces together to create impacts. A Report from the NOAA Science Advisory Board. 2008.
[8] For example: http://noaaoceanscience.wordpress.com/

collaborations are being developed (or already exist), mechanisms reinforcing these efforts should be pursued, including augmenting resources and personnel, or recognizing efforts with nominations and awards.

NEXT STEPS

Transforming NOAA's approach to ecosystem science will require dedicated and focused actions that are identified and implemented by NOAA scientists, managers, and leadership. Partnerships, both within and external to NOAA, will be critical to achieve interdisciplinary, cross-agency ecosystem science focused on understanding the fundamental patterns, processes, and drivers of ecosystems (including ecosystem change), while strategically incorporating relevant natural and social science into the research process. Transformation begins with action, and thus what NOAA does next is critical.

Workshop participants voiced a strong opinion that this report should be a living document that continues to grow and inform other efforts. While not an exhaustive list, future efforts should:

- Inform input into NOAA's Strategy, Execution and Evaluation (SEE) Process;
- Develop NOAA's Ecosystem Research Agenda;
- Develop and implement a framework that furthers our understanding of current NOAA's capabilities and gaps to organize and prioritize ecosystem research;
- Ensure sustained communication and exchange of ideas (e.g., best practices, communities of practice) following the workshop through collaboration tools (e.g., Wiki, blog, Google Docs);
- Inform NOAA's Five Year Research Plan;
- Explore mechanisms to synthesize and analyze thematic areas to derive overarching fundamental research questions (Wiki or future workshop);
- Share findings with the steering committee that leads NOAA's efforts to incorporate President's Council of Advisors on Science and Technology recommendations into NOAA policy;
- Identify "little bets"[9] that can be supported to begin to encourage innovation in ecosystem research and implement workshop themes as NOAA works towards a larger, sustained mechanism for interdisciplinary research; and
- Develop measures of success that demonstrate progress and highlight outcomes to society.

Why were 70-80% of the Oyster larvae dying?

Researchers in the Pacific Northwest studied the role of chemical oceanography and life history ecology to understand the impacts of ocean acidification on northwestern shellfish populations. High seawater acidity and low concentrations of aragonite, a form of calcium carbonate critical to shell formation, made it difficult for the oyster larvae to attach to their shells. Survival was affected when deep ocean water with higher acidity was pushed onshore. Now instead of treating the oysters for bacteria, shellfish farmers monitor seawater acidity, alter their timing of water intake into their hatcheries to avoid ocean water with higher acidity, and buffer the chemistry of the tanks to optimize larvae production. Although the effects of ocean acidification were less extreme in 2010 and 2011, these efforts ultimately helped bring the industry back from the verge of collapse.

[9] Sims, P. Little Bets: How Breakthrough Ideas Emerge from Small Discoveries. New York; Free Press, 2011.

APPENDIX 1: WORKSHOP ATTENDEES BY BREAKOUT GROUP, PROGRAM COMMITTEE, STAFF, & GUESTS

Safe & Sustainable Seafood

Clarissa Anderson	University of California Santa Cruz
Paula Bontempi	NASA
Steve Gittings	NOAA NOS Office of National Marine Sanctuaries
Mark Eakin	NOAA NESDIS Center for Satellite Applications and Research
Todd Gedamke	NOAA NMFS Southeast Fisheries Science Center
John Haines	US Geological Survey
Philip Hoffman	NOAA OAR Office of Laboratories and Cooperative Institutes
Mike Neubert	Woods Hole Oceanographic Institute
Kenric Osgood	NOAA NMFS Office of Science and Technology
Laurie Richmond	NOAA NMFS Pacific Islands Fisheries Science Center
Phyllis Stabeno	NOAA OAR Pacific Marine Environmental Laboratory
Juli Trtanj	NOAA NOS National Centers for Coastal Ocean Science, Hollings Marine Laboratory
Henry Vanderploeg	NOAA OAR Great Lakes Environmental Research Laboratory
Kristy Wallmo	NOAA NMFS Office of Science and Technology

Abundant and Diverse Wildlife

Krisa Arzayus	NOAA NESDIS National Coastal Data Development Center
Rusty Brainard	NOAA NMFS Pacific Islands Fisheries Science Center
Marie Bundy	NOAA NOS Office of Ocean and Coastal Resource Management
Dave Checkley	Scripps Institute of Oceanography
Joanne Flanders	NOAA OAR Office of Ocean Exploration and Research
Kelly Goodwin	NOAA OAR Atlantic Oceanographic and Meteorological Laboratory
David Green	NOAA NWS
Lisa Hayward	US Geological Survey
Rob Johnston	Clark University
Phil Levin	NOAA NMFS Northeast Fisheries Science Center
Susan Lovelace	NOAA NOS National Centers for Coastal Ocean Science, Hollings Marine Laboratory
Laura Petes	NOAA OAR Climate Program Office
Juha Siikamaki	Resources for the Future
Charlie Stock	NOAA OAR Geophysical Fluid Dynamics Laboratory
Ariana Sutton-Grier	NOAA NMFS Office of Habitat Conservation

Vibrant & Robust Coastal Communities & Economies

Paul DiGiacomo	NOAA NESDIS
Richard Feely	NOAA OAR Pacific Marine Environmental Laboratory
Mike Fogarty	NOAA NMFS Northeast Fisheries Science Center
Dave Foley	NOAA NMFS Southwest Fisheries Science Center
Mike Ford	NOAA NMFS NOAA Chesapeake Bay Office

Theresa Goedeke	NOAA NOS National Centers for Coastal Ocean Science, Center for Coastal Monitoring and Assessment
Troy Hartley	Virginia Institute of Marine Sciences
John Jacobs	NOAA NOS National Centers for Coastal Ocean Science, Hollings Marine Laboratory
Liana McManus	University of Miami Rosenstiel School of Marine and Atmospheric Science
LaToya Myles	NOAA OAR Air Resources Laboratory
Greg Piniak	NOAA NOS National Centers for Coastal Ocean Science, Center for Coastal Fisheries and Habitat Research
Mark Plummer	NOAA NMFS Northwest Fisheries Science Center
Tracy Rouleau	NOAA NWS
Dave Schwab	NOAA OAR Great Lakes Environmental Research Laboratory
Annica Wayman	US Agency for International Development

Sustained Cultural and Recreational Benefits from the Coasts and Oceans

Marion Adeney	US Agency for International Development
Greg Arthaud	USDA Forest Service
Marie Colton	NOAA OAR Great Lakes Environmental Research Laboratory
Peter Edwards	NOAA NMFS Office of Habitat Conservation
Alan Haynie	NOAA NMFS Alaska Fisheries Science Center
Stephen Jameson	NOAA PPI
Chris Kelble	NOAA OAR Atlantic Oceanographic and Meteorological Laboratory
Nicole Kurkowski	NOAA NWS
Winnie Lau	Forest Trends
Patricia Livingston	NOAA NMFS Alaska Fisheries Science Center
Bill McAnally	Mississippi State University
Janna Shackeroff	NOAA NOS Office of Ocean and Coastal Resource Management, Coastal Programs Division
Karsten Shein	NOAA NESDIS National Climatic Data Center
Pete Wiley	NOAA NOS

Workshop Program Committee

Laura Letson*	NOAA OAR/NMFS	Co-chairperson
Bob Wood*	NOAA NOS	Co-chairperson
Marie Bundy*	NOAA NOS	
Paul DiGiacomo*	NOAA NESDIS	
David Fluharty	University of Washington	
Philip Hoffman*	NOAA OAR	
Ming Ji*	NOAA NWS	
Liana McManus	University of Miami	
Kenric Osgood*	NOAA NMFS	
Jake Rice	Canada Department of Fisheries and Oceans	
Jim Sanchirico	University of California Davis	
Oscar Schofield	Rutgers University	
Ariana Sutton-Grier*	NOAA NMFS / Policy Office	
Pete Wiley*	NOAA NOS	

*Denotes member of the Organizing Committee

Workshop Staff

Dan Farrow	NOAA	Lead Facilitator
Ruth Kelty	NOAA NOS	Facilitator
Kirstin Larsen	NOAA NMFS	Facilitator
Frank Parker	NOAA OAR	Facilitator
Shelby Walker	NOAA OAR	Facilitator
Mike Allen	NOAA OAR	Lead Recorder
Joe Bartosik	NOAA OAR	Recorder
Emily Gamelin	NOAA OAR	Recorder
Charlie Morris	NOAA PPI	Recorder
Danielle Tillman	NOAA OAR	Recorder

Workshop Guests

Paul Sandifer	NOAA NOS	Senior Science Advisor to the Administrator
Richard Merrick	NOAA NMFS	NMFS Chief Scientist
Alexander MacDonald	NOAA OAR	OAR Deputy Assistant Administrator

APPENDIX 2: WORKSHOP AGENDA

Workshop Goals and Objectives

Help NOAA to develop a comprehensive Ecosystem Research Agenda that strategically aligns and integrates the agency's science assets, partnerships and capabilities to facilitate the research needed to support the sustainable use, protection, and restoration of coastal and marine ecosystems, as well as the ecosystem services that they provide.

Anticipated Products and Outcomes:

- **A Report Out for each ecosystem service theme** – the Report Out will characterize and evaluate NOAA's ecosystem research portfolio for each of the ecosystem service (ES) themes that are the focus for the workshop. The Report Out will identify the most important:
  - Ecosystem services related to NOAA's mandated responsibilities that contribute to the theme;
  - Research topics associated with these ecosystem services;
  - Research issues or questions (current or emerging) related to the important research topics (the target is the three to five most important issues per major research topic);
  - A brief problem statement (what, why, rate of change, tipping point) for each major research issue or question.

- **Improving the development and implementation of NOAA's ecosystem research agenda** – the objective is to develop potential solutions to perceived barriers towards implementing a more comprehensive Ecosystem Research Agenda for NOAA.

- **White Paper for NOAA's Research Council** – the White Paper will be written following the workshop and will provide:
  - Input to NOAA's 5 Year Research Plan;
  - Input to NOAA's Ecosystem Research Agenda;
  - Improved integration both within NOAA as well as between NOAA and its partners (including Federal agency, Cooperative Institute, NGO, and academic collaborators) to address the ecosystem research challenges identified in the workshop; and
  - Opportunities to begin or strengthen networks and collaborations between researchers both within NOAA and between NOAA and its partners.

