**Leadership for Coastal Resilience**
**A Proposed Project for the NOAA Science Advisory Board**

## Context

Coastal Resilience has been identified by the NOAA Science Advisory Board (SAB) as a potential Long-Term Priority, is named as Goal 5 within the Decadal Vision for America's Oceans, and is a pillar of NOAA's Blue Economy. Threats to the economies, ecological integrity, and residents of coastal areas occur at weather to climate time scales, e.g., through extreme weather events, sea/lake level changes. The coasts of the United States - on the ocean and the Great Lakes - comprise a trillion-dollar property market; provide intermodal transportation hubs for global trade; and support ecosystems, harbors, and facilities essential to fisheries production, including a growing interest in aquaculture. Coastal areas are essential to the Blue Economy, and changes at the coast can have cascading impacts to the broader national economy and national security readiness.

## Objective

The SAB will develop a White Paper that identifies the challenges of future decades and how NOAA can work across line offices, with other Federal agencies, and with the private sector to ensure coastal infrastructures, and those who rely on it, are resilient to both acute and chronic threats.

This White Paper will support NOAA's national leadership role in coastal resilience as the issue comes to the fore in cross-agency discussions, e.g., the National Science and Technology Council's Subcommittee on Resilience Science and Technology (SRST), Subcommittee on Global Change Research (SGCR), Joint Subcommittee for Ocean Science & Technology (SOST), and Interagency Council on Advancing Meteorological Services (ICAMS), as well as cross-agency planning for impactful events, e.g., major hurricanes. Understanding roles of government, at all levels, and the private sector will be key, including developing and supporting strategic Public Private Partnerships.

## Approach

The SAB will develop the White Paper by:

- Mapping the work of NOAA line offices and programs to coastal resilience issues to show the multifaceted nature of its contributions and their maturity, and to support a one-NOAA approach. The mapping will enable an assessment of the potential for crosscutting, integrated approaches to provide improved service delivery and establishing the required observations, modeling, and research pipelines needed to support these services over the coming decades.
- Gathering information, e.g., through a survey or structured interviews, from key personnel in NOAA and other agencies on key information and R&D needs in the next two decades.
- Identifying coastal stakeholders in key sectors, e.g., ports, fisheries, aquaculture, tourism, offshore energy, renewables, and tailoring the survey/interview approach to those issues. Members of other NOAA advisory groups with coastal interests, e.g., Hydrographic Services Review Panel, National Sea Grant Advisory Panel, could also be surveyed.
- Synthesizing the findings to highlight key areas of need, then assessing NOAA's existing capabilities, and identifying gaps and potential in those key areas.

- Recommending actions that NOAA can pursue both internally and with partners to further position the agency as a national leader in coastal resilience to improve management of coastal resources.

The SAB will work with Mark Osler, NOAA's Senior Advisor for Coastal Inundation and Resilience, and others in NOAA as appropriate. Individuals from SAB Working Groups may also be engaged. As well as the work described above, a panel discussion of outside experts may be convened as part of an SAB meeting.

**Expected Outcome**

NOAA possesses a clear congressional mandate to deliver coastal resilience science and decision support. Several NOAA Office and Programs are already active in this space and delivering national leadership on coastal resilience issues. Drawing the wider expertise of NOAA toward coastal resilience in an integrated way can steer an R2O approach for coastal resilience agency wide.

NOAA's mission positions it as a leader among federal agencies as a forward-looking research and development and service provider that can anticipate needs, develop partnerships, and foster collaboration to support resilient coastal ecosystems, commercial activities, and communities.

**Timeline**
The White Paper would be produced in 6-12 months.

***ESPP: Earth System Prediction and Predictability--towards improved products and services.***

**Objective – what is key question to be answered?**
How can NOAA best respond to the demand for broader forecasting services (from fisheries to space weather) by advancing geophysical observations, modeling systems, and computational resources and architectures and transferring improvements to operations and services?

**Value – why is this topic important?**
NOAA's forecasting capabilities remain one of the most valued and critical services NOAA offers with estimates of financial impacts of hundreds of millions of dollars for weather forecasts and trillions of dollars for climate impacts. NOAA has ongoing activities improving geophysical observations, modeling systems, and computational approaches and architectures that continue to add value to the weather, water and climate enterprise. NOAA's engagement with the broader community through establishing an Earth Prediction Innovation Center is likely to reap considerable more benefits, leveraging expertise from across the community. Appropriately responding to the vast demand for NOAA's forecasting capabilities can save lives and properties and enhance the national economy in the coming years and decades.

