Tools to Enhance the Resilience of Coastal Communities
A Proposed Project for NOAA Science Advisory Board Consideration

Context. Coastal Resilience has been identified by the NOAA Science Advisory Board (SAB) as a potential Long-Term Priority. Climate change threaten the residents, economies, and ecological integrity of coastal areas, e.g., through extreme weather events, sea/lake level changes. The ability to adapt to these ongoing coastal changes has important implications for coastal communities and the nation. NOAA currently produces scientific observations, modeling, and tools important to furthering coastal resilience but fall short of an integrated program across the agency. These NOAA science outputs must be better designed, aligned, and integrated to serve the coastal resilience needs of the nation.

Objective. The SAB will foster the scoping of a holistic NOAA coastal resilience program, spanning observations, modeling, external funding, tools, and local service delivery to the public, which enhances the ability of coastal communities (i.e., ocean and Great Lakes), ecosystems and economies to anticipate, track, and adapt to effects of coastal change, and make recommendations to NOAA on its development.

Approach. The SAB will convene a series of focus groups to identify potential approaches to forming a one-NOAA approach to coastal resilience, encompassing observations, modeling, tools, and regional service delivery. Topics and participants will be identified by a SAB/NOAA team through discussions or surveys of NOAA staff, SAB and working group members, and will include potential users. The focus groups will develop outlines of development approaches, resource needs (time, expertise, funding), potential collaborators, and expected outcomes and outputs. Integrated NOAA programs should look to the problems of future decades as well as those of today. Reports from the focus group discussions will be used to develop a 'white paper' report, including recommendations for a path forward. These will be discussed at the SAB and transmitted to NOAA for further action, pending SAB approval.

Value. The nation's coastlines and coastal communities face the adverse impacts of accelerated climate change and a corresponding increase in risks and costs associated with adapting to/mitigating the adverse impacts of such change. Coastal communities throughout the United States- whether they be on the ocean or the Great Lakes- comprise a trillion-dollar property market, provide intermodal transportation hubs for global trade, and support harbors and facilities essential to fisheries production, including a growing interest in aquaculture. Changes at the coast can have cascading impacts to the broader national economy and national security readiness. Leveraging the skills and resources of NOAA to enhance coastal resilience through provision of tailored state of the art science and services provides value to NOAA, all who rely on the coast, and to the nation.

Breadth. Breadth of the work is through engagement of multiple line offices, integration of ideas from outside experts, potential users, and across disciplines. The expectation is that addressing coastal resilience issues also requires a breadth of disciplines and skills – from climate and weather to economies and ecology, research, modeling, visualization, and outreach.

Transformational. The goal is to move from post-processing extant NOAA science and data to proactively designing and developing coastal resilience focused observations, modeling, and service delivery seamlessly across the agency. Climate change will transform our coasts with impacts to economies, ecosystems, and millions of citizens. By providing science and services that allow users to explore future conditions and assess resilience options, there is an opportunity to reduce impacts and support adaptation to change.

Fit to NOAA. NOAA possesses a clear congressional mandate to deliver coastal resilience science and decision support to the general public. NOAA line offices are already active in this space and delivering national leadership on coastal resilience issues, however this expertise is today still largely focused within a select few Office and Programs. Drawing the wider expertise of NOAA toward coastal resilience in an integrated, yet focused way, makes the most of current work, and steers an R2O approach for coastal resilience agency wide.

S&T Partnerships

Objective – what is key question to be answered?
Identify new ways for NOAA to think, work and plan-- possibly breaking with traditional ways-- with Private and Academic sectors

Value – why is this topic important?
Past efforts of previously unprecedented collaborations across sectors (including activities which led to the Fair Weather Report) brought remarkable advancement for the entire sector. Great changes in science and technology make now a particularly valuable time for continued new thinking about collaborations because of the strong advances in the academic and private sectors. The improved and renewed partnerships will likely result in products and services, saving lives and property while promoting prosperity. The increased pressure for NOAA to embrace this topic means that there is an opportunity for the SAB to help prioritize and structure efforts in this area.

Scope – bullets describing key aspects to be addressed
- Response to partnership references in the Weather Act
- Work collaboratively with Blue Economy subcommittee of OEAB where appropriate
- Recent and future commercial data buys
- Appropriate use of Cooperative Institutes
- NASA's recent collaborations can serve as an example
- Artificial intelligence and cloud computing offer new opportunities
- Academia as well as both small and large companies need more welcoming avenues for communication and collaboration

Boundaries – identify any boundaries/limits to help define scope
- Efforts will not duplicate what is already being handled in other parts of NOAA

In discussions: Betsy Weatherhead, Ruth Perry, Jean Vieux, Mohan Ramamurthy

Climate Observations

Objective – what is key question to be answered?

