

**66th Meeting of the NOAA Science Advisory Board
December 16-17, 2019**

Location: Sheraton Silver Spring Hotel
8777 Georgia Avenue
Silver Spring, MD

Presentations for this meeting have been posted on the Science Advisory Board (SAB) website:
<https://sab.noaa.gov/SABMeetings/SABMeetingDocuments.aspx#10424270-meeting-documents-for-16-17-december-2019-meeting>

SAB members in attendance:

Ms. P. Lynn Scarlett, Chief External Affairs Officer, The Nature Conservancy (Chair); Dr. Robert Grossman, Frederick H. Rawson Professor and Jim and Karen Frank Director, Center for Data Intensive Science, University of Chicago; Dr. Eugenia Kalnay, Professor, Department of Atmospheric and Oceanic Science, University of Maryland; Mr. John Kreider, President, Kreider Consulting LLC; Mr. W. Christopher Lenhardt, Domain Scientist, RENCi University of North Carolina Chapel Hill; Dr. Ruth Perry, Marine Scientist and Regulatory Policy Specialist, Shell Exploration and Production Company; Dr. Robert Rheault, Executive Director, East Coast Shellfish Growers Association; Dr. Elizabeth Weatherhead, Senior Scientist and Fellow, Jupiter Intelligence; and Mr. Robert S. Winokur, Consultant (ret. NOAA, Navy)

NOAA senior management and Line Office representatives in attendance:

RDML (ret. USN) Timothy Gallaudet, PhD, Assistant Secretary of Commerce for Oceans and Atmosphere and Deputy NOAA Administrator; Mr. Craig McLean, Assistant Administrator for Oceanic and Atmospheric Research and performing the duties of NOAA Chief Scientist; Mr. Kevin Wheeler, Deputy Chief of Staff for Policy; Mr. Stuart Levenbach, Chief of Staff; Dr. Steven Thur, Director, National Centers for Coastal Ocean Science, National Ocean Service; Dr. Louis Uccellini, Assistant Administrator for Weather Services and Director, National Weather Service; Mark Paese; Deputy Assistant Administrator for Satellite and Information Services, NESDIS; Ms. Maureen Madden, Deputy Director, Center for Satellite Applications and Research, NESDIS; Dr. Cisco Werner, Director of Scientific Programs and Chief Science Advisor, National Marine Fisheries Service; Dr. Gary Matlock, Deputy Assistant Administrator for Science, Oceanic and Atmospheric Research; David Michaud, Director, Office of Central Processing, National Weather Service; and Dr. Hendrik Tolman, Branch Chief, Marine Modeling and Analysis Branch, National Weather Service.

Staff for the Science Advisory Board in attendance:

Dr. Cynthia Decker, Executive Director and Designated Federal Officer; Ms. Courtney Edwards; and Ms. Caren Madsen

December 16, 2019

Opening Statement of the Chair

Lynn Scarlett, The Nature Conservancy and Chair, NOAA SAB

Chair Scarlett welcomed the attendees to the meeting and called for introductions.

SAB Consent Calendar

Lynn Scarlett, The Nature Conservancy and Chair, NOAA SAB

- September 2019 SAB Meeting Minutes
- Working Group Status Reports
- EISWG Renewals/Extensions

Bob Winokur made a motion to accept the items on the consent calendar; Elizabeth Weatherhead seconded the motion and it passed unanimously.

NOAA Update

RDML Timothy Gallaudet (USN, ret.), Assistant Secretary of Commerce for Oceans and Atmosphere and Acting NOAA Administrator

Summary

RDML Gallaudet discussed progress made on NOAA's three overarching priorities of

- (1) reducing the impact of weather and water events,
- (2) maximizing the economic contributions of ocean and coastal resources, and
- (3) space innovation.

The EPIC (Environmental Prediction Innovation Center) has moved forward rapidly and a request for proposals (RFP) will be issued soon. A workshop on the next steps for EPIC has advanced much of the discussion and planning. NOAA will be applying FY20 appropriations toward the effort once they are available. The Weather Service has been performing exceptionally well and impact-based decision support services (IDSS) activities are at their highest level ever. Disaster preparedness trainings instructed about 2,600 people in 2019. The National Ocean Service (NOS) has flown aerial imaging flights following hurricanes Michael and Dorian, which were extremely valuable in supporting emergency managers and response efforts.

Research supporting these activities has progressed, such as in predicting extreme events upstream of dams and reservoirs and operational warnings for storm surge. The first new National Marine Sanctuary in 20 years was established in 2019 at Malloys Bay on the Potomac River. A Presidential memorandum on ocean mapping, exploration, and characterization was issued which directs NOAA to develop a national strategy with the Ocean Policy Committee to map the shoreline and nearshore of Alaska and develop more efficient ways to permit research activities in the U.S. Exclusive Economic Zone (EEZ). NOAA is currently chairing the Committee on the Marine Transportation System (CMTS) and has advanced its navigation data and technology capabilities and service to the interagency committee. The National Marine Fisheries Service (NMFS) added new areas of fishing and catch limits for West Coast groundfish which will lead to many more jobs and increase economic impact while keeping the stock sustainable. Forty-six fish stocks have been restored and only 28 are currently classified as overfished, which is an all-time low.