**Scope – bullets describing key aspects to be addressed**

- Thoughtful balance of observations, theory, computation and simulations
- Precipitation and non-temperature parameters
- Enhanced involvement of academic and private sector through EPIC
- Marine predictions
- Human interactions with traditional environmental prediction
- Sub-seasonal to seasonal predictions
- Strong focus on Research to Operations and Products

**Boundaries – identify any boundaries/limits to help define scope**

- Areas where forecasts have been traditionally strong, including temperature

**In discussions:** Eugenia Kalnay, Betsy Weatherhead, Ko Barrett, John Dunne, Wayne Higgins, Nate Mantua, Brian Gross

**Assessment of NOAA's Capability to Understand Regional Sources of Environmental Impacts**

**Context:** NOAA currently collects and analyzes a multitude of observations to monitor health of the Earth system. Examples range from measurements of atmospheric gases (e.g., $CO_2$, methane, ozone) to health of coastal features (e.g., coral reefs and mangroves) to ocean contaminants and debris (plastics/microplastics) to observations of fishing vessels and marine mammals. A wide range of tools is used to collect information on concentrations, sources/sinks, and lifecycles of critical substances.

The information is scientifically valuable and critical to understand and assess changes in our dynamic Earth system. Results are reported regularly to the international community through NOAA reports, scientific papers, and both national and international assessments. The information would be even more valuable and policy relevant if it were assessed and effectively communicated in a concise, cohesive manner to diagnose persistent regional sources and agents of environmental impact.

**Objective:** Primary objectives of the SAB study are to: 1) identify current capabilities across NOAA's portfolio used to identify regional sources and agents of environmental impact; and 2) recommend strategies and tactics which NOAA can use to better detect and communicate regional sources and agents.

**Scope:** The study will review current and potential future NOAA capabilities to identify and understand regional sources and agents creating significant environmental impacts, either positive or negative. The study will also recommend more effective approaches to integrate and leverage information for improved understanding, including application of social science expertise to increase effectiveness of communication with policy makers.

The SAB study has three primary goals:

1) Review current NOAA activities to monitor environmental impacts and identify causes of the impacts;
2) Recommend approaches to synthesize/integrate source information across NOAA to enable more effective diagnosis of sources of environmental impact, particularly in policy relevant situations; and
3) Assess and recommend potential new approaches which NOAA could employ to improve understanding of the sources and impacts at multiple levels.

The timeline for this work is envisioned as 12 to 18 months, with periodic reporting on each of the three goals and a six-month cadence.

**Value:** The important work that NOAA does monitoring the health of the environment is currently under-utilized. Synthesis of what work is being done, what sources can be detected, and documenting what could be done if needed, will allow other agencies of the government and interested parties (national and international) to be more aware of the broad range of impacts to the global environment. As a result, NOAA can be a world leader in not only monitoring but also attributing activity and changes in the oceans and atmosphere. This result will be valuable

to NOAA. In addition, it will be instrumental to help close the communication gap between science and policy, thereby assisting national and international policy makers striving to improve governance and management of Earth's resources.

**Study Approach:**

1. ***Review current NOAA activities to monitor environmental impacts and identify causes of the impacts***

NOAA is highly respected internationally for its role in monitoring and understanding the global environment. Participation in international activities, including multi-national campaigns, international meetings, and peer-reviewed publications have been valuable for bringing NOAA to this highly respected place. The range of information spans as broadly as monitoring ecosystem environments, measuring atmospheric trace gases, and observing ocean health including fish and marine mammals. The ability to understand sources of environmental impact depends on the stressor: identification of point sources of ozone-depleting substances uses different resources than identification of regional release of methane. The first goal will be to identify current capabilities for attributing agents of environmental influence (positive or negative) or regions of change across the globe and to understand the granularity permitted by current S&T. Attribution may be to regions of the Earth, individual agents such as countries or corporations operating boats/managing activities, or groups of individual agents.