Day 1 – November 29 Setting the stage, exploring the research issues and questions for each ecosystem service theme	
8:00 am	**Coffee and Chat** (*Great Hall South*)
8:30 am	**Introduction and Overview** (*Great Hall South*) • Welcome – Laura Letson and Bob Wood, Co-Chairs • Why are we here? – Paul Sandifer, Sr. Science Advisor to the NOAA Administrator • Ecosystem Service Themes – Bob Wood • Workshop Objectives, Products, and Outcomes – Bob Wood • NOAA's Ecosystem Research Mandates and Portfolio – Laura Letson • How are we going to get there? – Dan Farrow, Lead Facilitator • Questions?
10:30 am	**Break** (*Great Hall South*)
10:50 am	**Breakout Session #1** *Overview discussion of ecosystem service themes*: • What do these mean to you? • What are the key issues for NOAA's programs, products, and services? • How are they changing over time, and what are the drivers of these changes? **Room Assignments** (refer to map and table): • Safe and Sustainable Seafood: *Ellsworth West Room* • Abundant and Diverse Wildlife: *Ellsworth East Room* • Vibrant and Robust Coastal Communities & Economies: *Fenton Room* • Coastal and Ocean Cultural Uses: *Colesville Room*
12:00 pm	**Lunch and Networking** (*Great Hall South*)
1:00 pm	**Breakout Session #2** (*Room assignments from Session #1*) • What are the ecosystem services (ES) that contribute to the themes? • Which are most impacted by the roles and responsibilities that NOAA is mandated to carry out? • Of these, which are the most important from an ecosystem research standpoint? • What are the key research topics associated with the most important ESs? Which are most important to address? • What are the key research issues or questions associated with the most important research topics?
2:30 pm	**Break** (*Great Hall South*)
2:50 pm	**Breakout Session #3** (*Room assignments from Session #1*) • Continue determining answers to the questions in Breakout Session #2 and determine priorities for Day 2 Breakout sessions
5:00 pm	**Adjourn**
5:30 pm	**Networking Hour and Group Dinner** (optional; McGinty's Pub)

Day 2 – November 30 Continue to explore research issues and questions Share expertise and perspectives with group Ambassadors	
8:00 am	**Coffee and Chat** (*Spring Room)*
8:30 am	**Charge for Day 2** (*Spring Room*)
8:45 am	**Breakout Session #4** Continue determining: • What are the ecosystem services (ES) that contribute to the themes? • Which are most impacted by the roles and responsibilities that NOAA is mandated to carry out? • Of these, which are the most important from an ecosystem research standpoint? • What are the key research topics associated with the most important ESs? Which are most important to address? • What are the key research issues or questions associated with the most important research topics? **Room Assignments** (refer to map and table): • Safe and Sustainable Seafood: *Ellsworth West Room* • Abundant and Diverse Wildlife: *Ellsworth East Room* • Vibrant and Robust Coastal Communities & Economies: *Fenton Room* • Coastal and Ocean Cultural Uses: *Colesville Room*
10:30 am	**Break** (*Spring Room*)
10:50 am	**Breakout Session #5** (*Room assignments from Session #4*) • Continue determining answers to the questions in Breakout Session #4 • Summarize progress on identifying research gaps and questions for the theme • Select Ambassadors to send to other theme Breakout Groups
12:00 pm	**Lunch and Networking** (*Spring Room*)
1:00 pm	**Breakout Session #6** (*Room assignments from Session #4*) • Facilitator, Recorder, and Group members brief Ambassadors on progress • Ambassadors reflect on complementarities and potential gaps from their original groups • Refine and press forward based on discussions with Ambassadors
2:30 pm	**Break** (*Spring Room*)
2:50 pm	**Breakout Session #7** (*Room assignments from Session #4*) • Continue determining answers to the questions in Breakout Session #6 • Develop initial draft for Breakout Group Reports on Day 3 using template
5:00 pm	**Adjourn**

Day 3 – December 1 Share progress and Sew together the Ecosystem Research Quilt (morning) Creating a comprehensive NOAA ecosystem research agenda (afternoon)	
8:00 am	**Coffee and Chat** (*Spring Room*)
8:30 am	**Charge for Day 3** (*Spring Room*)
8:45 am	**Breakout Session #8** • Prepare final group Report Out **Room Assignments** (refer to map and table): • Safe and Sustainable Seafood: *Ellsworth West Room* • Abundant and Diverse Wildlife: *Spring Room* • Vibrant and Robust Coastal Communities & Economies: *Fenton Room* • Coastal and Ocean Cultural Uses: *Colesville Room*
9:30 am	**Plenary Session – Reports from Breakout Groups** (*Ellsworth Room*) • 9:30 – 9:45 am: Safe and Sustainable Seafood • 9:45 – 10:00 am: Abundant and Diverse Wildlife • 10:00 – 10:15 am: Vibrant and Robust Coastal Communities and Economies • 10:15 – 10:30 am: Coastal and Ocean Cultural Uses (including recreation)
10:30 am	**Break** (*Spring Room*)
10:45 am	**Sewing together the Ecosystem Research Quilt** (*Ellsworth Room*) • 10:45 – 11:00 am: Questions for group reports • 11:00 – 11:30 am: Integrating the group reports
11:30 am	**Summary thoughts from NOAA leadership – Paul Sandifer** (*Ellsworth Room*)
11:45 am	**Lunch and Networking** (*Spring Room*)
12:45 pm	**Sewing together the Ecosystem Research Quilt – Part II** (*Ellsworth Room*)
2:00 pm	**Informing a comprehensive NOAA ecosystem research agenda – Part I** (*Ellsworth Room*) • Discussion about developing potential solutions to perceived barriers
2:30 pm	**Break** (*Spring Room*)
2:50 pm	**Informing a comprehensive NOAA ecosystem research agenda – Part II** (*Ellsworth Room*)
3:30 pm	**Closing Remarks – Laura Letson and Bob Wood** (*Ellsworth Room*) • Review and summarize progress • Next Steps
4:00 pm	**Adjourn**

APPENDIX 3: GLOSSARY OF KEY CONCEPTS AND DEFINITIONS

Key Concepts

- ECOSYSTEM
- ECOSYSTEM SERVICE THEME
- ECOSYSTEM SERVICE
- ECOSYSTEM RESEARCH TOPIC
- ECOSYSTEM RESEARCH ISSUE OR QUESTION

Additional Concepts

- ECOSYSTEM RESEARCH AGENDA
- ECOSYSTEM SCIENCE PORTFOLIO
- ECOSYSTEM-BASED MANAGEMENT (EBM)
- INTEGRATED ECOSYSTEM ASSESSMENTS (IEAS)
- COASTAL AND MARINE SPATIAL PLANNING (CMSP)

This glossary of working definitions of the above concepts is provided to promote effective, clear, and consistent communication during the Workshop. We understand that some participants may prefer other definitions, but to minimize the time spent debating different interpretations of terms, we hope that participants find these acceptable and will use these within the context of the Workshop. These concepts and definitions were compiled and developed by the ERSCW Planning Team, with references noted as appropriate.

ECOSYSTEM

A geographically specified system of organisms (including humans), the environment, and the processes that control its dynamics (from **NOAA's Next Generation Strategic Plan**, p. 37),

ECOSYSTEM SERVICE THEME

A term developed for this Workshop to provide an organizing framework for NOAA's ecosystem research needs. An Ecosystem Service Theme describes a major outcome that the public wants or would derive from a healthy, sustainable, and well-managed ecosystem. The four Themes chosen reflect those societal outcomes that represent a major focus of NOAA mission and mandates. It is the first level of the Workshop's analysis framework.

ECOSYSTEM SERVICE

Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits. This is the second level of the Workshop's analysis framework, below ecosystem research theme (from the Executive Summary of the **Millennium Ecosystem Assessment,** p. 3).

ECOSYSTEM RESEARCH TOPIC

For the purposes of this Workshop, an Ecosystem Research Topic is a physical, chemical, biological, or social phenomenon or action that impacts the sustainability of an ecosystem service. This is the third level of the analysis framework, below ecosystem research theme and ecosystem service.

ECOSYSTEM RESEARCH ISSUE OR QUESTION

For the purposes of this Workshop, an Ecosystem Research Question or Issue is a more specific and focused information need directly related to improving the understanding of an Ecosystem Research Topic. This is the

fourth level of the analysis framework, below ecosystem research topic, ecosystem research theme, and ecosystem service

Additional Concepts

ECOSYSTEM RESEARCH AGENDA

NOAA's stated goals, priorities, and rationale for conducting ecosystem research. A NOAA-wide Ecosystem Research Agenda would leverage and integrate the combined competencies of NOAA's Line Offices and partners to build a new/additional capacity to understand and forecast/predict ecosystem dynamics and services at multiple scales. The Agenda is independent of Federal budget or fiscal processes, but describes ecosystem science activities specifically enough to aid in developing compelling budget and performance narratives.

ECOSYSTEM SCIENCE PORTFOLIO

The integrated science activities, facilities, and products developed by NOAA Federal scientists, university partners, outside collaborators, and sister Federal agencies (within NOAA activities) that characterize the ecosystems NOAA is tasked with understanding and managing.

ECOSYSTEM-BASED MANAGEMENT (EBM)

Ecosystem-based Management is an integrated approach to management that considers the entire ecosystem, including humans. The goal of ecosystem-based management is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services humans want and need. Ecosystem-based management differs from current approaches that usually focus on a single species, sector, activity or concern; it considers cumulative impacts of different sectors. Specifically, ecosystem-based management:

- emphasizes the protection of ecosystem structure, functioning and key processes;
- is placed-based in focusing on a specific ecosystem and the range of activities affecting it;
- explicitly accounts for the interconnectedness within systems, recognizing the importance of interactions between many target species or key services and other non-target species;
- acknowledges interconnectedness among systems, such as between air, land and sea; and
- integrates ecological, social, economic, and institutional perspectives, recognizing their strong interdependences.

(From "*Clarifying the Relationships among Ecosystem Based Management; Integrated Ecosystem Assessments; and, Coastal and Marine Spatial Planning: -- NOAA Response to SAB/ESMWG Letter of April 5, 2010"* -- March 2, 2011, p. 1)

INTEGRATED ECOSYSTEM ASSESSMENTS (IEAS)

NOAA defines IEAs as a synthesis and quantitative analysis of information on relevant physical, chemical, ecological and human processes in relation to specified ecosystem management objectives‖. Integrated Ecosystem Assessments provide a process to work closely with stakeholders and managers to identify priority management issues and provide robust decision-support information. IEAs integrate diverse ecosystem data, including socio-economic information, to analyze ecosystem and community status relative to a defined issue and then predict future status based on forecasts of natural ecosystem variability coupled with evaluation of alternate management strategies. Through this process the benefits and risks to social and ecological sectors – the tradeoffs – of alternate management actions are evaluated and defined to inform stakeholders and managers in their decisions. Through continued evaluation of performance, the IEA process allows adaptive management.