What key observations are needed to augment current climate observing capabilities to understand, monitor, improve prediction to save lives and properties on seasonal to decadal time scales?

Value – why is this topic important?

NOAA, as the lead climate agency, requires observations for model development and seasonal forecasting capabilities as well as understanding future extreme events including heat, droughts, tropical cyclones, extreme wind, air quality, and wild fires. Our current observing systems are inadequate to improve both our understanding of these phenomena and adequately forecast each of these threats even on a seasonal basis. Climate observations will be particularly valuable in support of the blue economy. The value of climate observations has been estimated in the trillions of dollars. Increased observations are needed to improve climate predictions and will help mitigate and prepare for a wide range of hazards including droughts, fires and floods. Enhanced observing capabilities are significantly transforming our ability to understand the Earth's climate and better prepare for potential disasters, particular tropical cyclones, inundation, severe wildfires, air quality and droughts.

Scope – bullets describing key aspects to be addressed

- Planning for future climate observations
- Identifying requirements for key parameters
- Evaluating existing climate observing capabilities
- Communicating research needs for the development of innovative observing approaches
- Preparing for new climate forecasts responding to stakeholder demand

Boundaries – identify any boundaries/limits to help define scope

- This effort will not replace but will complement NASA's decadal survey
- This effort will stay focused on observations—not prediction and predictability

In discussions: Betsy Weatherhead, Joellen Russell, Craig McLean and Neil Christerson

Space Weather

Objective – what is key question to be answered?

How can NOAA best advance forecasting capabilities with increased accuracy, lead-time, and geographic resolution, and transition those capabilities into operations.

Value – why is this topic important?

Space weather occurs regularly and many companies, such as those involved in aviation, satellite operations, oil field services, take actions on a daily basis based on space weather observations and prediction. NOAA works collaboratively on the scientific issues with other key agencies including NASA, DoD and NSF; NOAA serves the critical and singular role of forecasting for all affected agencies. FEMA, Dept. of Energy and the National Academies have all declared space weather forecasts and warnings critically important to the security and economic vitality of the Nation and have requested improved prediction capabilities to advance national preparedness for space weather events. The potential for disaster associated with an extreme space weather event is, by some estimates, second only to a global pandemic for its far-reaching and detrimental effects. The consequences of an extreme event are propelling executive action in the National Science and Technology Council (NSTC), legislation in Congress, and policy initiatives in intergovernmental organizations and nations around the world. Guidance from the SAB would be particularly valuable while such decisions are being considered.

Scope – bullets describing key aspects to be addressed

- Follow-on to NSTC-led recent 24 agency plan to observer, research, and mitigate impacts
- Examine data driven approaches and their potential for improving space weather forecasts
- Critical observations needed to improve space weather forecasts
- Modeling of multiscale coupling of Sun-Earth processes, collaboratively with NASA, NSF and DoD
- Examination of metrics for forecast skill
- Better characterization and forecasts of the environment at satellite orbits
- Public-private partnerships to bridge the “valley of death” and advance the transition of space weather research to operations

Boundaries – identify any boundaries/limits to help define scope

In discussions: Eugenia Kalnay, Betsy Weatherhead, Jon Linker, Louis Uccellini, Bill Murtaugh, Jenni Meehan, Elsayed Talaat

Noise Observations in Marine Sanctuaries

Objective: Expand NOAA's Ocean Noise Reference Station Network (ONRSN) to (1) monitor, assess and investigate baselines and trends in the "soundscape" in the different environments of the network of national marine sanctuaries, and (2) characterize sounds produced by living marine resources, other natural sources and human activity that contribute to the total noise background.

Value: NOAA has established 12 ocean noise reference stations with a system of passive acoustic recording systems to monitor long-term trends and changes in the underwater ambient noise environment; however, only four stations are located in marine sanctuaries. It is well acknowledged that the noise environment has been increasing for many years as anthropogenic activities in the ocean have increased. The increase in marine noise has an impact on the behavior of marine mammals and has recently been acknowledged to have an impact on acoustically sensitive fish and other organisms. National marine sanctuaries are of importance since these are designated areas of national significance, either of historic nature or to protect critical species and habitats. Sanctuaries are the home to a variety of ecosystems and endangered marine species. Increasing the acoustic monitoring network provides the opportunity to assess differences among the sanctuaries, establish noise baselines, and assess long-term temporal and spatial variations and impacts on these protected and vital ecosystems.