2. ***Recommend approaches to synthesize/integrate source information across NOAA to enable more effective identification of sources of environmental impact, particularly in policy relevant situations***

NOAA has a strong history of publicly sharing scientific information on the causes of environmental impacts globally. Cohesively integrating this information on regional sources of these impacts around the globe can have greater value if it is synthesized--to the extent possible--to identify specific regions or agents as sources of environmental impacts. The goal is to provide synthesis approaches which are brief, in readily understood language, and cover the full range of NOAA monitoring capabilities. Identification of which parts of NOAA are responsible for the information and any relevant documents will help establish the credibility of the findings as well as offer identification of appropriate points of contact for further investigations. A valuable component of this aspect will be to identify potential anomalies in different data sets. Focus of this aspect of the study is to assess how to compile, integrate, and communicate information more effectively.

3. ***Assess and recommend potential new approaches which NOAA could employ to improve understanding of the sources and impacts at multiple levels***

Observing and analytical capabilities are improving rapidly. New sources of observations include innovations from the public, private, and academic sectors. Knowing what NOAA could achieve with existing and emerging capabilities that are currently not exploited to full potential is important to increase efficiency and to allow rapid deployment of additional efforts on specific topics, should the additional information become critically important. Examples include application of both technology (e.g., satellites and UxS) and social sciences. Social media and public pressure for economic, social, and governance

(ESG) accountability provide significant opportunities for deepened insights into behavior of agents and their resulting environmental impacts (e.g., mining social media, use of ESG research compiled by the financial community, and global health indices developed by independent organizations). Potential options for enhanced capabilities include purchase of observations, expansion of NOAA's networks, assessing opportunities to declassify and apply classified data, advancing analytical techniques, leading/coordinating interagency efforts, and entering into public private partnerships. Evaluating these options now will enable more efficient and effective responses in the future as needs of the nation evolve.

**Boundaries:** The review will not carry out any new studies, but will gather information from all parts of NOAA on current capabilities and understandings. The review will not propose development of new technology, but will identify what is possible given current and evolving observing and analytical techniques. Any use of citizen science will be addressed with the prior SAB Citizen Science recommendations and data quality in mind.

**Integrating Social and Behavioral Science into NOAA for Improved Mission Focus**

**Objective** – *what is the key question to be answered?*
In what ways and in what areas can the social and behavioral sciences be better integrated into NOAA missions to optimize the impact of information and services? What are organizational and structural barriers within NOAA that might limit the use of social and behavioral sciences and what organizational infrastructure is needed to overcome these barriers?

**Value** – *why is this topic important?*
Integrating social and behavioral sciences will advance the accomplishment of both weather/water and Blue Economy priorities for NOAA. Scientific and technical advances all occur within the context of socio-technical systems. Understanding all aspects of these systems requires multi-disciplinary approaches that include all sciences needed to advance understanding. However, a lack of awareness and structural barriers might prevent co-production of knowledge and limits effectiveness and efficiency of research. The National Academies' Division of Behavioral and Social Sciences and Education and various national organizations that represent the social and behavioral sciences have provided ample evidence and perspective for how to better utilize social and behavioral sciences in addressing what seems to be physical/natural science or technological issues. In fact, NOAA has issued a series of reports to address this issue as well.

**Scope** – *bullets describing key aspects to be addressed*
Perceived under-utilization of social and behavioral sciences for mission-fulfilment of NOAA despite ample documentation on their value suggest organizational, structural and cultural barriers beyond awareness that need to be addressed. Some aspects which could be tackled include:

- Contributions of social and behavioral sciences to addressing critical issues in socio-technical systems. For instance, how can we make better use of propagation and treatment of uncertainty in the analysis of socio-environmental systems?
- Problem framing and research to better integrate social, behavioral, physical, and natural sciences to address community needs (connecting back to NOAA strategic plan).
- Improving communication of NOAA return on investment (ROI) to key audiences.
- Approaches to improve implementation of:
    - Seafood Executive Order
    - Fisheries management
    - Aquaculture
    - Weather Act
    - NWS IDSS
- Recommendations for more effective STEM education and outreach.
- Improving effectiveness of efforts to accelerate the Blue Economy (including all pillars/aspects).
- Identification of organizational, structural and cultural factors that might lead to under-utilization of social sciences.
- Recommendations moving forward for strengthening the role of social and behavioral sciences for mission fulfilment of NOAA.

