FROM: Subcommittee on Ocean Science and Technology

TO: Office of Science and Technology Policy

SUBJECT: Interagency Ocean Science and Technology Priorities for FY 2017

Introduction

The ocean, our coasts, and the Great Lakes feed our Nation, fuel our economy, support our cultures, provide and create jobs, give mobility to our Armed Forces, enable safe movement of goods, and provide places for recreation. Advances in science and technology and partnerships are necessary to help us better understand how these ecosystems function, what services and products they provide, how they influence and are influenced by human activities, and how best to inform management decisions. Federal funding of ocean science and technology is essential to enabling new and innovative opportunities to improve our understanding of ocean, coastal, and Great Lakes ecosystems, how they work, and how best to use their resources while maintaining their health and resilience.

This memorandum describes the recommended Fiscal Year (FY) 2017 interagency ocean science and technology priorities, which are areas that the National Science and Technology Council's Subcommittee on Ocean Science and Technology has identified as opportunities where interagency collaboration can yield significant advancement in the federal ocean S&T enterprise, including new interdisciplinary research approaches, advanced tools and techniques, and innovative technology and infrastructure.

These interagency ocean science and technology priorities for FY 2017 were identified in the context of and to advance the long-term vision founded in *Science for an Ocean Nation: Update of the Ocean Research Priorities Plan* and the National Ocean Policy. These priorities, briefly described below, are intended to complement those presented through Administration efforts such as the *National Strategy for the Arctic Region*, the *Hurricane Sandy Rebuilding Strategy*, *National Global Change Research Plan 2012–2021: A Strategic Plan for the U.S. Global Change Research Program*, and *The President's Climate Action Plan*. Of equal importance, leveraging opportunities with international partners have been identified for each priority area. Additional details are provided in the Appendix.

<u>Science to Inform Ecosystem-based Management</u>

Scientific understanding is essential to comprehending the fundamental structures, functions, processes, and human and natural interactions that shape ocean, coastal, and Great Lakes ecosystems and the services and products they provide. Research is needed to assess and predict the potential ecological and socioeconomic effects of human and natural impacts on ecosystems. Sound ecosystem-based management (EBM)[1] depends on the availability of reliable, accurate, and actionable ecological, social, and economic information. Interagency and international effort in the following areas will advance scientific developments:

- *Increase understanding and education to advance the value of scientific data, assessments, models, and best practices for effective EBM;*
- *Expand the use of existing, and advance the creation of new, scientific tools that support EBM;*

[1] As defined in *Implementing Ecosystem-Based Management: A Report to the National Ocean Council*, Ocean Research Advisory Panel, December 2013. (http://www.nopp.org/wp-content/uploads/2010/03/Implementing-EBM-v4.pdf).

- *Improve the incorporation of scientific data and predictive models, such as climate change projections, to enhance risk assessments and decision making.*

The Arctic Marine System

Rapid changes are being observed in the Arctic marine system as Arctic air temperatures increase at three times the rate of anywhere else on Earth. The consequences of rapid environmental change have significant ramifications for the health and well-being of people and communities, and impact economic development and homeland and national security. The best available information is needed to understand how Arctic weather, climate, sea ice, and ecosystems will be affected, and how the causes, consequences, and future trajectories will affect the rest of the Earth. In alignment with the *National Strategy for the Arctic Region*, agencies should increase understanding through scientific research and traditional knowledge, and work together and with international partners in the following areas:

- *Advance foundational science and technology for understanding and responsible stewardship of the Arctic marine system; and*
- *Improve sea ice, weather, and climate observing and prediction capability at a variety of scales for safe and effective navigation and operations, and advancing understanding of the response of the Arctic marine system to further change.*

Integrated Climate Science for Ocean Stewardship

Planet-scale changes in the climate system can have significant effects on the nation's valuable coastal and ocean ecosystems including changing sea levels, temperature, circulation, chemistry, productivity, diversity, and ecosystem and public health. These changes can both positively and negatively impact the many people, businesses, communities, and economies that depend on coastal and ocean systems for jobs, safe seafood, clean water, coastal protection, safe transportation, and other products and services. Coordinated interagency and international effort in the following areas will advance the science necessary to understand risks and impacts, support and enable informed decision making, and build capacity and understanding to continually assess the impacts of climate change on coastal, ocean, and Great Lakes ecosystems and communities:

- *Develop early warning systems for changes in ocean and coastal ecosystem health;*
- *Advance understanding of current and future climate impacts on oceans and surrounding communities; and*
- *Broaden integrated understanding of changing risks from climate-related hazards and their interactions with risks due to extreme events and human use and development.*

Ocean Observations, Modeling, and Data Accessibility

Observations of the ocean, coasts, and Great Lakes improve our understanding of weather, climate, ecosystems, and ocean conditions, allow us to forecast key environmental processes, and strengthen resource management decision-making at all levels. Progress in all areas described in this memo is dependent on observing capabilities and capacity. Working with partners from local to international scales improves access to open, machine-readable observational data for use by many different sectors—from commercial and recreational interests to government and academia— for multiple purposes. Observations also feed directly into modeling efforts to improve our understanding of past events, current conditions, and projections into the future. Agencies should coordinate to address the following areas:

- *Sustain and advance ocean, coastal, Great Lakes, and global observing system infrastructure, including the operational federal network of data collecting buoys operated by the National*

Weather Service National Data Buoy Center (NDBC) as well as the U.S. Integrated Ocean Observing System (IOOS) to address current and emerging local, national, and global issues, including the other priority areas in this memo;

- *Develop and share decision-support tools to identify coastal land protection and restoration priorities, assess and forecast community and ecosystem resilience and vulnerability, and evaluate the efficacy of management strategies to enhance coastal and marine health, safety, and sustainability; and*
- *Develop and improve upon the integrated ocean and coastal data and information management system to support archival capability for and access to observational data and derived information, including socioeconomic data.*

Selection of Future Interagency Ocean Science and Technology Priorities

Specific ocean science and technology priority areas and interagency activities may change from year to year, but the societal themes and cross-cutting topics in *Science for an Ocean Nation* and science to support National Ocean Policy implementation will serve as the foundation of the annual priorities in the long-term. The SOST will develop annual priorities to advance this foundation, and present the priorities within the context of this long-term vision.

APPENDIX

Science to Inform Ecosystem-based Management

- *Increase understanding and education to advance the value of scientific data, assessments, models, and best practices for effective ecosystem-based management (EBM)*
    - Use results from 2014 questionnaire conducted on federal agency programs and projects that use EBM (conducted by the National Ocean Council EBM Interagency Group) to analyze EBM successes and shortcomings, and identify and fully describe the key characteristics of effective federal EBM efforts. Document the results and make the information available to federal agencies; and
    - Implement guidelines for education, outreach, training, and knowledge-sharing by communicating the core principles of EBM and the role of Adaptive Management including best practices and optimal management strategies, and decision-support tools among the partners involved in the "end to end" process from initial launch of EBM planning efforts, the acquisition of scientific information, analysis, and the implementation via decision-making.
- *Expand the use of existing, and advance the creation of new, scientific tools that support EBM*
    - Using tools such as the Integrated Ecosystem Assessment (IEA), implement a science-driven framework of integrated observations, monitoring, research, and modeling to provide a sound scientific basis to inform resource management decisions;
    - Engage partners and stakeholders, including international partners such as the United Nations Environment Programme (UNEP), to expand the use of tools for EBM (e.g., IEAs), including monitoring of natural and human systems; and
    - Develop science-based tools that integrate natural and human dimensions that enable resource managers to make sound decisions, including coupled ecological-economic models and increased integration of socio-cultural information for decision making.
- *Improve incorporation of scientific data and predictive models, such as climate change projections, to enhance risk assessments and decision making*
    - Advance fundamental understanding of marine ecosystem structure, function, and processes, which may include interdisciplinary research incorporating climate variability and change, anthropogenic impacts, and/or the human dimension at a variety of scales;
    - Improve incorporation of climate change projections in EBM tools to improve assessments of risks that are associated with various decision options; and
    - Using ocean.data.gov (http://www.data.gov/ocean/) and other scientific data sources, identify federal and regional science information gaps that impede science-based EBM. Prioritize the gaps and implement plans to fill the gaps with particular focus on basic natural and socioeconomic data that will enhance our understanding of the cumulative ecosystem effects of various human and natural forces.