Scope: Examples of possible scope and examples to be investigated

- The current passive monitoring systems rely on using identical moored acoustic buoys. With advances in the development of autonomous systems, such as sea gliders, wave gliders and saildrones, the noise monitoring network can be expanded to build a deployable, adaptive, and integrated autonomous and static network to collect multiyear and comparable data across NOAA's National Marine Sanctuary System.
- Incorporate autonomous aerial systems, high-frequency radars and satellite imagery to correlate the oceanographic environment with the local anthropogenic environment to assess changes and trends in the soundscape.
- Assess relative impacts of potential noise sources on the total noise background in each sanctuary. Since sound travels over large distances it is important to distinguish between locally generated noise and that from distant sources.
- With advances in acoustic monitoring and modeling and with advances in data synthesis (e.g. artificial intelligence), characterize and quantify human uses of national marine sanctuaries and evaluate the feasibility of establishing a noise prediction system for selected sanctuaries.
- Assess impacts of increases in anthropogenic noise on the behavior and population of marine mammals, fish and other organisms.

Boundaries: This effort should be harmonized and conducted within the context of the Ocean Noise Reference Station Network, policies concerning the management and operation of the National Marine Sanctuary System, community engagement and coordination with related activities of the US Navy and the Bureau of Ocean Energy and Management. This effort is for environmental characterization and can help to influence acoustic data standardization efforts, but is not to establish regulatory standards.

5G (Impact to Microwave Passive Sensing from Interference caused by 5G)

Objective – what is key question to be answered?

What are the current impacts of 5G technologies and can the impact be mitigated?

Value

Multiple agencies and private sector entities rely on NOAA's weather forecasts, allowing the saving of lives and property. The FCC sale and the subsequent commercial use of airwave space is estimated by NOAA, NASA and NRL experts to have a direct negative impact on NOAA's satellite observation of the Earth's atmosphere, including temperature and humidity observations. The result is expected to be a noticeable degradation in forecasting capabilities. These impacts to the observing capabilities are not fully understood. Future impacts if further sale of airwaves take place without fully learning from this current situation will result in NOAA's critical forecasting service to the Nation to be further compromised to the detriment of current satellite investments and future forecasting capabilities. SAB could focus highest priorities for next steps on the issues identified in the Scope section. The 5G topics is an example of disruptive innovation, with possibilities for optimal response to this challenge if addressed thoughtfully.

Scope – bullets describing key aspects to be addressed

- What are the current impacts?
- How can impacts be quantified?
- How can impacts be mitigated?
- What can be done to offset negative impacts of interference?
- How can these results best be communicated?

Boundaries – identify any boundaries/limits to help define scope

- This effort will not look at policy decisions.
- This effort will not address how decisions should be made in the future, although results will be relevant to future policy decisions.

In discussions: Eugenia Kalnay, Betsy Weatherhead, Mitch Goldberg, Jordan Gerth, David Lubar, Otto Bruegman

Focus for the Future: Adapting to S&T Disruptive Innovations

Objective

Realizing the rapid and accelerating pace of change in S&T, how can NOAA identify and implement disruptive innovations to more effectively and efficiently meet its mission and vision statements?

Value

Today's pace of change in S&T exceeds society's ability to adapt and ability of government agencies to absorb the changes and capture value. The pace of change will accelerate in the future, and predicting occurrence of disruptive innovations (what and when) is nearly impossible. As a result, value of knowledge depreciates rapidly, and key attributes for success require people, systems, and strategies which are adaptable, resilient, and provide rapid flow of knowledge. As new S&T developments occur throughout the world, effectively applying them in a timely manner to operations and services is challenging, yet critical for NOAA to achieve its mission and vision.

Scope

- Evaluate case studies, for example:
    - How did NASA take advantage of private sector rapid innovation to reduce time and cost to return astronauts to space?
    - Why are disruptive innovations ignored, and what are consequences?
    - 5G as a disruptive technology
- Investigate strategies of successful tech companies
- Identify barriers for NOAA to adapt private sector developments and recommend potential solutions (both technical and administrative)
- Recommend approaches which can be further investigated by NOAA in their next long-term vision document

Boundaries

- Focus on disruptive innovations and exclude innovation which is evolutionary and/or predictable
- Focus on identifying and implementing innovations from private sector (not internal R&D innovations)

SAB Merged Topic Overview: Innovation Enhancement and Maximizing R2X

Innovation Enhancement, Continuous Improvement, Risk Management, Acceptance of Failure, Lessons Learned
[DRAFT SAB Topic Description -- 31 August 2020]

Objective

The focus of this topic is i) by examining selected projects and programs within NOAA that represent constructive innovation or effective R2X (Research to X=Ops or Services) to identify structured processes for surfacing, supporting and bringing to fruition innovation at NOAA and transitioning these innovations to operations/services; ii) reviewing the salient elements of these projects and programs; and iii) drafting a report summarizing findings and potentially making recommendations.