NOAA has created a list of six science and technology (S&T) focus areas, four of which the agency has released draft strategies on them and posted them for public comment, these are

- (1) unmanned systems,
- (2) omics,
- (3) artificial intelligence and
- (4) cloud computing

These are designed to improve coordination across Line Offices and provide institutional support. The agency is moving forward with the NOAA Satellite Architecture Study and has made great progress thus far.

RDML Gallaudet provided an overview of the White House Summit on Ocean Science and Technology and the Presidential memorandum that emerged from it. The focus of the summit was developing an interagency approach to partnerships in order to meet the government's mission. The White House Office of Science and Technology Policy (OSTP) led a follow up town hall after the summit in San Francisco focused on the intended path forwarded, including implementing the presidential memorandum, which is specific to mapping, exploration, and characterization with the intent to support the U.S. economy, national security, and natural resource conservation. Kevin Wheeler added that there will be a series of town halls and workshops across the country over the next several months with a report issued in the spring. This is a new process and NOAA is looking to the SAB to help forge novel partnerships and find new ways of doing S&T through partnerships with industry and philanthropic organizations. The National Oceanographic Partnership Program (NOPP) is up for reauthorization and there may be a larger role for the SAB in advising that process. Craig McLean said that the SAB's insight into what the commercial sector is envisioning for the future and how the government could expand their scientific horizons in order to provide information that would lower industry's costs would be especially helpful. RDML Gallaudet said that one of the highlights of the summit was the release of NOAA's four draft S&T strategies. The public comment period has closed for these but NOAA would still welcome SAB input.

Discussion

Chair Scarlett said the SAB may want to include an agenda item for formally commenting on the summit's report once it is available. She said the summit and the breakouts were excellent with wide-ranging discussions and a large breadth of participants.

Dr. Perry said that a few key priorities were identified by all parties during the summit and the SAB should continue to discuss how to help NOAA, not just in partnerships but also in unkninking some of the mechanisms that prohibit partnership. She asked what NOAA intends to do with the comments they receive on the four focus areas. RDML Gallaudet said they will consider them and to the extent they make sense and are aligned with OSTP and Department of Commerce intent, they will be factored in. Mr. Levenbach added that, for these strategies to be effective, everything that NOAA does from a scientific perspective needs to incorporate these strategies. RDML Gallaudet agreed and said that they need to be moving NOAA fellows and scholars into nontraditional areas, such as leveraging machine learning in weather modeling. The SAB's advice on potential partnerships in these rich areas would be helpful.

Mr. Kreider said the Ocean Advisory Board (OAB) has had many discussions about NOPP and most are frustrated by its original intent versus its present reality. There has been a lot of talk about reinvigorating it and as a focus area for partnerships, particularly with industry, to really make progress in areas of the economy, national security, and conservation. He asked if the Admiral considered it this way and, if it is a key focus area, what the SAB can do to help achieve its original intent and the agency's current vision for it. RDML Gallaudet said NOPP is a priority for NOAA and asked the SAB to consider what elements in its reauthorization NOAA might want to include and how can they get the Navy more interested in the program. Another area SAB's input would be useful is how to get NOPP more attention and interest from the private sector that could match funding.

Chair Scarlett asked Mr. Wheeler to expound further on the kinds of partnerships that are envisioned and what the barriers are. Mr. Wheeler said that, legislatively speaking, there are "anti pass the hat" provisions that make comingling funds difficult. This is something they are looking to address in the reauthorization. There are also legal burdens of ensuring that the private sector is not supplementing federal appropriations. NOAA is also looking for industry and philanthropic organization to understand that the agency wants and needs to partner and that there are mechanisms for doing so. Mr. McLean said he would like the SAB to be advocates within their communities for a reinvigorated NOPP. It is an important tool that has been overlooked due to past practice. There are also operational challenges. Federal agencies need to ensure they are sending the right people to meetings in order to have serious and effective conversations on the subject. Mr. Kreider said there does not seem to be a sense of urgency on the topic and the OAB had a difficult time coming up with an example of when multiple agencies have come together to achieve something in the past that was not considered a crisis. Dr. Uccellini discussed NCEP (National Centers for Environmental Prediction) as an example, which implemented the SAB's recommendation of utilizing the NOPP model on their weather computer to move towards the weather-water connections they build off of today. The Navy was the other agency organizing the model for operational use and NWS now uses their data assimilation system and have adopted their ice model. This is the basis for the real-time Ocean Forecast System.