(From "*Clarifying the Relationships among Ecosystem Based Management; Integrated Ecosystem Assessments; and, Coastal and Marine Spatial Planning: -- NOAA Response to SAB/ESMWG Letter of April 5, 2010"* -- March 2, 2011, p. 2)

COASTAL AND MARINE SPATIAL PLANNING (CMSP)

NOAA's approach to CMSP mirrors that outlined in the National Ocean Policy and Framework for Effective Coastal and Marine Spatial Planning (Final Recommendations of the Ocean Policy Task Force, July 2010).

—Coastal and marine spatial planning is a comprehensive, adaptive, integrated, ecosystem-based, and transparent spatial planning process, based on sound science, for analyzing current and anticipated uses of ocean, coastal, and Great Lakes areas. Coastal and marine spatial planning identifies areas most suitable for various types or classes of activities in order to reduce conflicts among uses, reduce environmental impacts, facilitate compatible uses, and preserve critical ecosystem services to meet economic, environmental, security, and social objectives. In practical terms, CMSP provides a public policy process for society to better determine how the ocean, coasts, and Great Lakes are sustainably used and protected - now and for future generations.

(From "*Clarifying the Relationships among Ecosystem Based Management; Integrated Ecosystem Assessments; and, Coastal and Marine Spatial Planning: -- NOAA Response to SAB/ESMWG Letter of April 5, 2010"* -- March 2, 2011, p. 2)

APPENDIX 4: ECOSYSTEM SERVICES

The following is a partial list of the benefits that may be derived from ecosystem services, by service category, with examples. This is not meant to be in any way comprehensive or authoritative, but merely to be a basis for discussion of benefits derived from services.

Category	Ecosystem Service	Benefit Type	Benefit
Provisioning	Food	Market economic value	Revenue, income, jobs
Provisioning	Air supply	Non-market economic value, well being	Use value, health
Provisioning	Raw materials	Market economic value	Revenue, income, jobs
Provisioning	Medicinal resources	Market value, well being	Revenue, income, jobs, decreased morbidity/mortality
Provisioning	Ornamental resources	Market economic value	Revenue, income, jobs
Regulating	Climate regulation attenuation	Non-market economic value, well being	Use value, health, resiliency
Regulating	Pollutant	Non-market economic, well being	Use, non-use value, decreased morbidity/mortality
Regulating	Soil and sediment balance	Market/non-market economic values	Revenue, income, jobs, safe navigation, use values
Regulating	Hazard moderation	Market/nonmarket economic values, value of property, safety	Revenue, income, jobs, decreased risk to property, decreased hazard risk (to life and limb)
Cultural	Science and education	Market/non-market economic value, well-being, value of property, safety	Solve practical problems, make informed decisions, contribute toward sustainably functioning ecosystems
Cultural	Spiritual	Well being	Variable – based on nature of spirituality
Cultural	Aesthetic	Market/non-market value, well-being	Property values, use value, enjoyment
Cultural	Existence	Non-use value	Economic benefit from knowing resources exist

Category	Ecosystem Service	Benefit Type	Benefit
Cultural	Historic	Community fabric, better informed decisions	Historical context for decisions, understanding of community fabric
Cultural	Recreation	Market/non-market value	Revenue, income, jobs, use value
Supporting*	Nutrient balance	Contribution toward final demand for services (all)	All benefits derived through a functioning ecosystem
Supporting*	Hydrological balance	Contribution toward final demand for services (all)	All benefits derived through a functioning ecosystem
Supporting*	Biological interactions	Contribution toward final demand for services (all)	All benefits derived through a functioning ecosystem

* Supporting services represent intermediate services or services that contribute to final demand for the other three categories. The benefits are imbedded in the ecosystem services from the other categories.

APPENDIX 5: BACKGROUND INFORMATION PROVIDED TO PARTICIPANTS

What is NOAA and how is it organized?

Through its long-standing mission of science, service, and stewardship, the National Oceanic and Atmospheric Administration (NOAA) generates tremendous value for the Nation—and the world—by advancing our understanding of and ability to anticipate changes in the Earth's environment, by improving society's ability to make scientifically informed decisions, and by conserving and managing ocean and coastal resources.

NOAA's mission is central to many of today's greatest challenges. Climate change. Severe weather. Natural and human-induced disasters. Declining biodiversity. Ocean acidification. Threatened or degraded ocean and coastal resources. These challenges convey a common message: human health, prosperity, and well-being depend upon the health and resilience of coupled natural and social ecosystems. Managing this interdependence requires timely and usable information to make decisions and the science that underpins our knowledge of these systems. NOAA's mission of science, service, and stewardship is directed to a vision of the future where societies and their ecosystems are healthy and resilient in the face of sudden or prolonged change. – NOAA's Next-Generation Strategic Plan

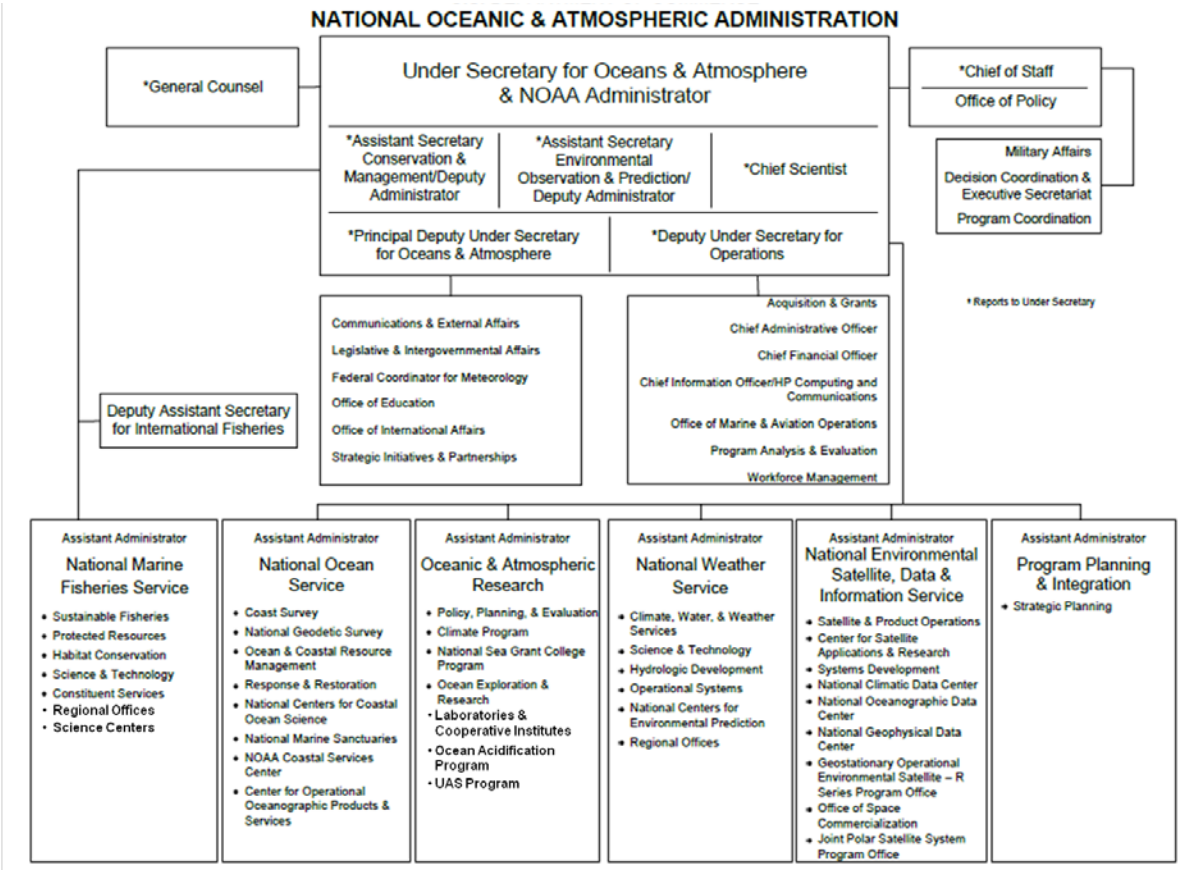

Figure 1: NOAA Organizational Chart. NOAA is organized into four service Line Offices (LO), a research LO and a strategic planning LO, each contributing to NOAA's ecosystem research activities.

What is NOAA's definition of Ecosystem Research?

NOAA defines *ecosystem research* as the systematic study directed toward fuller scientific knowledge or understanding of geographically determined systems of organisms (including humans), the environment[1], and the processes that control the system dynamics.

[1]Environment is the biological, chemical, physical, and social conditions that surround organisms.

- Adapted from Murawski & Matlock, 2006 and NSF, 2004

Why is NOAA holding a Science Challenge Workshop on Ecosystem Research?

The answer is two-fold. First, this year NOAA is holding four Science Challenge Workshops to expand on recommendations from NOAA's "Workshop on Strengthening NOAA Science" that was held in April 2010. That workshop identified two ecosystem-related grand challenges:

- Assess and understand the roles of ecosystem processes and biodiversity in sustaining ecosystem services.
- Develop and evaluate approaches to substantially reduce environmental degradation.

Second, NOAA leadership highlighted the need to "Develop and implement a NOAA-wide ecosystem research agenda" as a priority action in the December 2010 NOAA Annual Guidance Memorandum. As a result, NOAA will implement a portfolio approach to ecosystem research using a systems-based understanding of phenomena that transcends individual disciplines. NOAA will need to "improve how we characterize, model, and where possible, predict the behavior of systems as wholes, rather than as parts of systems in isolation" to support our service and stewardship mission.

What does the workshop seek to achieve?

The workshop will help NOAA to develop a comprehensive ecosystem research agenda that strategically aligns and integrates the agency's science assets, partnerships and capabilities to facilitate the research needed to support the sustainable use, protection, and restoration of coastal and marine ecosystems, as well as the ecosystem services that they provide.

NOAA's Ecosystem Research Portfolio

NOAA conducts ecosystem research on a variety of topics pursuant to authorizing legislation from Congress. Ecosystem research at NOAA may be differentiated from other types of research activities by its strategic design to improve our ability to manage, protect, and restore coastal and marine ecosystems, and sustain the ability to deliver a realistic portfolio of ecosystem services to society. This research includes studies conducted at multiple spatial and temporal scales, using observational, laboratory, field, and modeling techniques.