This topic conceptualizes an innovation pathway which starts with the challenges identifying and trying promising, but risky new ideas, then identifies successful pilots or proofs of concept, and facilitates normalizing their use as part of improving day-to-day activities supporting the NOAA mission at all levels.

The types of issues that may inhibit successfully moving along the innovation pathway include organizational culture elements such as risk aversion, acceptance of failure, learning, and an ethos of continuous improvement. Additionally, these cultural aspects may find expression in policies and procedures. Other relevant aspects may include technologies or other material items, as well as in other innovations in areas such as methods or modeling. While we would not necessarily attempt to cover all of these different dimensions of the topic, in the examination of the examples it may be possible to classify salient aspects along these various dimensions.

Value

Assumption: there is plenty of innovative work at NOAA by individuals and small teams, but it can be challenging at times to develop new innovative ideas to the point at which they impact the NOAA enterprise.

- Identifying and supporting innovative projects can further NOAA's mission areas
- Some innovative projects will allow NOAA to accomplish new tasks in mission areas that are beyond reach today
- Some innovative projects can result in cost efficiencies
- Seeing innovative projects supported throughout their lifecycle will improve morale for both those involved and those who can see the impact

The potential value to NOAA of examining effective R2X to includes:

- Improving the return on investment of scarce resources
- Improving technology readiness and adoption
- Improving the learning culture in NOAA
- Develop ways to more deliberately and efficiently move proven new ideas to operations

- Enhancing efforts to promote continuous improvement
- Improved efficiencies of current processes and increased mission impact
- Increased workforce morale as they see their pilots implemented

Scope

- Developing new mechanisms to identify potentially innovative projects and providing seed funding to them
- Developing new mechanisms to sustain identified potentially innovative projects throughout their lifecycle, and, importantly, to stop currently funded projects if they are proving promising so that funds can be used for new potential projects.
- Developing new mechanisms to deploy into production potentially innovative projects; in other words, finding new mechanisms to move promising projects from research into production
- Developing new recognition models for those who do innovative work
- Approaches to identifying and evaluating promising R2X pilots or proofs of concepts as candidates
- NOAA conceptions of technology readiness levels
- Dimensions of Continuous Improvement
    - Managing risks associated with failure to realize a return on investment
    - Ways to be more risk tolerant or accepting of failure
    - Instilling a learning culture
- Technologies: e.g. computing and information technology; sensors and instruments
- Methods: e.g. models, analytical tools, scientific methodologies, laboratory or similar methods/processes
- Approaches to allocating research funding

Boundaries

Items that are out of scope:

- Administrative topics such as procurement processes, hiring, or budgeting
- Technologies related to administrative functions
- Hiring practices
- Review of specific projects
- Any other topic identified under this topic that does not align with the SAB Terms of Reference

Rapidly Changing Marine Environment

Objective – What is the key question to be answered?

The rate of change in the marine environment in the next 10-20 years is going to be greater than the last 10-20 years. How will NOAA's practices need to evolve over the next decade to keep up with, and anticipate, possible future ocean states and the impact on its resources?

Value – Why is this topic important?

Rapid changes are occurring in fundamental ocean hydrographic structures, as well as biogeochemical properties. We have observed changes at the base of the food web up, their impacts on upper trophic levels, and on the overall health and productivity of the oceans. In addition, rapidly changing conditions are creating more frequent severe events. Questions we now face include (among others):

(i) how will physical structures (e.g., oceanic fronts, location of ice-edge) transform and at what rate?
(ii) how will variables/resources of interest, e.g., fisheries, be affected/redistributed and coastal resilience be impacted?
(iii) will rates of physical change in the environment be too fast to allow biological adaptation?
(iv) will current explanatory capabilities change?

Scope – In the face of rapid changes, NOAA will need to prioritize what aspects they should consider in order to continue to achieve their goals. The study should consider areas of concern and potential impacts of rapid/accelerating rates of change. These will help establish directions for innovation in next generation observing systems, analytic methods, and modeling approaches. At the same time, since changes are measured relative to baselines, we will need to evaluate how we maintain our time-series (enhance them where needed, or shift them into areas where gaps exist). The study should also investigate opportunities for NOAA to partner with the private sector (particularly academia and philanthropic organizations).