Dr. Colman said he was encouraged by the continued prioritization of EPIC. The broader community is engaged, but not necessarily fully aligned. He asked what NOAA viewed as the challenges ahead for EPIC and how the SAB and the Environmental Information Services Working Group (EISWG) can support the agency's priorities. Mr. McLean agreed that there is a division within the community about how EPIC should work. While the work on EPIC is not done, NOAA has greatly improved the mechanisms and engagement needed for it to be successful. He was surprised to receive an open letter to NOAA, offering the opinion that greater independence was needed and stating that there are parts of NOAA resisting the effort. Within NOAA, there is outward and enthusiastic support of the effort, some confusion about what all of the elements entail, and some people saying that a new way of doing business is unnecessary. NOAA needs to define with much greater clarity what the simple components of EPIC are and what the mechanics look like. If the community can work together on this in a less fractionated way they will see very positive outcomes. Dr. Uccellini said that the U.S. recognizes that one of the biggest weaknesses of their model from an operational perspective is in engaging the larger

research community, especially the academic community. A path was laid out in August and they are proceeding with it despite not having received the full budget for it.

Dr. Weatherhead said that what is needed is a sustained continual relationship with the private sector similar to the engagement NOAA has had with the academic community, which is a result of the communication they have through the Cooperative Institutes. There is no such engagement with industry and, as a result, NOAA may continue to be surprised by letters that are not well-informed and do not represent the whole community. She would like to see NOAA develop a strategy for developing relationships, rather than one-off meetings. Mr. Levenbach said there are two strategies: one is to have more private sector members on the SAB and the other is through the Ocean Research Advisory Panel (ORAP), as a place where industry would sit with academia and others to advise an interagency group on ocean-related research and priorities. ORAP is currently struggling to get federal support due to differences of opinion within Navy leadership about the future of the panel. As a mechanism to get the private sector's input on ocean-related issues, NOAA is eager to see ORAP reinvigorated and is willing to take ownership of it if the Navy doesn't want it. Dr. Uccellini discussed NWS' mechanisms for interacting with the private sector. Model assessments bring out the most interaction and every one done online includes the private sector. Model development, however, is a different story as some private companies are more willing to share code than others.

Chair Scarlett said that this discussion raised issues that are as much about governance as communications. Many issues can be mitigated with strong anticipatory communications that discuss the kinds of issues the agency is grappling with as a way of signaling that people are working on them and invite input. Unless NOAA addresses governance, coordination, and communications, the promises of partnerships are going to go unfulfilled. An ongoing topic for the SAB has been the social science dimensions to each of the agency's priorities. Unless NOAA and the SAB more fully deal with the findings of social science that are illuminating people's interface with different technologies and research, NOAA will fall short of being able to fully utilize them. This topic was removed from the SAB's Work Plan, but it needs to stay in the SAB's considerations. Dr. Uccellini agreed with this and said that NWS' interest has been tied to human factors, such as changing risk preferences. He and Mr. McLean take it very seriously and have spent time with people at the National Science Foundation (NSF) to find out how to tap into social science research and the people doing it.

RDML Gallaudet briefly commented on three further recent developments: (1) Support for OSTP's position on research security; (2) the announcement of contracts with three commercial cloud providers; and (3) the increasing emphasis on the Indo-Pacific from the administration which is reflected in NOAA's focus on the area.

Plans for the FY 2020-2021 SAB Work Plan

Lynn Scarlett, The Nature Conservancy and Chair, NOAA SAB

Chair Scarlett provided opening remarks on the progress to-date on the SAB's work plan. The SAB has been working towards the completion of the FY 2018-2019 work plan and some of those topics may carry over to the next work plan. The SAB began discussions of potential work plan topics in the spring of 2019 and the standing working groups have contributed ideas for new

topics. The SAB and the working groups developed these topics working together in order to be useful and address agency priorities. In July 2019, the SAB identified the topics. At this meeting, the SAB will identify initial priorities and topics, then work closely with NOAA to set priorities and refine them into a draft document. This draft work plan will be vetted by NOAA and then the SAB will revise the plan based on their input. Chair Scarlett discussed the status of the two main priority areas (reducing the impacts of extreme weather and water events and increasing the sustainable economic contribution of our fishery and ocean resources) and associated topic areas from the 2018-2019 work plan. Four topical areas were discussed at the July SAB meeting:

- Enhancing innovation
 - SAB could examine NOAA's approach to innovation by thinking of a more structured pathway to innovation
- NOS relevant issues
 - NOS has not seen itself in the past plan. How can the SAB incorporate more of the NOS needs into the next plan?
- Social sciences
 - How can the next work plan address the social sciences and weave them into emerging technologies better?
- Partnerships and innovation
 - Can or should partnerships be emphasized more in the new work plan?

