Revised October 29, 2018

NOAA SCIENCE ADVISORY BOARD

2018-2019 Work Plan

INTRODUCTION

In 2016, the NOAA Science Advisory Board (SAB) developed a Concept of Operations. As part of this document, the SAB and NOAA agreed that every two years, in conjunction with the renewal of the SAB Charter, a work plan should be developed, based on the agency's mission and priorities and grounded in research and development plans of the agency, line offices, and program levels, as appropriate. This plan is the first such biennial work plan to be developed.

NOAA MISSION

Science, Service and Stewardship

1. To understand and predict changes in climate, weather, oceans and coasts;
2. To share that knowledge and information with others; and
3. To conserve and manage coastal and marine ecosystems and resources.

NOAA PRIORITIES

1. Reduce the impacts of extreme weather and water events
2. Increase the sustainable economic contributions of our fisheries and oceans (blue economy)

SAB ROLE

The SAB may serve different roles in providing advice to NOAA.

- It may serve as a "think tank" to give high-level thoughts on "blue sky" or "over the horizon" topics that are just emerging in science or society.
- It may delve into specific topics that cut across all or much of the agency and require in-depth consideration.
- It may react quickly to issues that come up on an *ad hoc* basis and due to unforeseen circumstances.

Each of these situations may require different interactions with NOAA, use of different member structures and processes, and varying types of "products" to address them. This work plan covers short-term topics of interest and several that will require more in-depth analysis over the next 18 months. Issues that arise in the third (*ad hoc)* category will be addressed as they arise.

The SAB, in the past, created working groups (WGs) consisting of additional experts to address ongoing issues (standing WGs) and short-term questions raised by NOAA (*ad hoc* task forces). The SAB Work Plan is not intended to preclude such options, but they should be used to enhance the ability of the SAB to provide NOAA with the best advice possible. The SAB may determine that delivery of some elements of the work plan may best be generated by a WG, or significantly informed by inputs from WGs. For example, work proposed by the Environmental Information Services Working Group (EISWG) under Priority 1 illustrates this sort of approach.

PROCESS

To develop a set of potential projects, the SAB convened two subgroups, one for each priority area, to further develop work plan options for those priority areas. They reviewed the draft document, refined, revised and/or added to those topics identified in each of the two priority areas, reflecting on NOAA priorities, topics raised by members, and ideas coming from SAB working groups. The subgroup(s) formulated a set of potential projects for the SAB with appropriate timeframes, level and types of expertise needed, and a notional plan for addressing each one

Topics discussed with RDML Tim Gallaudet included ocean exploration, the water cycle, aquaculture, autonomous systems, and decision support, but there could be others within the context of the NOAA priorities. These topics were considered for the draft of the SAB Work Plan discussed at the April 2018 SAB meeting.

Subsequent to the SAB meeting in April, the SAB subgroups and staff made changes to the language based on discussions. Two of the SAB working groups, the Ecosystem Sciences and Management Working Group and the Climate Working Group, also reviewed the draft Work Plan at their meetings, provided input, and suggested areas where they might contribute. This version of the Work Plan reflects discussions by NOAA leadership and SAB members at the April SAB meeting and additional discussions on a number of topics since that meeting.

The SAB discussed the Work Plan with NOAA leadership in its webinar meeting on May 24, 2018 and approved all work plan topics except topics 7 and 9 that were discussed at the July 17-18, 2018 meeting. As a result of that discussion, the SAB agreed that advice to NOAA on all topics should include the following:

- Address the potential of public-private partnerships where the definition of private partnerships includes industry, academia and non-governmental and inter-governmental organizations.

- Specific recommendations for what NOAA should change or add in the future rather than making recommendations that the agency should continue what it is already doing.

At the July 2018 meeting, Work Plan Topic 9, New Technologies for Fisheries Stock Assessments, was approved and assigned to the Ecosystem Sciences and Management Working Group for action. No decisions were made on Topic 7, Evaluating NOAA Coastal Sciences; RDML Tim Gallaudet said NOAA agreed to provide more detail on the scope of this topic.

Actions from the July 2018 meeting included that thee SAB champions for each Work Plan Topic will establish an implementation plan for the topic that includes a timeline, deliverables and a discussion of next steps.

PRIORITY 1: REDUCE THE IMPACTS OF EXTREME WEATHER AND WATER EVENTS.