In 2011, NOAA conducted an inventory of that research to compile the current programs conducting research, their primary research questions, legal mandates, and major internal and external partners. Below are some of the key findings. Additional information from the inventory will be presented during the opening plenary of the workshop.

NOAA offices identified primary and secondary mandates driving their ecosystem research. The major mandates in Table 1 represent the majority of ecosystem research funding identified in the inventory. Note that a number of the "other mandates" represent important foci of current ecosystem research and future NOAA research initiatives. Many of these laws also represent important mandates for ecosystem-based management (e.g., the National Marine Sanctuaries Act, the National Coastal Monitoring Act). Additional information on these mandates is available at http://ecosystems.noaa.gov/statutory_mandates.htm.

Table 1: What are NOAA's major ecosystem research mandates?

Coast and Geodetic Survey Act	… shall conduct and sponsor applied research to improve surveying and cartographic methods, instruments, and equipments and assure the future availability and usefulness of ocean satellite data to the maritime community.
Coastal Zone Management Act	"…development and implementation of management programs to achieve wise use of the land and water resources of the coastal zone, giving full consideration to ecological, cultural, historic, and esthetic values…"
Coral Reef Conservation Act of 2000	"…include mapping, monitoring, assessment, restoration, and scientific research that benefit the understanding, sustainable use, and long-term conservation of coral reefs and coral reef ecosystems…"
Endangered Species Act	"The purposes of this Act are to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions set forth in subsection."
Harmful Algal Bloom & Hypoxia Research & Control Act	Expands the mandate for NOAA to advance the scientific understanding and ability to detect, monitor, assess, and predict HAB and hypoxia events.
Magnuson-Stevens Reauthorization Act	"To provide for the conservation and management of the fisheries… " "… [fisheries research] to acquire knowledge and information, including statistics, on fishery conservation and management and on the economics and social characteristics of the fisheries."
National Sea Grant College Program Amendments Act of 2008	"… to promote research, education, training, and advisory service activities in fields related to ocean, coastal, and Great Lakes resources."
Ocean Exploration and Research Acts	"… conduct interdisciplinary voyages or other scientific activities in conjunction with other Federal agencies or academic or educational institutions, to explore and survey little known areas of the marine environment, inventory, observe, and assess living and nonliving marine resources, and report such findings"

Table 2: Other Ecosystem Research Mandates

Antarctic Marine Living Resources Convention Act of 1984	Marine Mammal Protection Act
Article 76 in the Convention on the Law of the Sea	National Coastal Monitoring Act
Clean Water Act Amendments of 1990	National Invasive Species Act
NOAA Aquaculture Policy	National Marine Sanctuaries Act
Comprehensive Everglades Restoration Plan	National Ocean Policy
Comprehensive Environmental Response, Compensation, and Liability Act	Ocean and Coastal Mapping Integration Act
Federal Ocean Acidification Research and Monitoring Act	Oceans & Human Health Act
Integrated Ocean Observing System Act	Ocean Research Priorities Plan
Marianas Trench Marine National Monument Proclamation	Oil Pollution Act
Marine Debris Research Prevention and Reduction Act	Outer Continental Shelf Lands Act

NOAA offices identified a series of topic areas and research questions in the 2011 inventory from which the list shown in Table 3 was developed.

Table 3: What are NOAA's major ecosystem research topics?

Air Chemistry	Fishing Practices and Technology
Catch Share Science	Oceans & Human Health
Climate	Invasive Species
Conservation and Management	Marine Debris
Corals	Ocean Acidification
Damage Response and Assessment, and Restoration Science	Safe and Sustainable Seafood
Ecological Assessments/ Characterizations	Social Science
Exploration	Water Levels
Fish Stock Assessment Science	Coastal Water Quality
Fisheries Statistics	

How has NOAA sought to synthesize ecosystem research?

Each of NOAA's service and research Line Offices (Figure 1) is engaged in ecosystem research to some extent. Additionally, NOAA's Office of Policy Planning and Integration is providing strategic guidance for developing the ecosystem research agenda. Some areas of responsibility include (note this list is not all inclusive):

- The National Marine Fisheries Service (NMFS) is responsible for NOAA's Healthy Oceans goal and implements fisheries research (Sustainable Fisheries), marine mammal and protected species research (Protected Resources), and habitat research (Habitat Conservation).
- The National Ocean Service (NOS) is responsible for NOAA's Coastal goal, which includes coastal habitats, corals, oceans and human health (harmful algal blooms, pollution), and water quality research.
- The National Weather Service (NWS) is working across line offices to develop operational ecosystem forecasting capabilities that support the above mentioned mission goals, as well as others.
- The National Environmental Satellite, Data and Information Service (NESDIS) develops tools and products to interpret ecosystem properties from remotely sensed data.
- The Office of Oceanic and Atmospheric Research (OAR), NOAA's research line office, conducts ecosystem research in the oceans and Great Lakes. As the lead for NOAA's Holistic Understanding of the Earth System objective, OAR is leading the development of NOAA's portfolio approach to ecosystem research.
- OAR, NMFS, and NOS also manage a significant portfolio of extramural ecosystem research partnerships through Sea Grant, the Cooperative Institutes, the National Centers for Coastal Ocean Science, the National Estuarine Research Reserves, and numerous competitive grant programs.

Because ecosystem research activities are distributed across the agency, NOAA has already made some efforts to better integrate aspects of its diverse programs. Some examples include:

- Integrated Ecosystem Assessment Program: NOAA's IEA program promotes the development of IEAs in US Large Marine Ecosystems to provide "a synthesis and quantitative analysis of information on relevant physical, chemical, ecological and human processes in relation to specified ecosystem management objectives" (Levin, et al. 2008, 2009).
- Coral Reef Conservation Program: CRCP is a partnership between the NOAA Line Offices that work on coral reef issues, bringing together expertise from across NOAA for a multidisciplinary approach to managing and understanding coral reef ecosystems.
- Fisheries and the Environment: FATE advances the understanding of environmental impacts on living marine resources and uses this information to improve stock and ecosystem assessments.
- Ecosystems & Fisheries-Oceanography Coordinated Investigations: joint programs between NMFS and OAR that studies relationships between the marine environment and the survival of commercially valuable fish in the Gulf of Alaska and eastern Bering Sea.

Other NOAA Ecosystem Resources

The internet URLs listed below link to other publicly available NOAA documents that describe NOAA ecosystem research activities and the guidance that directs them.

- NOAA Research Council
    - http://www.nrc.noaa.gov/plans.html Includes links to:
        - Strengthening NOAA Science: Findings from the NOAA Science Workshop (April, 2010)
        - **NOAA 5 Year Research Plan for 2008-2012**
        - **20 Year Research Vision**
- Ecosystem Science Capabilities Required to Support **NOAA**'s Mission in the Year 2020
    - http://coastalscience.noaa.gov/documents/tm74.pdf
- 2013-2017 Annual Guidance Memorandum (December, 2010; see page 14)
    - http://www.ppi.noaa.gov/wp-content/uploads/FY13-17_AGM.pdf
- NOAA's Integrated Ecosystem Assessment Program
    - http://www.st.nmfs.noaa.gov/iea/

Figure 2: NOAA's Regional Ecosystems

Additional Information

Selected Text

ANNUAL GUIDANCE MEMORANDUM (December, 2010)

Develop and implement a NOAA-wide ecosystem research agenda: Develop and implement a NOAA-wide ecosystem research agenda [that][10] would [integrate and] leverage the combined competencies of NOAA's Line Offices [and partners] to build a new [/additional] capacity to understand, [forecast/ predict], and [characterize risk for] ecosystem dynamics and services at multiple scales. Specifically NOAA should: 1) develop a long-term adaptive ecosystem research and monitoring plan focusing on physical, biogeochemical, ecological, and socio-economic trends in time and space; 2) expand NOAA's ecosystem assessment, service, and coupled modeling capabilities to enable us to forecast critical ecosystem functions and services; 3) examine how human communities are affected by and respond to both acute (e.g., oil spills, harmful algal blooms, extreme weather, hypoxia, pathogens, chemical contaminants) and incremental events and changes (e.g., climate change, ocean acidification); 4) investigate and assess unexplored and ecologically, economically, and culturally important coastal and oceanic regions; and 5) expand sampling and testing techniques to ensure safe seafood.

CORPORATE PORTFOLIO ANALYSIS DECISION MEMORANDUM (April, 2011)

Issue: NOAA-wide Ecosystem Research Agenda. NOAA currently implements a variety of scientific programs and activities that contribute to the corporate ecosystem research portfolio – e.g., research on aquaculture, invasive species, ecosystem health and forecasting, ocean acidification, coral reefs, biodiversity, and social science.

(A23) In coordination with NMFS and NOS analyze base program components (resources, drivers, capabilities, strategies, business models, etc.), and propose NOAA portfolio approach, including recommended actions for ecosystem research and appropriate components of the "Ecosystem Science Framework". Account for (1) all NOAA ecosystem research activities, existing or planned through FY18; (2) the resources associated with these activities; (3) which line offices and line office units conduct these activities and toward which NGSP objectives they are conducted (per the SEE integration table); (4) how these activities support the achievement of NGSP objectives (per IP logic models); and (5) the relevant statutory drivers of each activity. Analysis should include external input and be used to inform FY12 SEE planning options (lead: OAR, working through the Research Council, to: PPI/NEP, due: September 30, 2011).

DRAFT ANNUAL GUIDANCE MEMORANDUM (November, 2011)

Priority: Strengthen ecosystem research for improved resilience. NOAA will conduct research on ecosystem impacts, processes, dynamics and biodiversity, and transition this research to enable ecosystem approaches to coastal management and community resilience. NOAA has a responsibility to support the sustainable use, protection, and restoration of coastal and marine ecosystems and the ecosystem services they provide to human communities. To do this, the next generation of NOAA service and stewardship capabilities will have to be based upon understanding of phenomena that transcends and links individual disciplines. NOAA R&D will focus on improving how we characterize, model and, where possible, predict the behavior of systems as wholes, rather than as parts of systems in isolation.

STRENGTHENING NOAA SCIENCE: *Findings from the NOAA Science Workshop* **(April, 2010)**

Grand Science Challenge

Develop and apply holistic, integrated Earth system approaches to understand the processes that connect changes in the atmosphere, ocean, space, land surface, and cryosphere with ecosystems, organisms and humans over different scales.

[10] [ ] indicate clarifications and additions to the language provided in the Annual Guidance Memorandum. These provide emphasis to integration of internal and external capabilities, leveraging partners, and providing tools, models and services that will improve understanding and decision-making.