In addition, the working groups' proposed topics included: an assessment of NOAA's progress towards meeting the sub seasonal and seasonal forecasting requirements; practical methods for adaptive risk management and decision-making under uncertainty; aquaculture and ecosystems in the 21st Century; socio-economic dimensions of Integrated Ecosystem Assessments; and S2S2D (sub seasonal-to-seasonal-to-decadal) as a pathway to improved predictions. The SAB has had briefings and discussions with experts on NOAA's S&T focus areas and those blue sky discussions have informed some of what NOAA has carried forward in its investments and decision making. The SAB's next steps will be to reach consensus on priorities and determine how to match topics to NOAA's priorities, then a subcommittee may pursue fine-tuning the priorities and topics, and have an outline of a work plan ready for the February 2020 SAB telecom meeting.

Discussion

Bob Winokur asked if the NOAA S&T focus areas will become the work plan's organizing principles, replacing the previous work plan's priorities. Chair Scarlett said there will be two sets of organizing principles: NOAA's S&T focus areas and the two umbrella focal areas of the previous plan.

Dr. Lenhardt asked about keeping the work plan moving forward with Chair Scarlett rotating off the SAB. Chair Scarlett said the SAB's concept of operations specifies that they create two-year work plans, so that is embedded in their process. NOAA leadership has also asked that she help the incoming Chair with the transition in order to make it as seamless as possible.

Dr. Uccellini urged the SAB to read the National Academies of Science report on social sciences and move forward from there, as it includes relevant foundational aspects. He also stated that the

topic of resiliency has emerged over the last year with respect to extreme weather and ocean events. NOAA has been getting more involved with other agencies and the administration on ways to address vulnerabilities and they are focusing on the ability to predict weather and coastal waters. NOS' extremely valuable response efforts continue to slip under the radar. It's not only the science that needs more visibility, but the science-service linkage with resiliency.

Mr. Levenbach said Vice Admiral Paul Gaffney is the incoming SAB Chair and he has been speaking with most of the NOAA and Line Office leadership and has many ideas he wants to discuss, as well as suggestions for the work plan. They will try to blend the work being done at the current meeting with his thoughts so there is continuity between the two.

Chair Scarlett asked the working group chairs to remind the SAB what the key topical areas are that they have been focusing on and want the SAB consider. Dr. Colman said the EISWG has focused on monitoring the progress of and activities associated with the Weather Act. They continue to receive reports from NOAA at a pace slower than mandated but at a pace at which they can handle them. They have been working with the Climate Working Group (CWG) on S2S2D and they would like to hear the SAB's thoughts on better defining their respective roles. EPIC is an emerging topic for the EISWG and will be a focus for the January meeting. Dr. Gentemann said the Data Archive and Access Requirements Working Group (DAARWG) will be presenting on NOAA's move to the cloud, analysis-ready datasets (ARD), licensing, and retraining of the community. This is very relevant to the discussion about community change regarding EPIC. Their recommendations focused primarily on large consortia bringing many voices together as they move forward. They are also looking at how NOAA data will evolve in the future as things start to move onto the cloud and how the Line Offices will respond to that.

Dr. Russell said that CWG will provide a review of the strategic plan for ocean acidification (OA). They also produced a white paper on S2S2D, focusing on how to push prediction science forward and what kinds of information from NOAA would be helpful in this regard now that FV3 (Finite-Volume Cubed-Sphere Dynamical Core) is available to be broadly used. They have offered to assist the EISWG in reviewing NOAA reports that are in the CWG's area of expertise. They are looking forward to more interaction with the Weather, Water, and Climate Board in the coming years. Dr. Johnston said the Ecosystem Sciences Management Working Group (ESMWG) has been focusing on new technologies for fishery stock assessments. They have focused not only on what the new technologies are, but how they fit within the broader institutions, systems, and people who are doing the stock assessments and what they are being used for. The report will provide a number of recommendations on how the technologies can be developed and what steps NOAA should take to ensure they are developed in a way that will be useful. They will be moving forward on the topic of decision making under deep uncertainty, focusing on an emerging suite of methods being developed in academia and the private sector. They are still debating whether to move forward with the aquaculture and ecosystems topic because NOAA and the SAB have recently done a lot of work on aquaculture and they want to make sure they're not duplicating those efforts. There is also a logistical concern because the person that was overseeing this topic recently stepped down from the working group and someone else would need to step up if they choose to move forward.