Topic 1: Oversee Development and Implementation of the Environmental Information Services Working Group Work (list from WRFIA):

The Environmental Information and Science Working Group was established by the SAB in 2009 and made permanent by provisions in the Weather Research and Forecasting Improvement Act of 2017 (Public Law 115-25), hereafter referred to as WRFIA. The primary task of the WRFIA is to reduce the impacts of extreme weather and water events to save lives and protect property. The WRFIA specifies certain activities where the EISWG is to advise and assist NOAA line offices in meeting the terms of the Act. These include:

1) To prioritize weather and climate research and development initiatives in NOAA
2) To advise on existing or emerging technologies from the private sector and academia for better monitoring and analysis of weather and climate events and improved weather and climate forecasting:
    - Earth system (ES) modeling. ES prediction capability, coupling, data assimilation, computation. Elements of modeling. Current focus on the dynamic core: what should the priorities be after that? What is the next missing key element(s) (e.g., different physics implementations)?
    - Observing component: how to apply new technologies (such as improved data assimilation) for a more comprehensive and cost-effective local, regional, national, and global weather and climate monitoring system; advise enhanced communication between NOAA weather forecasters and decision; makers at national, state, and local levels, e.g., city and county emergency managers.
3) To enable improved communication among NOAA, the private sector, and academia.

The EISWG is discussing these topics with the National Weather Service (NWS), Ocean and Atmospheric Research (OAR), and National Environmental Satellite, Data and Information Service (NESDIS). The NWS has asked for advice on how to include the academic and commercial weather communities to address the challenges of improving weather and climate monitoring, analysis, and forecasting and the innovations needed for such improvements. The EISWG is prepared to respond to OAR's call for advice on how better to position itself to prioritize its research and development efforts in this context. Because this is such a large and potentially daunting task, the EISWG has asked the line offices to provide it with their best options to which the WG can react in a timely and specific way.

In addition to the above, the EISWG is responsible for assisting NOAA (via reports and recommendations passed through the SAB) with reviewing and updating policies for interacting with the private sector (i.e., the partnership policy).

Oversight of the EISWG's work is an ongoing high-priority activity. The SAB will help implement this work by supplementing the SAB liaison with additional members of the SAB who will meet with the EISWG co-chairs on a regular basis by teleconference/webinar. In addition, EISWG will provide verbal updates on its activities at in-person SAB meetings.

SAB Champions—Bob Winokur and Everette Joseph

Topic 2: Review the Use of Observing System Simulation Experiments (OSSEs)

An OSSE is a modeling experiment used to evaluate the impact of new observing systems on operational forecasts when actual observational data are not available. OSSEs are done: 1) to find out if a new observing system will add value to NWP analyses and forecasts; 2) to make design decisions for a new observing system; and 3) to investigate the behavior of data assimilation systems in an environment where the truth from the Nature Run is known (paraphrased from Prive & Errico PPT, 2015). NOAA has a Quantitative Observing System Assessment Program that uses OSSEs for a number of purposes related to NOAA's observing and modeling activities for both the atmosphere and ocean. These OSSEs are mandated by Section 107 of the Weather Act and follow the rigorous methodology for performing OSSEs that was established by (Atlas et al., 1984) and described in detail by Hoffman and Atlas (2016).

The EISWG discussed this topic at its July 2018 meeting. The Climate Working Group has also expressed interest in this topic; 1-2 of its members may be willing to join the effort.

SAB Champion: Eugenia Kalnay

Topic 3: Enhance Strategic Investment and Use of Unmanned and Autonomous Systems

NOAA has a broad set of observing requirements to address its operational and research missions. Unmanned and autonomous systems (exclusive of satellites) have become an important element in augmenting traditional approaches to collecting environmental data, including weather, coastal, marine and polar observations. Underwater, surface and aerial versions of these systems have already been incorporated into many of NOAA's observing systems. The recent expansion and application of these systems and their sensor payloads have been particularly successful in addressing various NOAA Earth System and Weather Prediction observational needs. For example, unmanned aerial systems, such as the Global Hawk, have been used to collect data to support forecasting of high-impact weather and respond to natural and environmental disasters.