The Arctic Marine System

- *Advance foundational science and technology for understanding and responsible stewardship of the Arctic marine system*
    - Sustain a Distributed Biological Observatory (DBO) for long-term data on biological, chemical and physical variability, and ecosystem response to climate change;
    - Develop integrated ecosystem research in the Beaufort and Chukchi seas to identify and understand processes that control ecosystem structure and function as well as sensitivity to physical and chemical changes;

  - Support research in Arctic fisheries, protected species and marine ecosystems for sustainable use, conservation, and response to and protection from environmental disasters;
  - Survey and chart Arctic coasts and waters for safe navigation and coastal community resilience;
  - Improve oil and other hazardous material spill prevention, containment, and response infrastructure, technology, damage assessment, and restoration strategies to protect and conserve the Arctic environment; and
  - Coordinate with international partners (e.g., through the Arctic Council, International Arctic Science Committee, and the World Meteorological Organization) on Arctic science and technology to advance national and international interests and pursue global objectives including climate change and its impact on ecosystem and human health.
- *Improve sea ice, weather, and climate observing and prediction capability at a variety of scales for safe and effective navigation and operations, and advancing understanding of the response of the Arctic marine system to further change*
  - Sustain observations of sea ice extent, age, thickness, albedo and motion; air temperature, clouds, surface radiation, and atmospheric composition; ocean stratification, circulation and mixing, and carbon dioxide and methane emissions;
  - Understand key processes, and atmosphere-snow-ice-ocean-wave interactions and feedbacks through studies that include field experiments, airborne and satellite remote sensing and improved process modelling;
  - Develop fully coupled Arctic atmosphere-ice-ocean-wave models and Earth System Prediction Capability;
  - Assess sea ice, weather and climate predictability and improve coupled model physics to reduce the uncertainty of predictions;
  - Investigate data assimilation techniques for improved short-term prediction; and
  - Understand the effects of the changing Arctic on mid-latitude weather and Arctic and global sea level.

Integrated Climate Science for Ocean Stewardship

- *Develop early warning systems for changes in ocean and coastal ecosystem health*
  - Strengthen ability to track, assess and provide early warning of changes in marine ecosystems, including those that could directly impact human health (e.g., harmful algal blooms, safe seafood, water quality) by developing/improving the system of key metrics, indicators, observations and assessments in each region; and
  - Improve ability to forecast weather, ice, precipitation, and water level events that could impact ocean and coastal communities.
- *Advance understanding of current and future climate impacts on oceans and surrounding communities*
  - Improve characterization of climate impacts on ocean biogeochemistry (including ocean acidification) for use in assessing risks and developing management options;
  - Enhance understanding of climate-related risks and impacts on living marine resources and the people who depend on them (e.g., fish stocks, protected species, resource-dependent communities, including tribes); and
  - Integrate ocean, coastal, and Great Lakes climate change and ocean acidification risks, impacts, and vulnerabilities into international climate assessments.

- *Broaden integrated understanding of changing risks from climate-related hazards and their interactions with risks due to extreme events and human use and development*
    - Increase identification and assessment of integrated impacts from climate and non-climate stressors (e.g., population growth, coastal land, water, and ocean use, subsidence) on oceans and coastal watersheds (e.g., coastal-based energy infrastructure, navigation, dredging operations) and on living marine resources (e.g., anadromous fishes and shellfish, which are economically important and compose a significant aspect of many treaty rights in tribal communities along the coasts); and
    - Strengthen risk communications and behavior research for chronic and episodic events to better protect lives and livelihoods.