Dr. Werner said there is a strong commitment from the administration to moving forward in the area of projections and forecasts in the two month to three year time scales and constituents are demanding this information in order to plan ahead. NMFS is working with other parts of NOAA to look at how these forecasts can be integrated into their assessments and decision making. This is extremely important for them in terms of being ready to do the science and preparing for the cultural shift that needs to happen. Dr. Russell said the CWG is ready to be of service in this. Mr. McLean said NOAA will be opening a new computing facility in Mississippi which will make a huge impact on NOAA's current computing capability, but will still be a long way from what is needed. This is an area where the SAB's recommendations and advocacy could be very helpful. Mr. Levenbach said they are on the cusp of understanding the value of NOAA's environmental data and will soon be announcing a contract with three commercial cloud service providers. One benefit of putting NOAA data in the cloud is leveraging non-federal partners who understand social science well that can make decision support tools and products using NOAA's environmental information. This is an area NOAA is particularly interested in in terms of ecological and environmental forecasting. They would like the SAB's advice on the types of data they should be making publicly accessible on the cloud so they can incentivize their partners. Mr. McLean clarified that he was not disputing the value of the Big Data Project but that even cloud service providers agreed that if NOAA doesn't hold on to some of their own compute ability, the price for compute availability is going to go up in the future.

Dr. Russell said that states and land grant universities have a deep concern that there always be publicly available information from NOAA. Depending entirely on private providers and pay-to-play enterprises to provide the products that are required for states and citizens is not something they would be in favor of. Mr. McLean clarified that moving big datasets onto the cloud as part of the Big Data Project is an expedience mechanism so that the science community can get pre-organized data and, for a nominal fee, upload it and work on it so as to avoid redundancy. Weather forecasts and other NOAA services will still be freely available.

Dr. Colman asked if they could define more clearly when a work plan topic is complete. The reviews the SAB has had with NOAA have been fairly broad and high level, so they are not getting the feedback on whether the reports are helpful and what is being acted upon. Chair Scarlett said that when the reports are submitted, there is an agenda item included in the meetings for NOAA to respond and discuss the report, but there may be a way to summarize the results of the input. Dr. Colman said that the EISWG would benefit from more dialog on whether they are presenting information at the right level and making the right contacts. Chair Scarlett said the intention of these reports was to have a more expeditious timeline than formal reports which require NOAA feedback, but since the work plan topics are presented and discussed and this is captured in the minutes, there may be an efficient way to summarize key takeaways that would be helpful to the report preparers.

Dr. Weatherhead commented on the role of the private sector in NOAA's science enterprise. The private sector is definitely acting as partner even if NOAA is not benefitting. It is a partnership where they are both serving the end users and both the agency and industry have their roles. The private sector has a growing role here and if NOAA can set the expectations appropriately, all parties will be better off.

Continued General Discussion

Chair Scarlett led the further discussion, zeroing in on the concepts that got traction in July and included those discussed above. The four items that rose to the top included CWG's proposal on S2S2D, risk management and decision making under deep uncertainty, the issue of resilience under extreme events, and the challenges of fishery stock assessments under rapid change. A question for the SAB to consider was whether the risk management and decision making under deep uncertainty and resilience under extreme events should result in two work products or be blended into one.

Mr. McLean said the SAB has had the most success when they address topics that are broader than one Line Office application. Technology that would be beneficial to fishery stock assessments is effectively characterizing the marine environment and would be equally applicable to several Line Offices. It could tie in unmanned systems (UxS), omics, artificial intelligence (AI), and cloud computing. Coastal resilience has been identified as a top priority for many agencies and the SAB has not done much with this topic. In regards to tying resilience to risk management under deep uncertainty, he felt that there is a relation, but that there would be merit in addressing coastal resilience on its own.

Dr. Werner said it comes down to two time scales: one is the shorter time scale where something must be done about how NMFS does assessments because they can no longer assume that things are not changing, and the other is the longer time scale (10-20 year) that assumes the oceans will be much changed and NOAA will need to do many things differently, starting with how they sample the ocean. A fundamental shift is needed in terms of the Next Generation Data Acquisition Plan. Related to this is how NOAA will use all this data. The socio-economic side also needs to be integrated into decision making, with conversations with constituents taking place from day one. Management strategy evaluations (MSEs) are available that integrate all of these concerns and does so in a formal and quantitative way.

Dr. Thur said that the issue of coastal resilience in all forms has been of growing importance for NOS. There are skill sets within each of the working groups that could provide helpful advice on how best to approach the topic. He would especially appreciate the SAB's advice on the appropriate riskiness of NOAA's portfolios activities under both of these topics. Without a portfolio of activities that has an appropriate level of riskiness, NOAA is probably leaving undiscovered new opportunities for applications. He added that these topics, deep uncertainty, coastal resilience, and characterizing the changing marine environment could each have a role for multiple working groups. The current structure of the work plan is rather siloed and they are working on one item each, but in order to get robust advice on these topics it would be good for NOAA to hear from multiple working groups.

Dr. Weatherhead noted that each of the topics have a strong and growing private sector component and the SAB should go forward with that in mind. She added the possibility of climate observation systems as something that stretches across NOAA and engages the private sector. She said that as administrations come and go, there is very little pushback on the need for greatly enhanced observing systems. Planning that system wisely is an area where the SAB could be very helpful.