NOAA has been a leader in the application of unmanned systems and technologies in challenging environments: however, NOAA would benefit from an overall strategy for the crosscutting use of unmanned systems. While there are numerous important applications of autonomous systems across the agency, it is not clear there is a coherent agency-wide rationale for investments, priorities and partnerships in these systems. Each line office has its own rationale and specific priorities for investments in unmanned systems. While these investments have been important and have addressed key needs in each line office, an overall strategy could further enhance investments and applications of unmanned/autonomous systems and could identify efficiencies and eliminate redundancies, especially in times of constrained funding. As an example, a subset of an overall strategy could be the enhanced application of unmanned aerial systems for data collection and observations related to forecasts of high-impact weather, which could be an element of an observing system strategy identified in the WRFIA. There are numerous other applications in the marine and polar environments as well.

There will be a NOAA workshop on this topic in Fall 2018. The Executive Oversight Board is interested in having SAB advice on the effort. The SAB lead will meet with OAR and OMAO leadership to assess options for developing a whole of NOAA strategic plan or strategy for autonomous systems.

SAB Champion: Bob Winokur

Topic 4: Review Improving Data Collection, Management, Dissemination and Decision Support, and Leveraging New Approaches such as those encompassed in the domain of Artificial Intelligence (AI) and Data Science

NOAA has long had data at the core of its mission with highly heterogeneous coming generated from satellites and variety of other platforms and sensors. NOAA has also made significant

strides in creating an enterprise-wide approach to data curation and access. At the same time there are a number of trends that potentially influence ongoing and future NOAA activities related to data. These trends include increasing access to compute resources, the movement of both data and compute to the "cloud", continuing exponential growth of data, new analytical methods, and new sources of data.

In the context of this topic, these broad trends will be consolidated into three themes: 1) new data science methods; 2) new computing technologies supporting data science; and, 3) new types of data. New data science methods include machine learning, deep learning, and AI techniques. New computing technologies include distributed computing trends, cloud technologies, and new computing architectures. New types of data include crowd-sourced data, and data related to economic and human decision-making behavior.

With all of the recent advances in machine learning and AI, it is timely to review whether and how these technologies can help NOAA when creating tools for decision makers in the fisheries, ecosystems, climate, weather, and other oceanic and atmospheric discipline areas. What kinds of research should NOAA undertake to be able to incorporate machine learning into its decision-support services and tools? What kinds of data, data sets, and technology are needed for NOAA to engage with machine learning tools? An example of the relevance of this type of technology is the Weather Company, an IBM business, and the National Center for Atmospheric Research (NCAR), which recently formed a partnership to enhance the weather and climate prediction capabilities of IBM's Watson. More broadly, if data gathering and analysis about fisheries, ecosystems, climate, weather, and other oceanic and atmospheric information are thought of as *environmental intelligence*, how can data science, machine learning and AI advance NOAA's production and delivery of environmental intelligence to improve public-sector management and private-sector decision-making and result in improved outcomes for the public?

While NOAA has expanded its observing and prediction systems, it also needs to continue improving its ways of collecting, managing, and disseminating data to respond to changing science and technology. These data are generated from the satellites and the variety of platforms and sensors already deployed and from new sources, including the analyses of physical samples, e.g., 'omics, and from social science sources such as analysis of economic and human decision-making behavior. NOAA needs to explore ways of integrating these data, improving access, and assuring the quality and integrity of data from these new sources. In addition, NOAA could also explore more use of citizen science to enhance a shrinking workforce and to vastly enhance possibilities of expanding data. As an example, eBird operated by the Cornell Lab of Ornithology, has vastly expanded data points on bird locations, numbers, migration patterns, etc. beyond anything that any workforce—public or academic—could ever provide.

The considerations outlined in these three themes apply across many of NOAA's priorities.

SAB Champions: Robert Grossman and Chris Lenhardt

Topic 5: Social Sciences and Decision Support in NOAA (relevant both to Priorities 1 & 2)

In July 2015, the NOAA Social Science Committee released *Vision and Strategy: Supporting NOAA's Mission with Social Science*, which set the agency's social science vision and strategy for the next 3-5 years. The document provides opportunities to align office and program efforts with the goals, objectives, and strategies outlined within. Some examples of NOAA social science programs aimed at presenting NOAA data and information tools in a usable format to both private and public partners include:

- Weather-Ready Nation Ambassadors Program;
- Impact-Based Decision Support Services (IDSS);
- SKYWARN Storm Spotter Program;
- Storm Surge Program; and
- Climate Program Office Communication and Education Program (CommEd).