***Recommendation 4**. Assess and understand the roles of ecosystem processes and biodiversity in sustaining ecosystem services and the connections among ecosystem condition, resilience, and the health of marine organisms, humans, and communities.*

One of the primary aims of NOAA science is to provide information that will help improve human well-being while sustaining and, where necessary, restoring the planet's life support system. … Science focal areas include:

1. Understanding connections between ocean condition and human health;
2. Developing system models to elucidate the cumulative consequences of changes in multiple ecosystem components on continued provision of ecosystem services;
3. Consequences of changes in biodiversity and habitats for the stability and magnitude of critical ecosystem services such as fishery landings, shoreline protection, recreation value, and the resulting socio-economic condition of nature-dependent economies;
4. Understanding how human communities respond to ecosystem changes; and
5. Market and non-market valuation of ecosystem benefits.

***Recommendation 6**. Develop and evaluate approaches to substantially reduce environmental degradation, overfishing, and climate change in ways that maximize benefits and minimize adverse impacts.*

Understanding the consequences of human activities and natural factors on ecosystem conditions will help NOAA provide science-based guidance on approaches for managing or coping with environmental change. … Specific science needs include:

1. Identifying a set of indicators and thresholds that track sustainability and illuminate trade-offs for shared objectives for marine ecosystems;
2. Learning from protection and restoration actions and their effectiveness in sustaining ecological function and other social goals;
3. Linking the cumulative effects of human actions and climate to changes in habitats, water quality, and species status;
4. Developing a capability to evaluate proposed responses to the challenges of climate change, including a broad range of potential mitigation and adaptation actions; and
5. Developing integrated ecosystem forecasting/early warning capabilities for both predicting and anticipating natural and human-caused ecosystem changes and their implications for ecological and human health.

APPENDIX 6: DETAILED ECOSYSTEM SERVICE AND RESEARCH QUESTION LISTS

SAFE AND SUSTAINABLE SEAFOOD

REPORT OUT

Overarching questions

- How will climate change impact food web dynamics? (fill in w/other stressors and ecosystem processes)
- What are the most effective harvest control mechanisms to maintain sustainable ecosystems and fishing communities?
- What level of monitoring of pathogens/toxins is necessary to continue to ensure public safety?
- How does (insert stressor) increase toxicity/pathogenicity of seafood?

Other Important Ideas

- Concentrated, controlled empirical ecosystem study
- Technology and tools
- Forecasting and predictive ability
- Long term observational data and process studies
- Monitoring and early warning

ECOSYSTEM SERVICES AND RESEARCH TOPICS

Ecosystem Service: The group chose to focus exclusively on Safe and Sustainable Seafood as its service.

Goal: Reliable and actionable forecasts of quality and quantity of seafood resource

Research Topics (^ = focus for research questions)

Four Main topics

1. Understanding ecosystem interactions
2. Impacts of individual and multiple stressors
3. Managing sustainable harvest
4. Seafood quality

More detailed topics

1. *Aquaculture^*
2. Better information/data/understanding
3. Communication of risk
4. Fisherman behavior
5. Fleet dynamics
6. Global change (climate change, OA, UV radiation, shifting species ranges)
7. Governance
8. Habitat
9. Healthy seafood populations
10. Import/export
11. Invasives
12. Natural disaster response
13. Seafood testing/tracking/communication
14. Viable fishing communities
15. Warning/advising system
16. *Water quality^*

Research Sub-topics

Understanding ecosystem interactions

1. Food web structure and dynamics
2. Including harvesting, human-fishery interactions
3. Temporal/Spatial structure
4. Biogeochemical cycling
5. Land-sea interaction
6. Ice-air-sea interactions
7. Contaminants and nutrients
8. Habitat structure and function
9. Life history parameters
10. Disease ecology
11. Physical characteristics of ice-air-sea

Impacts of individual and multiple stressors

1. Harvesting
2. Climate and global change (including ocean acidification)

3. Invasive species
4. Land-Sea-Human interactions
5. Habitat loss
6. Natural variability
7. Extreme events – natural and man-made

Managing sustainable harvest

1. Governance
2. Community (stocks/populations)dynamics - Spatial and temporal rates of mortality, growth and reproduction
3. Informed decision making (development of tools, evaluation of decisions)
4. Harvesting Technology
5. Aquaculture
6. Fishing community
7. Economic Dynamics

Seafood quality

1. Safety – pathogens, bio-toxins, chemicals & pharmaceuticals
2. Seafood tracking & traceability
3. Emerging diseases and contaminants
4. Nutritional quality
5. Communication of risks/benefits
6. Consumer preferences
7. Governance

Example In-depth Research Questions

1. What are the major emerging disease and contaminant risks that will affect seafood safety over the next 10 years and how will we track/monitor them?
2. What are the social and ecological impacts of various forms of human governance and organization in marine ecosystem management? In safe and sustainable seafood?
3. What is the interaction between natural biogeochemical cycling of nutrients and land-based or terrestrial/ human nutrient inputs in driving toxin production and pathogens in the marine environment?
4. Impacts of climate change on distribution, abundance and sustainability of living marine resources (or safe and sustainable seafood)? (fill in with other stressors)
5. How do multiple stressors interact to affect safe and sustainable seafood?
6. What are the more sensitive indicators of ecosystem integrity that allow us to determine if ecological sustainability is being achieved?
7. How do we develop decision tools that better incorporate complex ecosystem dynamics?
8. How can we develop better decision tools for managers to understand complete ecosystems?
9. What is the trophic structure/linkages within ecosystems (e.g., food habits)?
10. What are the likely major changes to ecosystems over the next 10-20 years that will impact living marine resource management and how?

BRAINSTORMING RESEARCH QUESTIONS

Research Questions: Aquaculture

Ecosystem Impacts

1. What is the role of marine aquaculture in disease transmission?
2. How does one translate any of these questions into a mathematical model?
3. How does aquaculture impact genetic structure of wild fish stocks?
4. How does an aquaculture facility in the open ocean affect ecosystem health and function?
5. To what extent does escape from aquaculture facilities promote invasion by non-native species? (why: controls need to be established to eliminate this possibility)
6. How can aquaculture facilities be monitored to detect new diseases from them, or to protect them from emerging toxins and pathogens?
7. Are the conditions in shellfish-growing zones altered by the byproducts of the industry such that dangerous conditions could arise (i.e., toxins/pathogens, decreases in water quality)
8. Is there a threat of harmful toxin production in algal aquaculture and is this regulated?
9. What should they be monitoring for around aquaculture facilities to detect pathogens and toxins?
10. What are environmental- water quality, habitat destruction impacts of aquaculture activities?

11. What are the best ways to reduce the impact of offshore aquaculture facilities on native animals (e.g., disease transmission) (why: some facilities are known to promote disease transmission into native populations)
12. How can aquaculture facilities and impacts be incorporated into ecosystem models and vulnerability predictions?
13. How do particular aquaculture activities impact the productivity of the surrounding natural ecosystems?
14. How vulnerable are wild food resources to introduced/escaped species; diseases, or other inputs associated with aquaculture?
15. What are the primary benefits of aquaculture (e.g., increased protein)? What are the primary disadvantages (e.g., invasive species, enhanced disease, water quality)? Does one outweigh the other?
16. How does aquaculture impact/facilitate disease? (through antibiotic use)
17. What is the potential for "invasive" species events from non-native aquaculture species? (e.g., Asian oysters in Chesapeake Bay)
18. Are there potential genetic impacts on wild population for other than anadromous (e.g., salmon) type species?
19. How does aquaculture influence water quality in surrounding waters? Potential variables include nutrients, suspended particles, pathogens, toxins
20. Does finfish aquaculture promote hypoxia?
21. What is the optimal balance between aquaculture production and negative impacts on ecosystem function?

<u>Threats/Challenges to Aquaculture</u>

1. How will climate change influence aquaculture?
2. How do changes in water quality influence aquaculture operations? What is done differently when water quality declines?
3. What threat does ocean acidification pose to shellfish aquaculture?
4. What are economic consequences of extreme events (storms, HABs, hypoxia) to aquaculture operations? Are they more or less vulnerable/exposed to such events than traditional fisheries?
5. What metric or information do shellfish growers need to adequately (cost-effectively) manage their harvest in the face of water quality threats? (scale?)

<u>Attitudes and Perceptions</u>

1. What are consumer preferences for aquaculture vs. wild sea food? At different prices?
2. What are local and national attitudes and perceptions of aquaculture?
3. What are public preferences for aquaculture?
4. What are the best approaches to shifting fishermen to aquaculturists?

<u>Wild vs. Farmed</u>

1. Is there a price premium for wild-caught seafood vs. aquacultured seafood? (why: incentives to change fishing practices or aquaculture practices)
2. How do we maintain a safe food supply from aquaculture?
3. What are the health consequences of consuming fish produced in aquaculture relating to wild caught fish?
4. Might an increased reliance on aquaculture result in reduced food security? (i.e., by increasing vulnerability to disease, terrorism, etc?)
5. What are the health benefits of aquaculture vs. wild fish?

<u>Standards/Best Practices</u>

1. What would encompass a set of standards or practices for sustainable aquaculture?
2. What are the most efficient aquaculture activities for specific ecosystems?
3. How can we ensure that coastal aquaculture systems don't impair nearshore ecosystems and the fisheries they support?(why: we need to avoid problems that we know exist in areas with high numbers of aquaculture facilities)

Ecological & Economic Trade-offs

1. Examine end to end costs of production of fish from aquaculture as opposed to harvesting wild caught fish (why: the total impact of aquaculture in the ecosystem has not usually been measured)
2. How do we quantify the impact of aquaculture – through loss of available space for 'wild' food resources or impacts of changing nutrient/food availability on the total food productivity of an ecosystem?
3. What is the effect of aquaculture programs/facilities on water quality in coastal systems (oceanic, likely negligible)?
4. Do the economic benefits of aquaculture outweigh the costs? What is the return on investment and how does it vary by species?
5. If have heavily degraded system, is it worth using/dedicating to aquaculture? (CMSP)

Food Supply

1. What other food and nutrition products can be sustainably developed to provide protein and other health benefits? (for aquaculture facilities)
2. To what extent does aquaculture contribute to seafood consumed in the United States?