Dr. Matlock suggested considering the topic of forecasting ecological change affecting NOAA's mission. Developing forecasts that address ecological change that would provide a glimpse into what goes on in ecosystems in a broader context would allow NOAA to use more of their science in a less siloed way to inform the public of what might happen.

Dr. Uccellini urged them not to merge the resiliency and risk management topics. NOAA is just scratching the surface of risk management issues and how it affects their ability to create products in the extended range. The resiliency topic is emerging in many areas, including national security. He noted that the World Meteorological Organization (WMO) passed its second declaration ever in support of the growing private sector across the entire value chain to address the risks related to extreme weather, climate, water, and environmental events. The private sector is an integral and growing part of every component of the Weather Service's portfolio.

Dr. Johnston clarified that the ESMWG was not considering addressing forecasting under deep uncertainty, but rather how to move forward with making decisions when you can't format the forecast as well as you might like or much at all. This brings in the physical science and social science aspects. The topics of coastal resilience and change in coastal and marine ecosystems are very heavily connected with what they are doing. They intend to address broadly the topic of deep uncertainty and then draw examples from those two topics.

Dr. Kalnay discussed resilience in the face of extreme events and said that NOAA already has many of the tools it needs. She suggested that NOAA call for proposals on this and recommended Brian Hunt as a person with success in preparing to use AI to estimate long-term precipitation. She noted the importance of recognizing the human impact on nature and that dynamical models do not include a bidirectionally coupled human system like they should.

Dr. Russell discussed S2S2D in more detail and how she sees it linking to other things the CWG has been discussing. They are most excited about the opportunities that come with FV3 moving into a more operational configuration. Earth system prediction is needed at more scales, both spatial-temporal and systems, and the opportunities here are enormous. Chair Scarlett suggested including in the work plan a review of the CWG report and development of possible next steps for NOAA. Mr. McLean agreed with this approach and said that he is ever more convinced that NOAA does not collect data in a way that is sufficient for the future and they don't integrate data in a way that is effective for the present. Any advice the SAB could provide on this would be welcome. Dr. Russell said that she wants to see all of NOAA's data turned into initial prediction data, but at present it has likely not even been assessed whether this could be done. Dr. Uccellini said NWS was confident that FV3 would take them from the weather to the climate domain as long as they had the hydro model incorporated. If they chose to take this on, he encouraged the CWG to review NOAA's current next steps with respect to the improved prediction S2S2D. He also noted that this is all part of the Unified Forecast System (UFS) that NOAA has been promoting for a long time and has implications both for EPIC and the cloud computing discussions. Dr. Russell said that the CWG viewed their report as more of an extension of the NWS strategic plans which they felt were on track.

Chair Scarlett asked if these four items should be on the work plan, and if there were any volunteers to lead a more refined write-up of the elements and/or act as an additional liaison to the working groups for the work plan. The SAB will review the CWG report on S2S2D and then decide how to proceed. Dr. Perry will develop the work plan element for risk management and decision making under deep uncertainty, focusing on the mission-oriented integration and innovation aspects, along with technology and NOAA's other mandates and the regulatory decision-making that needs to happen. This was the number one issue that came up at the White House summit and there is an opportunity to provide feedback on approaches that NOAA may be able to utilize, not just in its scientific mission but in its regulatory mission as well.

Mr. Kreider asked for clarification on the scope of "characterizing the changing marine environment" and how this could be narrowed into something that is meaningful. Mr. McLean said one option is to do what would be feasible for the workload of the SAB. To him, it was more about modernizing the way NOAA does the characterizing, assessing if they are doing enough with what they already have, and what new factors they should be looking at and collecting. He felt that having input from the SAB as to whether or not NOAA is at an optimum level methodologically would be helpful. Dr. Werner said that the reason they need to measure things differently is that things are changing from the base of the food web up, impacting the overall health and productivity of the oceans. The questions NMFS is now facing are: where are things going to be; when are they going to be where they're going to be; and what's the different state of disjointedness of what's going to happen. A joint effort from biogeochemistry up to top predators and everything in between is needed in order to gain an understanding of what the new oceans will look like. Mr. Levenbach said that generally when they talk about innovative technologies in the federal government, it relates to how to bring technologies into the programs. NOAA also needs to consider what they should study in order to achieve their goals. Some of the questions they can address are different because of new capabilities.

Dr. Thur said he believes 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. If that is the case, what NOAA has been measuring may need to change as well. He also hypothesized that the rate of change in NOAA's practices over the next decade will be greater than in the previous decade and said that he would value advice from the SAB on both issues.

Dr. Kreider agreed to work with NOAA to draft a paragraph on the scope of the topic.