**Boundaries** – identify any boundaries/limits to help define scope
This work needs to be limited to NOAA, not other agencies or organizations, and it needs to be limited to research, not application (simply due to the SAB focus).

**Technology, Data, and Observations to Improve Understanding and Prediction of Earth Systems at S2S2D Time Scales**

## Objective

The primary objective of this study is to assess approaches NOAA can use to apply technology, data, and observations to improve understanding and prediction of earth systems at S2S2D time scales. Observations are essential for improved understanding and model validation/verification so that NOAA can better predict future extreme events.

## Value

The convergence of weather, climate, and Earth system modeling/Earth System Prediction and Predictability (ESPP) will enable NOAA to dramatically improve national forecasting abilities, observation quality control, data assimilation, and model physics, among other areas. An immense value to our economy and preparedness would result from a superior capability to understand and predict at S2S2D time scales extreme events, such as excessive heat, drought, tropical cyclones, flooding, air quality, and wild fires. Observing systems and resulting data are critical to achieve this objective, and effective approaches are constantly evolving.

## Scope

Understanding and predicting Earth systems at S2S2D time scales require a wide variety of tools and integrated efforts to make observations, process data, effectively apply the data to improve next-generation Earth system models, and make data/information available in a meaningful manner to a variety of users. Cooperation across NOAA to provide a comprehensive outcome is essential.

This study will focus on observations and effective application of resulting data to understand and predict events at time scales beyond current weather forecasting. The study will address the following aspects:

- ***Role of observations to improve ESPP at S2S2D time scales – needs and gaps***
    - The primary goal is to identify needs and gaps for observations critical to support NOAA's mission in advancing S2S2D predictions.
    - Measurements of physical and chemical properties of the Earth system are essential in efforts to understand, model, and deliver high quality predictions of climate change, weather patterns, ozone layer depletion, air quality, and extreme events. Observations are also critical to understand atmosphere/ocean interactions and to validate and benchmark forecasting models.
    - The potential impact on model development to include the capability to assimilate new observations will also be considered.
    - This task will assess critical observation needs and identify gaps for improved ESPP understanding and model validation. A primary focus will be on ability to predict at increased time scales extreme events (e.g., excessive heat, drought, tropical cyclones, flooding, air quality, and wild fires).

- ***Requirements and approaches to improve data availability and effectiveness for multiple users***
    - NOAA contributes significantly to earth system observations and data. These observations are relied on by other agencies, national and international, in meeting their needs. Observations are collected by multiple Line Offices within NOAA, and integrated approaches across the Agency will promote more valuable data sets. Focus of this task is to organize and standardize, to the extent practical, the data and interfaces through which observation data are disseminated.
    - Key considerations include standards for key parameters and metadata protocols. Applying and assimilating data from a variety of sources raises challenges with respect to calibration and data quality. The role of federated data networks is also critical.
    - The capacity of computing systems to ingest and process observations along with capacity of networks to deliver observations to the computing systems for processing in near-real time, will enhance decision-making and management.

- ***Harnessing technology revolution and partnerships for more efficient and effective applications of observations and data***
    - Recent technological improvements present an opportunity for revolutionary gains in tracking and better understanding, on a global scale. Key enabling technologies include sensors, communication networks, data systems, data processing innovations, and knowledge tools (e.g., maps and visualization).
    - The role of NOAA S&T Focus Areas of UxS, Cloud Computing, and Artificial Intelligence are particularly relevant to improve sources of environmental measurements and efficiency of data processing and analysis.
    - Public Private Partnerships (PPP) and approaches to acquire data as a service are critical enablers for NOAA.
    - This task will assess opportunities for NOAA to avail itself of new technology and approaches to increase efficiency and enhance usability and accessibility of observations.

- ***Applying observations and data for better science-based decisions and more effective policies***
    - Observations may be used to support improved NOAA services, assist policy formulation, manage environmental and natural resource issues, and articulate metrics in meaningful ways to decision makers. This task will recommend improved approaches to improve communication of observations for the purpose of more effective services and policies, both within NOAA and among other agencies.
    - Data are also important to assess and validate the level of improvements in predictions going forward.

**Boundaries**

This effort will focus on role of observations and resulting data, not prediction and predictability.