Research Questions: Water Quality

Fishing

1. Does fishing affect water quality (e.g., by removing bio-accumulators)? If so, how does that change policies designed to maximize economic rent?
2. Does water quality indirectly affect consumer demand for seafood?
3. How does water quality impact seafood safety?
4. How do changes in water quality affect the economic value of a fishery?
5. Which costs less, fixing a given water quality problem or abandoning a fishery?
6. How do forecasting efforts of HAB's or other events that may affect water quality affect fleet or fishing effort?
7. What happens to displaced fishing effort from a water quality decreasing event?
8. How will changes in water quality resulting from climate change, specifically acidification, affect harvestable species? (why: forecasting future options for fishing)

Forecasting

1. What is the optimal lead time for a forecast/warning for fish management and public health decision makers?

Life history responses and ecosystem structure

1. What types of water quality change are most important to safe and sustainable seafood? Which of these can be most easily managed? (Why: can we expect to do something about water quality)
2. How do species critical for ecosystem health (and productive fisheries) respond to change in temperature and salinity? How to temperature and salinity impact spawning, recruitment, survival, growth etc.?
3. Impacts of water quality on growth and survival of species?
4. How does water quality impact growth and abundance? (why: important to have thriving fish stocks to produce sustainable seafood)
5. What factors of water quality affect (directly – can do indirect next) 1.) Survival 2.) Growth 3.) Reproduction for "seafood" in general and/or by family species groups? (why: identify research/monitoring priorities)
6. How will climate change influence water quality and its impacts on safe and sustainable seafood? (why: climate change is expected to change location and quantity of rain events, including more severe droughts and floods)
7. What are the impacts of water quality on ecosystem functionality?
8. What changes in water quality enhance the risk of invasion by non-native species? (why: need to reduce risk of invasions and promote resistance w/in ecosystems)

Toxins and Pathogens

1. What toxicity levels in water contribute to toxins in fish that make them unsafe to eat?
2. What levels of pollutants can ocean sustain to maintain healthy seafood? (why: seafood safety)

3. Do coastal pathogens respond to changes in nutrient availability and nutrient composition either by increases in abundance or increases in "virulence"/toxicity or both?
4. How does water quality impact behavior/presence/amount of seafood parasites and diseases/pathogens? (why: parasites and pathogens impact safety/sustainability of seafood)
5. What aspects of crop development, urbanization, and land-use drive variability in water quality across the river-estuary-coastal boundary? (and can we model this aspect of the hydrology?)
6. What changes in water quality influence the occurrence of ciguatera? (why: reduce risk to seafood consumers and enhance ability to forecast and predict risk)
7. What diseases/pathogens/toxins should we monitor to inform seafood consumption?
8. Which toxins and pathogens are we currently not measuring/monitoring that have potential (large) human health implications?
9. How do toxins cycle and interact with biota leading to accumulations that impact food safety?
10. What sentinel fish, shellfish and marine mammals are most useful for understanding risks to humans from toxins, chemical contaminants and disease?

<u>Observations and Monitoring</u>

1. What are spatial and temporal scales of water quality events? (why: determine appropriate resolution for monitoring)
2. What are the optimal sensors and ocean observing systems needed to develop early warnings/forecasts of public health risks?
3. How can we more accurately and broadly assess water quality change and its potential impacts on safe and sustainable seafood? (why: most measurements are too local for management. Can we sue remote sensing and/or models to gather across space?)
4. What baseline disease and toxin data should be monitored over time to track changes in relation to climate and natural disasters?

<u>Nutrients and Pollution</u>

1. Predict the consequences of various levels of nutrient loading in nearshore zone on fishery production and health. (why: up to a point nutrient loading may increase production but after that lead to problems. What is balance?)
2. How does the quantity and timing of nutrient availability impact productivity and species composition?
3. What is the role of river discharge on proliferation of shellfish toxins and accumulation in the nearshore?
4. Does chemical composition/stoichiometry drive variability in coastal algal toxin production and shellfish toxicity?
5. Is coastal eutrophication (i.e., increased primary production) a factor in promoting finfish production or does it suppress seafood health via increased hypoxia, increase HABs, etc.?
6. What determines the delivery and availability of nutrients, toxins, pathogens to an ecosystem?
7. What are major sources of water pollution? (why: this will help us learn about how to limit/prevent water quality degradation)
8. What are the factors impacting water quality?

ABUNDANT AND DIVERSE WILDLIFE

*"Wildlife" = all living things

Potential alternative title: Productive and biologically diverse ecosystems

REPORT OUT

We identified: 12 ecosystem services supporting the theme, ~25 research topics, and ~60 research questions.

Our theme encompasses both better understanding of how abundant and diverse wildlife provide ecosystem services and better understanding the threats/impacts to wildlife and how that affects ecosystem services (consider having two columns for research questions: threats and benefits). We did not look at methodologies.

Emerging / Transformative Topics

- Workshop synthesized decades of ideas
- Transformative action will only come through comprehensive integration and **implementation**
- ALL HANDS ON DECK!

ECOSYSTEM SERVICES AND RESEARCH TOPICS

Ecosystem Services (* = focus for research topics)

1. *Climate Regulation**
2. *Existence/Bequest**
3. *Non-food Products (including pharmaceuticals)**
4. *Recreation**
5. Food
6. Aesthetics
7. Educational Opportunities
8. Cultural
9. Hazard Mitigation
10. Human Health
11. Spiritual
12. Water Quality/Pollution Regulation (i.e., control)

Research Topics – Existence/Bequest (^ = focus for research questions)

1. Resilience (close link with #7 below)
2. *Climate change (including ocean acidification)^*
3. Risks to threatened and endangered species
4. *Ecosystem structure and function (processes)^*
5. Productivity, biodiversity, trophic interactions, biogeochemistry, etc.; including humans
6. Valuation
7. Exploration/characterization
8. Ecosystem connectivity
9. Observation and monitoring
10. *Use conflicts^*
    a. Dredging
    b. Shipping
    c. Noise Pollution
    d. Invasive Species (sometimes a conflict)
    e. Energy Siting (wind, wave, oil, gas)
    f. Coastal Development
    g. Aquaculture
    h. Recreation – overuse
    i. Coastal Engineering
    j. Environmental pollutants
    k. Extraction of living and non-living resources
    l. Habitat loss
    m. Halpern (2008) threat categories

Research Topics – Climate Regulation (^ = focus for research questions)

1. Ecosystem structure and function (including diversity and invasive species)
2. Ocean acidification
3. Climate change (feedbacks)
4. *Biogeochemical, particularly carbon, dynamics (including carbon storage, greenhouse gas emissions, carbon sequestration)^*
5. Water cycle
6. Circulation (including upwelling)
7. Stratification
8. Use conflicts (including human activities, e.g., pollution, land use change)
9. Habitat change (in response to climate change and land cover change

Research Topics – Non-Food Products

1. Economic markets for non-food markets
2. Exploration
3. Habitat loss/alteration
4. Research to product pipeline (including property rights)
5. Climate change
6. Risks to T&E species
7. Use conflicts (including anthropogenic pollutants, extraction, etc.)
8. Ecosystem structure and function (including microbial communities and species interactions -- e.g., ecological interactions like competition lead to non-use products)
9. Geography
10. Social perceptions and attitudes

Research Topics - Recreation

1. Climate change
2. Environmental pollutants
3. Use conflicts
4. Invasive species
5. Habitat loss
6. Water quality
7. Valuation
8. Rec. infrastructure (i.e., "loved to death")
9. Human response to natural variability
10. Economic markets

BRAINSTORMING RESEARCH QUESTIONS

Research Questions – Existence/Bequest

Ecosystem Structure and Function

1. How will climate change impact the structure and function of marine ecosystems?
2. What is the role of biodiversity in maintaining ecological resilience in the face of climate change/ocean acidification?
3. What are the functional linkages between specific changes in ecosystem structure and function and the existence values generated by wildlife?
4. What is the relationship between ecological structure/function and existence value? (we need to know the shape of the curve; also, we need to include a temporal component – e.g., do we value a sustained relatively low value or a boom-bust more?)
5. What are the relationships and interactions between values for broader biodiversity and values for specific species? (Do people value wolves or do they value wolves within a diverse ecosystem – is it diversity itself or diversity to support a specific organism?) Account for both economic and ecological influences.
6. How do people value ecosystem structure and function including economic and more broadly social values and acceptable tradeoffs?
7. What are the effects of the changing ocean on food web structure and function? (Ocean acidification, temperature, circulation changes, nutrient cycling; requires observations, modeling, process/wet lab studies)
8. What are the biogeochemical (e.g., deoxygenation, pH change, ocean acidification) effects of changes in trophic structure?
9. What are the ecological effects (including dynamics, feedback loops, and tipping points) of human-caused disturbances on ecosystem structure and function? (including people's values for those effects)
10. What are thresholds/tipping points of biodiversity loss associated with collapse of ecosystem function?
11. What is the sensitivity of existence to changes in ecosystem structure and function? (e.g., service vs. production)
12. Which functional groups of biodiversity are most critical for sustaining ecosystem function?
13. What is the relation of existence and bequest in communities in relation to variations in time scales of change of populations?

Climate Change

1. How do changes in species distribution and abundance resulting from climate change impact existence values over a range of scales (regional to global)?
2. How will the existence/bequest value of wildlife change with climate change impacts on wildlife abundance and diversity? (e.g., shifting communities, species losses, new assemblages)

3. How does climate change influence food web structure, and how does this affect existence values from wildlife?
4. How do we assess existence/bequest value of wildlife in a world where climate change is changing baselines such that each generation has a different perception of the baseline?
5. How does climate change-related uncertainty influence existence values and associated policy support?
6. How do we develop ocean and coastal policy to adapt to and mitigate effects of climate on biodiversity at Federal, state, and local levels?
7. What adaptation measures can be taken to maintain existence/biodiversity in a changing climate?
8. Which species have high extinction risk due to climate change?
9. What are the effects of climate change on T&E species to sustain biodiversity?