Dr. Rheault said new tools and assessments may not be needed so much as working better with the tools already available and modifying the models so that they incorporate what is happening in the changing climate. Chair Scarlett encouraged Dr. Rheault to join the effort in refining this topic. Dr. Werner commented that if they keep using the same model and things are changing, the uncertainty is going to go up.

Mr. McLean reminded the SAB of the multiple agencies with an ocean portfolio that said coastal resilience was the most important topic for them. It will be important for the SAB to hear the NOAA programs state its relevance and for NOAA to see what kind of vision they could get from the board. If NOAA could declare for the SAB what their current state of science is along the coast, he would invite the SAB to offer an opinion as to whether that science is sufficient for

what is needed now or in the future. Focusing on the coasts may present the opportunity to go to a different scale of information. Dr. Werner commented on keeping the changing multisectoral uses of the coasts in mind, particularly in the energy sector, and how that may be different in the next twenty years. Dr. Russell said that prediction science for coastal systems is very high resolution and it is multi-stressor. NOAA is not currently monitoring the pH or oxygen in water. Tourism trumps all concerns when it comes to coastal economies and prediction science for the coastline is certainly NOAA's job. There may be many agencies with an ocean portfolio but they don't do prediction. Multi-stressor prediction is what is really worrying and has the potential for the biggest economic impact.

Dr. Johnston said the EMSWG is moving rapidly on the risk management and decision making under deep uncertainty topic and it would be great to have some assistance from the SAB. He encouraged the Board to coordinate through himself and Dr. Castellini to ensure everyone is moving in the same direction, but overall the conversation had been consistent with what the work group has been discussing.

Chair Scarlett will work with Dr. Decker to draft a note capturing some of this discussion. This will be circulated and once comments are received from the members, it will form the basis for an outline that will get more fully developed. As the SAB considers these topics and hear from NOAA on them, they should be thinking about private sector engagement, the relevant S&T focus areas that NOAA has flagged, and the social science dimensions in the work products that ultimately get developed.

Mr. Levenbach said NOAA and other federal agencies are working on the issue of research security and they may seek the SAB's input on this topic in the future. Mr. McLean said the Executive Branch has been moving towards increasingly tighter controls on the subject, including access of foreign nationals to nationally sponsored research. The JASON review stated that open research opportunities of intellectual advancement outweigh the protections sought by tightening controls. He recommended the SAB read this analysis. NOAA has been directed to take action on the issue and the cases that have come up inside NOAA raised the question of how attentive they have been and how attentive they need to be in the future.

Dr. Weatherhead asked that climate observations be discussed at the next SAB meeting as a possible focal point. Before the next meeting, she will work with Dr. Russell to draft a one-pager for the SAB to consider.

Data Access, Data Science, and AI-based Analysis of Environmental Data

Robert Grossman, University of Chicago and SAB Member

Christopher Lenhardt, RENCi and SAB Member

Dr. Grossman said that this is a very broad topic so the working group has decided to focus on four areas: (1) selected applications of AI and data science to the NOAA mission; (2) enabling technology, including the required data management and cloud infrastructure; (3) issues around preparing NOAA data resources to be AI and data science friendly; and (4) how AI and data science might accelerate NOAA's economic impact and contribute to an increase in U.S. competitiveness. Progress to date included requesting that DAARWG draft a brief report on

several topics and talking to NOAA's AI Working Group about their progress and requesting a briefing at a future SAB meeting. Next they intend to learn more about NOAA's future plans to put additional NOAA data into the cloud and its plans to share this data with the broader research community. The most significant thing to happen in this area in that last several months was the release of NOAA's Draft AI Strategy, which included five goals and several objectives related to each. Another important recent paper was from a Norway-U.S. workshop entitled "Machine Learning to Improve Marine Science for the Sustainability of Living Ocean Resources." It is a very busy time in this space, with many federal agencies and other organizations writing at least one report each. He commended the DAARWG for their work on the report "Preparing for a Cloudy Future" which included multiple recommendations and will be discussed later in the meeting. Recommendations from the consultation with the NOAA AI Executive Committee included establishing an AI Center and establishing partnerships and cooperative research and development agreements (CRADAs). Within 60-90 days following the meeting, the working group will synthesize the materials they have and produce a short report.

Mr. Lenhardt said a progress report to the National Strategy was just released which can be circulated to SAB members. NOAA figures prominently in the update and RDML Gallaudet is the liaison for the cross-agency White House initiative. NOAA's AI efforts are definitively aligned with the other priorities the SAB has been hearing about. NOAA is working on making connections within this domain.

Discussion

Chair Scarlett asked if, with all the various reports referenced, there are any key themes that are consistently emerging and of particular interest to NOAA. Mr. Lenhardt said a lot of it is a reaction to the spread of the use of the technology, addressing questions like: How do you avoid duplicating effort? How do you ensure everyone has the right understanding about the techniques? How do you ensure that it is seen as an adjunct and not an end in itself? These are the key themes coming out right now, perhaps because of where AI currently is on the hype cycle. Dr. Grossman added that he's been pleasantly surprised that the reports have had the right perspectives and expectations in this field.