1. *Enhance Use of Decision Support Products, Processes, & Tools for NOAA Social Science Projects*

The SAB can review one of NOAA's Social Science programs to see how it meets the goals set forth by the 2015 Social Science Vision and Strategy document. A potential focus could be on "impact-based decision support services of decision support products, processes, and tools", in keeping with the SAB identification of enhanced use of decision support as a priority topic. The SAB can also provide comments for consideration in the next iteration of the *Vision and Strategy: Supporting NOAA's Mission with Social Science* document.

In undertaking this review of the 2015 document and anticipation of a next iteration of the social sciences vision document, the SAB will:

- Examine the criteria NOAA uses to evaluate its social science programs to make sure each program meets the Social Science Vision and Strategy goal to strengthen societal decision-making. How can NOAA evaluate its social sciences goals?
- Assess what, if any, goals are missing from the three goals set by NOAA in the social science vision document. Are areas of social science not addressed in the document?
- Consider research opportunities to add to the current state of social science knowledge that would improve support for the goal of strengthening societal decision-making.
- Assess status and opportunities for enhanced use of machine learning and work with the Social Sciences Committee to evaluate progress on the Mission and Strategic Vision.

2. *Review of economic impact and economic values reports*

- Assess NOAA Social Sciences Projects, including, per the request from the NOAA Chief Economist Monica Grasso at the SAB meeting in October 2017, an assessment of three reports (timeframe determined by completion of reports but likely 3-6 months after that):
    - Cooperative Research and Development Agreements (CRADA) Economic Impact Study
    - Economic Value of Marine Vessel Observations
    - Economic Impact of Space Weather

Summary of Purpose

The SAB can recommend what science is needed to enhance, develop, and facilitate effective use of the basic decision support and social sciences products; recommend robust processes for working with academia, the commercial sectors, and others to develop what is needed to enhance the utility of decision support tools and social sciences applications; engage with decision support tool users and related stakeholders to identify needs; and develop an evaluation protocol embedded as an ongoing process within the spiral creation of the products and tools.

Enhancing the relevance and utility of decision support tools involves technical, scientific, and communications expertise, as well as understanding the processes and ways in which users frame problems, define needs and use information.

SAB Champions: Lynn Scarlett and Richard Moss

PRIORITY 2: INCREASE THE SUSTAINABLE ECONOMIC CONTRIBUTIONS OF OUR FISHERY AND OCEAN RESOURCES (BLUE ECONOMY)

I. Overview

A comprehensive understanding of the ecological and economic contributions of our Nation's coasts and oceans goes beyond extraction-focused considerations and beyond the six sectors typically used in assessments, such as that of the U.S. ocean and Great Lakes economies, which include living resources; marine construction; marine transportation; offshore mineral extraction; ship and boat building; and tourism and recreation. For example, beyond these six sectors, coastal ecological systems contribute to wave attenuation, reducing impacts to communities from extreme storms and serving as a form of coastal protection infrastructure. Currently, NOAA's Office for Coastal Management, using data from the Bureau of Labor Statistics and Bureau of Economic Analysis, annually values the ocean economy with "Economics: NOAA Ocean Watch (ENOW)", an online tool used to streamline the task of obtaining and comparing economic data, both county and national, for these six sectors dependent on the ocean and Great Lakes. ENOW's annual time-series data are produced for 400 coastal counties, 30 coastal states, eight

regions, and the nation. Many relevant tools are in place to track economic contributions – an important context for NOAA's work to see increases in this area. While many tools are available to assess economic contributions (monetized or otherwise), a broadening beyond the six sectors described above of the ecological and economic contributions of coastal and ocean systems is altering concepts of what constitutes the Blue Economy.

II. Science Advisory Board Focus

The SAB will develop science-based concepts and recommendations to support NOAA in the enhancement of the ecological and economic contributions of coastal and ocean resources and coastal communities and their sustainability by focusing on several critical, related areas: 1) coastal and marine aquaculture; 2) how healthy ecosystems support long-term economic resilience, and 3) coastal and marine transportation and support infrastructure, including working waterfronts. In so doing, the SAB will help answer such questions as "How might NOAA research best support the industries reliant on a sustainable fishery?", "What scientific research can NOAA undertake to support sustainable development of marine aquaculture?", 'How can natural system-dependent economic activities be sustained and enhanced as coastal areas change over time?', and "What can NOAA provide to support marine transportation needs to ensure sustainable coastal communities?"