Use Conflicts

1. How do we encourage policy that effectively balances and trades off market benefits from resources uses with existence benefits? (e.g., right whales vs. lobstermen)
2. What tools and methods do managers need to balance use and existence values for coastal management, fisheries, habitat loss, or conservation?
3. How do we help society choose between conflicting uses? (I.e., how do we minimize impacts to existence/ bequest value while meeting other societal needs (like wind and wave energy, resource extraction, etc.)
4. What is the shape of tradeoff curves between alternative uses and ecosystem structure and function? (indirect effects on existence/bequest through ecosystem structure and function)
5. How do we measure (and potentially change as needed) the public's perception of the importance of diversity when we're making decisions about tradeoffs between human uses?
6. What is the sensitivity of existence/bequest to the individual and cumulative effects (real and perceived) of alternative uses?
7. Which coastal and ocean uses enhance or degrade existence and bequest values and how?
8. How do anthropogenic discharges affect the population dynamics of wildlife? (e.g., disruption of reproductive cycles caused by chemicals, HAB threats caused by nutrients)

Research Questions – Climate Regulation

Biogeochemical, esp. Carbon, Cycling Dynamics

1. How is carbon sequestration impacted by pollution, ecosystem structure and function, and climate change?
2. How and to what extent can coastal blue carbon be factored into carbon markets and climate policy frameworks?
3. What is the capacity of a changed ocean system to regulate climate?
4. What are the wildlife (i.e., the living) components critical for climate regulation?
5. What is the influence of both diversity and changing diversity in coastal and ocean carbon cycling?
6. What is the role of coastal and ocean carbon cycling (e.g., acidification, circulation, stratification) on wildlife diversity?
7. How do we measure and educate and inform public perception of the tradeoffs between the climate benefits of ocean sequestration and the costs to ocean wildlife of carbon sequestration?
8. How do changes in ocean productivity and ecosystem structure affect the flux of carbon between the surface and deep ocean?
9. How will changes in biogenic mineral production (e.g., calcite) due to ocean acidification impact the flux of carbon between the surface and deep ocean, and what controls biogenic mineral production?

Research Questions – Non-Food Products (across multiple topics)

1. How do we manage for and value the potential provision of unknown future products that rely on biodiversity?
2. How do we identify critical regions and habitats (hot spots) that support (or will support in the future) non-food product development? (i.e., identify indicators of potential product development)
3. What are the tradeoffs between provision of food and non-food products?
4. What is the appropriate way to document and characterize the biodiversity (including microbes) of coastal and marine systems and their natural products (and support research pipeline)?

5. What is the relationship between biodiversity (1) discovery of new compounds, and (2) production of existing compounds? (Maximum sustainable yield for pharmaceuticals=MPY)
6. What habitats/regions are critical for non-food/pharmaceutical production?
7. What are barriers to moving natural products to market? (research-to-product pipeline)
8. Are there alternative methods to discovering new natural products? (research-to-product pipeline)
9. What are impacts of extraction on ecosystem services and ecosystem structure/function?

Research Questions – Recreation (across multiple topics)

1. What is the relationship between ecosystem structure (size spectrum, diversity, abundance, distribution) and recreational activity/value? ("fishing down the recreational value")
2. How should we consider tradeoffs between recreational benefits (realized often by higher income groups) and non-recreational benefits to lower income groups?
3. How do we balance priorities to manage for broad recreational access for all groups versus managing to optimize benefits?
4. How do we make recreational activities "greener"? (i.e., how do we better measure stressors in order to minimize impacts of recreation?)
5. How do we protect what we're trying to promote? (i.e., in supporting recreation, we may overuse ("love to death") the resource and harm it; we need to balance use and protection)
6. How do we value recreation appropriately to evaluate tradeoffs with other, competing economic activities?
7. How do managers balance public infrastructure for recreation with protection of abundant and diverse wildlife?
8. What is the value of biodiversity for recreation?
9. What level of biodiversity is necessary for a satisfactory recreational experience?
10. How do invasive species influence the value of recreational opportunities?
11. How do we communicate the link between recreational activities and biodiversity?

VIBRANT AND ROBUST COASTAL COMMUNITIES AND ECONOMIES

This workgroup spent a significant amount of time developing a framework for understanding ecosystem research. Below are the major take home messages developed.

REPORT OUT

Ecosystem-based management is transformative. It requires ecosystem research that integrates the atmospheric, terrestrial, aquatic, and socioeconomic science components of NOAA, and provides a framework to do so. To do this well, we must fundamentally change and innovate our approach to research.

Focusing on the ecosystem services that support our shared goals (e.g., vibrant and robust coastal communities and economies) is the first of these innovations.

The second innovation is a framework that organizes our ecosystem research in a way that demands integration across disciplines and offices, and from the atmosphere to the land to the oceans.

The overarching question is: ***What are the linkages between single and multiple stressors and the delivery ecosystem services?***

- This includes natural and anthropogenic stressors and pressures, including climate change and ocean acidification.
- Focus on things for which we can develop and implement adaptation and mitigation strategies. What can we do to effect change?

Answering this overarching question requires that we develop a multi-scale understanding of:

a. Human activities and natural variability that affect/modify the ecosystem.
b. "Production" of ecosystem services and the links between them (includes valuation)
c. Link between a and b (carrying capacity, thresholds, including valuation)
d. Institutional and cultural context in which a and b are linked.
e. Effects of management strategies (adaptive, mitigation, enhance) on ecosystem services (includes valuation)
f. Links between ecosystem services and the goal (e.g., vibrant and robust coastal communities and economies, abundant wildlife, safe and sustainable seafood……).

This approach to ecosystem research will require innovation in observing, monitoring, and research methods. Our supporting question is: ***What observing systems, technologies, data collection methods, etc… do we need to answer these ecosystem research questions?***

This framework is:

- A tool for identifying complementary relations among individual ecosystem research efforts
- A means for assessing current research resources within NOAA and across NOAA and non-NOAA research efforts
- A method for setting research priorities based on complementarities and gaps

NOAA cannot do this alone. This will require strong partnerships between LOs, agencies, academia and industry.

ECOSYSTEM SERVICES AND RESEARCH TOPICS

The group also addressed the primary ecosystem services underlying their topic and characteristic (not prioritized) research questions that could be addressed for a selection of those ecosystem services.

Ecosystem Services (* = focus for research questions)

1. Ecological buffering
2. Seafood
3. *Hazard protection**
4. Biodiversity

5. Carbon sequestration
6. Biological filtration
7. Climate regulation
8. *Water quality**
9. Water quantity
10. *Food security**
11. *Recreation and tourism**

BRAINSTORMING RESEARCH QUESTIONS

Recreation and Tourism

1. What is the benefit to the participant/communities/suppliers of tourism?
2. How to predict pathogen levels to optimize use of this service? Which are harmful? What effect do pathogens have on beach closures?
3. What causes harmful algal blooms? How do we predict them?
4. How do we integrate capacity to solve science/policy questions?
5. What is the fate and transport of contaminants in coastal systems?

Hazard Protection

1. What are the determinants of spatial location choice along coastlines (value, hazard, hazard perceptions)?
2. How are anthropogenic stressors and climate change affecting/impacting the ability of ecosystems to serve as a hazard protection?
    a. How does changing ice affect the vibrancy of coastal communities?
3. What are the desired end points of hazard protection, the various natural and anthropogenic methods to achieve that end, and the tradeoffs between them (including impacts to other ecosystem services)?
4. What are the implications of the jurisdiction, organizational/political choices made by coastal communities in dealing with natural and human hazard protection?
5. What aspects of ecosystems provide hazard protection and how do human activities impact the provision of that service?
    a. How do we quantify the physical quantity and the value of protection? (Mechanisms/processes) (National Capital Project doing this)
    b. How much wetland, kelp forest, reefs are needed to protect the coast/community?
6. Are there non-market values of the coast?
7. How does climate change and ocean acidification alter the capacity of ecosystems to provide protection?
8. How does the absorption of a particular hazard affect the ability of the ecosystem to survive/thrive/rebound? How do we measure an ecosystem's resiliency to such events?
9. Which land use or habitat changes compromise ecosystem services capacity to protect communities from hazardous events?
10. What's our ability to model and predict?
11. What are relative costs of natural events (damage & recovery) for communities based on presence or absence of ecological buffers?
12. Can we quantify (+/-) changes in coastal/natural amenities due to natural events/disasters?
13. What are the technologies that can improve warning system of hazards?
14. How do we forecast the climate variability impact on hazards?

Water Quality

1. How do changes in land cover and use affect water quality?
2. What is the connection between the physical environment and water quality?
3. What are the impacts of water quality on various ecosystem components & biological processes? (forecasts)
4. How does climate change and ocean acidification affect the water quality and the ecosystem of the ocean?
5. How does water quality affect the quantity and value of recreation and tourism?
6. What's the relationship between water quality in coastal environments and off-shore environments?
7. What are the indicators that measure water quality and associated human health? How does a detriment to human health as a result of poor water quality affect the coastal economy?
8. How far inland are coastal water quality impacts felt?
9. What are the methods needed/to be developed? (process)

10. How do we integrate NOAA's wet and dry sides to address coastal water quality issues?
11. What are the biodiversity impacts? (Need to go in both directions. How does one affect the other?)
12. How do we take successful regional institutional processes to integrate and apply them on a national scale? What are the challenges and opportunities thereof? (process)
13. What are the thresholds/indicators for social, economical, and ecological impacts? What do the associated changes/tipping points mean?
14. What are jurisdictional impacts?
15. What are the low-cost improved methods?
16. What are the observing systems (NOAA & Interagency) needed to measure, develop & predict water quality? (Remote sensing, in-situ, modeling capabilities)
17. What are the data collection systems needed to measure, develop & predict human behavior?
18. How do we integrate the forecasting of ecological & human conditions?
19. What mechanisms exist that enable NOAA & other Federal agencies in managing sources of material fluxes that change water quality? (EPA?)
20. To what end are we managing fresh water?
21. What is the contribution of intact ecosystem processes to achieving water quality? What is the economic value of the contribution?
22. How does poor water quality impact use of ecosystems?
23. What is the opportunity cost to communities with low water quality?
24. What are the relative risks/impacts of poor water quality on people/groups of people?
25. What aspects of water quality impact protected species?
26. What significant weather events affect water quality? Timelines/baselines, etc?
27. What are the relative impacts of the anthropogenic stressors that impact the ecosystem versus natural variability?
28. What are the political/social dynamics that affect the health of an ecosystem (disproportional impacts)?
29. To what degree does climate change alter our perspective of water quality?

<u>Food Security</u>

1. What is the spatial and temporal variability?
    a. What are the competing factors that lead to the variability?
    b. Why is the variability important?
2. How do climate change processes, including ocean acidification and stratification affect Food Security?
    a. Hypoxia and stratification
    b. Ocean acidification
3. What other ecosystem service is this dependent upon?
4. How do land uses in the watershed impact next year's supply?
5. How does the interaction between fishing, habitat, and population affect ecosystem health?
6. Which consumption or extraction behaviors affect human health?
7. How does food security affect the economic security of a coastal community? How are they related? Where in the U.S. are the impacts the greatest? What are the causal links?
8. What are the alternative food supplies in the ecosystem?
9. What are the emerging contaminants (i.e., personal care products) and how do they impact coastal communities? What are the human behaviors to exacerbate or mitigate this? What are the drivers of these behaviors?
10. Given a changing climate & current level of use, what are the ecosystem requirements for biomass & species to remain healthy?
11. What is the relationship between the stressor and the ecosystem service? (i.e., non-linear/linear; thresholds) Then follow that link back to the user (so what? Document the impacts)
12. How will human institutions evolve to do ecosystem management? Organizational/institutional soc? Psych?
13. Can aquaculture assist in providing a sustainable food supply?
14. What are the most efficient/effective adaptation strategies to maintain food security?
15. What's the relationship between water quality and biomass?
16. Is it an open or closed system?