Ocean Observations, Modeling, and Data Accessibility

- *Sustain and advance ocean, coastal, Great Lakes, and global observing system infrastructure, including the operational federal network of data collecting buoys operated by the National Weather Service National Data Buoy Center (NDBC) as well as the U.S. Integrated Ocean Observing System (IOOS), to address current and emerging local, national, and global issues, including the other priority areas in this memo.*
    - Increase and improve observing capabilities, such as the Ocean Bottom Seismograph Instrument Pool (OBSIP), High Frequency (HF) Radar surface current monitoring network, Tropical Pacific Observation System, Tropical Atmosphere Ocean Array, Marine Biodiversity Observation Network, and the Argo network of ocean floats;
    - Increase the availability of and improve interagency cooperation and collaboration in the use of platforms and sensors for making *in situ* observations, including Gliders/Autonomous Underwater Vehicles (AUVs), profiling floats, Unmanned Aerial Systems (UASs); drifting ice-tethered systems such as buoys, autonomous weather stations, under-ice profilers; fixed systems such as moorings, cabled observatories, Coastal-Marine Automated Network (C-MAN) stations, and tide gauges; and ice-hardened or ice-breaking research vessels;
    - Implement a national Animal Telemetry Network (ATN);
    - Increase passive acoustic observing capability through establishment of a national Ocean Sound and Noise Monitoring Network;
    - Continue development of new remote sensing capabilities, such as ICESat-2, GRACE Follow On and the US-India NISAR mission; sustain and advance satellite ocean observation capabilities on the International Space Station; and sustain and advance operation of existing satellite ocean observation capabilities, e.g. QuikSCAT, OSTM, Aquarius, ISS/RapidScat, MODIS (Terra and Aqua) and VIIRS(NPP);
    - Improve regional ocean observation systems to better track and assess climate-driven changes in U.S. ocean ecosystems, particularly sustained observations of physical, chemical, biological, geological, socio/economic and human health variables and indicators in the Arctic marine system, coastal areas, ocean, and Great lakes;
    - Improve understanding of ocean acidification via engagement with the Global Ocean Acidification Observing Network (GOA-ON);
    - Enhance, coordinate, and integrate global ocean observations that are critical to addressing current and emerging global issues, including engaging with international partners under the Global Earth Observation System of Systems (GEOSS) framework, including the Intergovernmental Oceanographic Commission (IOC) and Global Ocean Observing System (GOOS), International Maritime Organization (IMO), and the Joint

WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM); and
    - Improve projections of climate change and predictions of weather and shorter-term climate and their effects on coastal communities and the nation in support of the Global Climate Observing System (GCOS) Implementation Plan.
- *Develop and share decision-support tools to identify coastal land protection and restoration priorities, assess and forecast community and ecosystem resilience and vulnerability, and evaluate the efficacy of management strategies to enhance coastal and marine health, safety, and sustainability*
    - Expand the U.S. IOOS Coastal and Ocean Modeling Testbed (COMT) to accelerate advances needed in order to transition models from research to operations;
    - Accelerate the development of the National Unified Operational Prediction Capability (NUOPC), a Commerce and Defense Department (Navy, USAF) cooperative initiative to transition new technology, eliminate unnecessary duplication, and achieve a superior National global ensemble atmosphere/ocean prediction capability;
    - Improve modeling capabilities, such as the Hybrid Coordinate Ocean Model (HYCOM) by increasing the resolution and coupling of coastal ocean modeling capability for the U.S. (including circulation, waves, storm surge, and tides) and standards and techniques for using unstructured grids; and
    - Implement results of the National Ocean Policy action, "Develop a national modeling strategy to determine how regional-scale models supported by IOOS regions can be integrated into Federal efforts," including advancing model coupling, enhancing data assimilation capabilities using IOOS observing platforms, improving ensemble predictions, and developing pan-regional cyberinfrastructure across the IOOS regional associations.
- *Develop and improve upon the integrated ocean and coastal data and information management system to support archival capability for and access to observational data and derived information, including socioeconomic data.*
    - Increase awareness and adoption of interagency data management frameworks like the Common Earth Observation framework of the U.S. Group on Earth Observations (USGEO) http://www.whitehouse.gov/administration/eop/ostp/nstc/committees/cenrs/usgeo);
    - Increase the stewardship, preservation, and sharing of observation data by ensuring archiving of data sets at one of the National Oceanic and Atmospheric Administration (NOAA) Environmental Satellite, Data, and Information Service (NESDIS) data centers, increasing the number of data sets available publicly through modern data access services such as the NOAA Environmental Research Division's Data Access Program (ERDDAP), and developing the U.S. IOOS Regional Association data assembly centers as the distribution mechanism for regional ocean data and information;
    - Further develop the decision making tools such as the Environmental Response Management Application (ERMA);
    - Improve access to high quality data, using tools such as the U.S. IOOS Data Catalog and Asset Viewer (http://www.catalog.ioos.us), ocean.data.gov (http://www.data.gov/ocean/), and the National Science Foundation Earth Cube; and
    - Verify the national deployment of data management frameworks by rigorous testing and evaluation strategies, such as the U.S. IOOS Systems Integration Test, and implement well-accepted international standards for data transmission formats, metadata, and version control via the Global Telecommunications System (GTS).