Topic 6: *Sustainable Marine Aquaculture*

The SAB will develop guidance on the most effective deployment of NOAA's science enterprise investments for science and research that supports increasing aquaculture production in the U.S.

Increasing aquaculture production is a priority of the Secretary of Commerce. It has great growth potential, contributes to seafood supply and food security, and may improve the U.S. trade balance with other nations. The Department of Commerce Strategic Plan identifies the need to support research to advance marine aquaculture. In addressing this goal, the SAB will collaborate with a sister federal advisory committee, NOAA's Marine Fisheries Advisory Committee (MAFAC) that has worked on aquaculture issues for many years. MAFAC established an Aquaculture Task Force (ATF) composed of experts from around the nation, to provide advice on the Gulf Aquaculture Fisheries Management Plan, streamline permit application processes, and advise as to how aquaculture operations can support coastal resilience.

The SAB seeks baseline information on US marine aquaculture science and research. At the July SAB Meeting in New Hampshire, the SAB received presentations from NOAA scientists, managers and external experts on the status of marine aquaculture science and research, particularly related to production constraints and social acceptance of aquaculture products. NOAA would like the MAFAC Aquaculture Task Force to review the draft and identify industry-driven research priorities that will advance domestic marine aquaculture production.

Following that effort, the SAB examine the draft SASP and industry priorities to optimize the future research program by:

1. Ensuring that the science is done well and the appropriate tools are brought to bear to answer the questions industry has identified;
2. Providing guidance on how to best allocate the resources of the NOAA labs (i.e. Fisheries Science Centers and NOS) and the extramural research programs to ensure efforts complement and maximize the value of NOAA aquaculture science investments (i.e. long term projects vs. short term RFPs and public private partnerships).

Projected time line: The NOAA Aquaculture Science Review is projected to be available in draft form by December 2018.The MAFAC Aquaculture Task Force will be asked to identify industry priorities as early as possible in the development of the science review.

The NOAA SAB will review the draft and the industry priorities and produce a report with the above deliverables approximately 3-6 mo. from the completion of the Draft Review and the ATF priority document.

SAB Champion: Bob Rheault

Proposed Topic 7: ***Evaluating NOAA Coastal Sciences.***

This topic will be re-scoped and addressed in the future, pending input from NOAA Line Offices and discussion with NOAA leadership.

Champion: TBD

Topic 8: ***Coastal and Marine Transportation and Support Infrastructure***

U.S. ports and harbors support all sectors of the marine economy. NOAA's role in supporting coastal and marine commerce is spread across the agency from weather forecast and hydrographic survey to sea-level rise projections and fisheries management, among others, with ports and harbors being an area where many of these interests intersect. The SAB will work in collaboration with members of the Hydrographic Services review Panel to consider the use of emerging technology, leveraging information developed for navigation for other NOAA needs, and the development of tools to support multiple uses such as marine transportation fisheries and aquaculture.

SAB Champion: Denise Reed

Topic 9: ***New Technologies for Fisheries Stock Assessments***

Detail provided to the SAB by RDML Gallaudet who proposed the work topic:
"Evaluate fisheries monitoring technologies to improve stock assessments. This evaluation should consider how to optimally balance electronic monitoring, eDNA, and other technologies as well as incorporate the results of the UxS and machine learning topics (Topics 3 and 4)."

The National Marine Fisheries Service proposed that the Ecosystem Sciences and Management Working Group (ESMWG) review a report or reports and other documents that NMFS would provide to the ESMWG on relevant technologies for stock assessment, including an assessment of ecosystem considerations. In addition, the ESMWG will review the IRT of the fleet study, inasmuch as this report covers topics related to stock assessment technology. As part of this review, the ESMWG will consult with Bob Grossman and Chris Lenhardt, Champions for topic 4, on machine learning as relevant to stock assessment.

The ESMWG will provide findings back to the SAB for review and approval before transmission to NOAA.

Assigned to: Ecosystem Sciences and Management Working Group