17. What is the trade-off between productivity and edibility (nutrition/fish health)?
18. What's the trade-off between food for human consumption versus the consumption by other ecosystem components? (Orca/salmon, by-catch)
19. What are the competing user groups?
20. How do we fully integrate the natural and social science?
    a. Both a process thing (a barrier?) and a research theme. We need to develop a methodology to ask and answer those questions.
21. Is Drivers, Impacts, Pressures, State, and Response (DIPSR) model a barrier to integrating social and biophysical sciences?

COASTAL AND OCEAN CULTURAL USES (INCLUDING RECREATION)

REPORT OUT

We first changed our title to "Sustained Cultural and Recreational Benefits from the Coasts and Oceans." We identified at least eight Ecosystem Services that support this theme. We highlighted eight research topics. We developed 25-30 research questions.

Issues and Challenges for Cultural Benefits:

- Historically, less attention to cultural Ecosystem Services at the Federal level
- Need to characterize these types of services
- How do you balance, tradeoff, and integrate qualitative and quantitative information about cultural uses of the ecosystem?
- Issue of social justice/equity/fairness

Integration

- Culture should be integrated across all groups, not separate
- Integrating the science of social and natural systems/scientific method/understanding
    - Integrating social science from the design-stage
    - Scale of systems
- ES are affected by the watershed
- Citizens away from the coast have values for coastal ecosystems
- Integrated ecosystem science requires overcoming institutional barriers

Holistic Science is Hard

ECOSYSTEM SERVICES AND RESEARCH TOPICS

Ecosystem Services

1. Recreation
    a. Land
    b. Water-surface
    c. Water-sub-subsurface
2. Traditional/spiritual practice
3. Coastal Living
4. Cultural identity
5. Education
6. Understanding
7. Aesthetics
8. Heritage

Research Topics / Attributes (* = focus for research questions)

Research topics and attributes were viewed as crosscutting multiple Ecosystem Services as opposed to applying to only one.

1. *Water quality/quantity**
2. *Biodiversity**
3. ~~3.~~ Human population dynamics
4. Coastal erosion
5. *Climate change**
6. Culturally-important species
7. Invasive species
8. *Ecosystem service valuation**
9. Ecosystem and human health connection
10. Psychology of risk
11. Communication
12. Economic sector make-up
13. Demographics
14. Restoration Trends
15. Human-use mapping
16. Land-use/land-cover
17. Air quality
18. *Management Strategies**
19. *Cultural connections to the water**
20. Habitat interaction and use
21. Heritage site preservation
22. Restoration design and evaluation
23. Catastrophe adaptation and mitigation
24. Sea level rise and coastal inundation
25. Human/community surveys
26. Characterize cultural and recreational ecosystem services*
27. Evaluation and assessment

28. Local and traditional knowledge and practice
29. *Social and economic dependence on ecosystems**
30. Vulnerability to ecosystem loss/change
31. Runoff
32. Storm buffers (dependent on regional culture)
33. Ecosystem engineering philosophy
34. Biotechnology
35. Social marketing
36. Knowledge, attitude, and beliefs of management actions on controversial topics

BRAINSTORMING RESEARCH QUESTIONS

Water quality/quantity

1. What are people's attitudes, perceptions, beliefs, uses, and public discourse about our coasts and ocean and management?
2. Characterize and monitor for decision-making the water quality/quantity impacts on cultural and recreational benefits of our ocean and coasts.
3. How are fresh/saltwater interfaces and habitats changing; what impact is this having on cultural/recreational ES's and how are human use and climate change affecting these?
4. How can NOAA work with other institutions and stakeholders to improve the conservation of coastal and ocean cultural and recreational benefits in the face of water quality and quantity challenges?

Biodiversity (including invasive species)

1. What is the public's understanding of the linkages b/w biodiversity and the species/ecosystem services they care about? What is their WTP?
2. How do we characterize and understand the links and interactions b/w cultural, socioeconomic and biological diversity?
3. How do we identify and manage invasive species threats and changes and sociocultural and economic impacts and interaction.

Climate Change

1. Impacts
    a. What are the impacts and the tipping points of climate change on the cultural recreational ecosystem services?
2. Risks/Vulnerability
    a. What coastal communities and cultural identities are particularly vulnerable to OR particularly resilient to the environmental impacts of climate change? (over different spatial and temporal scales)
3. Science/Communication
4. Management
    a. How do we manage cultural and recreational Ecosystem Services in the context of shifting baselines?
5. Adaptation
    a. What are the adaptation and mitigation strategies that coastal communities can adopt to respond to the potential loss of cultural and recreational ecosystem services due to climate change impacts?
    b. How can climate change research be performed and presented to reduce mutual hostility? (group thought should be moved to social marketing)

Ecosystem Service Valuation

1. How can ES be characterized quantitatively (value or quantity) or qualitatively?
2. What methods, models, data are required to characterize ES?
    a. Ensure comparability from place to place
    b. Scalability also needs to be addressed.
3. How can ES characterizations be used toward more effective decision-making and policy development? (tipping points, end points)
    a. How can ES characterizations be used toward a better public understanding of ES and that their values should be incorporated into economic issues?
    b. How can ES characterizations inform decisions regarding trade-offs?

Cultural connections to the water

1. Assess and map cultural value and use
    a. How can we best survey, characterize, and preserve different cultural connections to oceans and coastal environments?
2. Interaction between ecosystem and community health
    a. How do changes in the coastal and ocean ecosystems affect cultural identity and community well-being? (and vice versa)
3. Tradeoff between cultural uses
    a. How do we make trade-offs among different cultural uses of coastal and marine resources, when necessary? (note equity, fairness, social justice)

Management Strategies

1. Impact of Management Strategies on Society
    a. How do EBM strategies impact and affect society's cultural and recreational benefits from ocean and coastal resources?
2. Scale of Management and user conflict
    a. What effective management strategies can sustainably balance multiple conflicting demands for several (political) levels? (state, local, tribal, Federal)
3. Ecosystem Services in decision-making
    a. Which ES are used in decision-making and which are not? If not, what are the barriers?
4. Cultural and Stakeholder engagement
    a. How do you best utilize cultural identities to inform and improve management?
5. (Big System – theoretical): Can we get to clean water and air, and sustainable ecosystem services, in a capitalist system, with time?

Social and economic dependence on ecosystems

1. How do we characterize social and economic dependence on ecosystems to inform analysis?
2. How do we improve our understanding of the relevant processes linking social and economic well-being to the ecosystem?
3. How do we incorporate this understanding into integrated model(s) that in form management and decision-making? (SOCIAL AND ECOLOGICAL)

Characterize cultural and recreational ES

1. How do social and ecological system structure composition, function, and their variability relate to the supply of cultural and recreational ES (CRES) in time and space?
2. What is the current inventory and status (i.e., condition/quality) of CRES?
3. How can market/non-market values of CRES inform decision-making and adaptation strategies through tradeoff analysis, scenario building, etc.?

APPENDIX 7: INITIAL LIST OF IDEAS OF WHERE TO LOOK FOR BEST PRACTICES

Below is a "starter" list of communities of practice that could be reviewed for best practices and other lessons learned. The sources, identified in parentheses, can provide more information. A dynamic list will be developed so additional sources can be added as they are identified.

- OAR-NMFS Ecosystems & Fisheries-Oceanography Coordinated Investigations program (http://www.ecofoci.noaa.gov/)
    - BEST/BSIERP (http://bsierp.nprb.org/)
        - NSF/NPRB/NOAA Bering Sea ecosystem study
        - Addresses physics, climate, social, and other sciences
        - Multi-year, multi-funded
        - Ecosystem process studies, etc.
    - Aleutian Islands Fishery Ecosystem Plan (http://www.fakr.noaa.gov/npfmc/conservation-issues/aifep.html)
        - Interagency
        - Multiple stressors
- Strategic Environmental Research and Development Program (http://www.serdp.org/)
    - Dept. of Defense program
- Oceans and Human Health Initiative (http://oceansandhumanhealth.noaa.gov/)
    - Some parts have been very successful
- Landscape Conservation Cooperatives (http://www.fws.gov/science/shc/lcc.html)
    - Just getting started, so may not have many best practices yet.
- Integrated Ecosystem Assessment program (http://www.st.nmfs.noaa.gov/iea/index.html)
- Coral Reef Conservation Program (http://coralreef.noaa.gov/)
- NOAA Chesapeake Bay Office (http://chesapeakebay.noaa.gov/)
- Ecosystem-Based Management (EBM) Tools Network (EBMTools.com)

Science Advisory Board Reports with Similar Findings from the Workshop

- Integrated Ecosystem Assessments (SAB Letter Report 5 April 2010) http://www.sab.noaa.gov/Reports/2010/SAB-iea-let-trans-Final.pdf
- Integrating Social Science into NOAA Planning, Evaluation and Decision Making: A Review of Implementation to Date and Recommendations for Improving Effectiveness (April 2009) http://www.sab.noaa.gov/Reports/2009/SAB_SSWG_Report_FINALtoNOAA_041609.pdf
- Engaging NOAA's Constituents: A Report from the NOAA Science Advisory Board Final Report (March 2008) http://www.sab.noaa.gov/Reports/EOEWG/EOEWG_Final_Report_03_20_08.pdf
- One Ocean, One Health: NOAA in the Lead. 2010. http://www.sab.noaa.gov/Reports/ohwg/docs/SAB_Report_on_Oceans_Health_Final_to_NOAA.pdf
- Other SAB Reports can be found at: http://www.sab.noaa.gov/Reports/Reports.html

APPENDIX 8: ACRONYMS

CRES	Cultural and Recreational Ecosystem Services
EBM	Ecosystem-based Management
EPA	Environmental Protection Agency
ES	Ecosystem Service
FTE	Full Time Equivalent
LO	Line Office
NASA	National Aeronautics and Space Administration
NESDIS	National Environmental Satellite, Data, and Information Service
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
OAR	Office of Oceanic and Atmospheric Research
OHHI	Oceans and Human Health Initiative
PPI	Office of Program Planning and Integration
RC	NOAA Research Council
SES	Senior Executive Service
ST	Science Technical position
T&E	Threatened and Endangered