Boundaries – identify any boundaries/limits to help define scope. The expansion in the use of OSSEs (Observing System Simulation Experiments), climate scenarios (e.g., from GFDL), and methods that utilize advanced uncertainty models can help define frame areas of fastest change or those that will be most likely affected. This information can help focus areas of highest interest – for sustained observation, exploration, or modeling. The study should focus on what observations, analyses, and modeling efforts add best value and minimize efforts on how they will be done.

Understanding Complex System Through Transdisciplinary Research at NOAA

Objective – *what is the key question to be answered?*
What are key competencies and practices needed to tackle interdisciplinary approaches through collaboration towards addressing critical issues of complex systems? What are structural, organizational, institutional and cultural barriers for interdisciplinary collaborations overall, and at NOAA specifically?

Value – *why is this topic important?*
Many challenges NOAA addresses through its mission involve intersecting sciences; social, physical, economic, and informational complexities and dynamic interfaces among these dimensions. In short, NOAA's mission involves complex systems; in fact, complex systems are ubiquitous in NOAA's mission-driven research. Complex systems require inter-, cross- or transdisciplinary approaches. However, research and wisdom from practice have revealed a myriad of barriers that stand against effective and efficient approaches towards addressing issues related to complex systems. These need to be addressed urgently.

Scope – *bullets describing key aspects to be addressed*

- What is the nature of complex systems, and how do they differ from other systems in terms of their characteristics?
- Building on the National Academies' report on the Science of Team Science, what do inter-, cross- or transdisciplinary collaborations mean within the context of NOAA?
- What are organizational, structural and cultural factors that might lead to under-utilization of inter-, cross- or transdisciplinary collaborations in order to understand and (where needed) "manage" complex systems?
- What are recommendations moving forward for strengthening the role of inter-, cross- or transdisciplinary collaborations for mission fulfilment of NOAA, specifically as they relate to complex systems?

Boundaries – *identify any boundaries/limits to help define scope*
While the issue of addressing complex systems through research and application is not unique to NOAA, and will need to be informed broadly by foundational research and neighboring fields, the work of the SAB work likely need to be focused on NOAA. While the SAB's focus may lie on research, full understanding of complex systems within the mission of NOAA will require translation to societal benefits, and therefore aspects of applications.

NOAA SAB potential topic R&D Risk management of publishing/peer review

Objective: The proliferation of online journals, predatory journals and Pre-Print sites appears to be exacerbating concerns about the peer review process, and could exacerbate the corrosion of the public's faith in science.

Value: NOAA publishes close to 2000 documents a year.

Scope: The general review process, (including the matter of predatory journals) is addressed in the NMFS' ***Fundamental Research Communications Policy***. It is presently under internal review/clearance and the present draft is now being considered by NOAA's ***Scientific Integrity Committee***. Once cleared, it should go to SAB for review and comment. The SAB could consider whether the policy should be adopted throughout NOAA to ensure that our scientific publications are sound and accurate meeting the highest possible standards of scientific integrity.

Boundaries: NOAA has initiated an internal publication review process "Research Publication Tracking System" https://www.fisheries.noaa.gov/inport/item/27877 that follows that of journal reviews (internal review, responses and approval at the Center Director level). It is not clear if the SAB should have a role in reviewing or commenting on the process either while in development or following internal review.

The SAB could explore issues like funding for page charges, practices such as, recommending reviewers for publications who might be associates or collaborators or shopping publications that have been rejected by one publisher to another journal. Broader examination of the publication process or recommendations to other agency scientists is probably beyond the scope of what the SAB could hope to explore.

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 of NOAA work can the social and behavioral sciences contribute to the mission success of NOAA, specifically when used in direct conjunction with physical & natural sciences and technological advances? 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?*
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 question that could be tackled might be:

- What are 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?
- How can problem framing and research integrate social, behavioral, physical, and natural sciences to address community needs (connecting back to NOAA strategic plan)?
- What are organizational, structural and cultural factors that might lead to under-utilization of social sciences?
- What are 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).

ESPP (fit into federal government; ongoing multi-agency effort; it is noaa's job to do prediction; air quality, ocean, fish, weather, climate)

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)?

Value – why is this topic important?
NOAA is the only agency with prediction in its requirements. 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. 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

- Work within the multi-agency ongoing effort to better define the role of NOAA
- Thoughtful balance of observations, theory and simulations
- Precipitation and non-temperature parameters
- Marine predictions
- Human interactions with traditional environmental prediction
- Sub-seasonal to seasonal predictions

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