Dr. Tolman commented that RDML Gallaudet has been very active in these efforts. He added that, even when efforts are aligned, AI itself is extremely varied even within a single organization. Different aspects of AI and machine learning are used for different ends, but these applications are very much aligned across agencies.

Mr. Levenbach said that one thing to consider is what AI-related decisions are moving through the process and how the SAB can provide input. The strategy document was expected to be finalized within 60 days, which may be too soon for the report. If the SAB or the working group has views on it they should get them in as quick as possible, but the implementation plan and the AI Center are both decisions that are operating on a longer timeframe and the SAB's input would be welcome. He suggested targeting these areas as places where they could have an impact.

Data Archiving and Access Requirements Working Group White Paper

Chelle Gentemann, Chair, DAARWG and Remote Sensing Requirements

Dr. Gentemann presented on the working group's draft white paper. DAARWG had been asked to respond to three questions: (1) How do you prepare ARDs? (2) How do you train researchers to work in the cloud? and (3) How do you prepare training data for machine learning? DAARWG added a fourth question regarding the process for agile cloud implementation and deployment, which they felt was critical and applied to all of these issues. The white paper includes the following recommendations:

Consortia:

Recommendation 0.1: Promote the creation of consortia focused on specific societal benefits that include private sector, public sector, NGOs and civil society that focus on developing cloud-based solutions using NOAA data

Recommendations for preparing analysis-ready datasets:

Recommendation 1.1: NOAA's strategy for providing public data access should:

- a) Account for the needs and priorities of all user communities through a systematic and rigorous process, including an analysis of existing data usage patterns;
- b) Publicly publish documentation that clearly describes the entire process of converting data access to ARDs, including its prioritization criteria and any technical processes utilized;
- c) Make available data in its existing format in the Cloud as soon as possible to maximize user benefit while their conversion to ARDs is ongoing.

Recommendation 1.2: NOAA should apply a clear, consistent, concise, and permissive open license to its data and software. NOAA should present this information alongside every dataset at all access points, and include it in the metadata.

Recommendations for training researchers to work in this area:

Recommendations 2.1: Offer trainings on existing open source technology (open source software libraries, containerization, software stacks, cloud deployments).

Recommendation 2.2: Build on existing open source training resources for onboarding new collaborators and retraining existing workforce.

Recommendation 2.3: Support open source software libraries.

Recommendation 2.4: Develop a mechanism to fund Hackweek style events to address specific infrastructure issues or science challenges.

Recommendation 2.5: Ensure interagency communication on lessons learned to help NOAA's approach to retraining its workforce.

Recommendation 2.6: Participate in consortia with external groups focused on using big data and cloud computing to address societal problems

Recommendations for preparing training data for machine learning:

Recommendation 3.1: Develop a NOAA-wide survey to identify pre-existing training datasets that may only require minimal reformatting and public distribution.

Recommendation 3.2: Connect external and internal experts to develop and publish guidance for data providers to help create clean, quality-control, and labeled ML training data.

Recommendation 3.3: Use the results from Recommendation 3.1 to identify where there are substantial synergies across training dataset development to develop an enterprise solution and minimize redundancies.

Recommendation 3.4: Publically share Recommendation 3.1 identified datasets in a widely accepted format.

Recommendation 3.5: Document the use of these new data.

Recommendations regarding process for agile cloud implementations and deployment:

Recommendation 4.1: Develop a categorization for where, and to what level, more formal software development processes would benefit NOAA.

Recommendation 4.2: When appropriate, NOAA should consider adopting an agile software development strategy, including test-driven, continuous integration and container-based deployment software

Discussion

Dr. Weatherhead said that what DAARWG recommends has a lot of overlap with what ECMWF (European Centre for Medium-Range Weather Forecasts) is doing in their Climate Data Store, to which they've put in 300-person years of effort to develop a cloud platform for environmental data. It would be nice if there was coordination in how things are done and even if the datasets themselves could be complementary and not redundant. Dr. Gentemann said they discuss in the report how many NOAA data archive centers have a lot of non-NOAA data on them. This will be something that all agencies will face and agencies should focus on providing their data initially because they don't want the overlap. There are cloud interoperability issues, but those are slowly becoming smaller. Dr. Weatherhead clarified that her question was not about the redundancy of information, but the approaches used to supply information and ensuring interoperability. Lessons learned from one group putting their environmental data on the cloud can benefit others doing something similar.

Mr. McLean said that the Department of Commerce's Chief Information Officer barred NOAA from using GitHub several years ago, but one lab did it anyway and demonstrated the proof of its effectiveness. Dr. Tolman added that the Office of Oceanic and Atmospheric Research (OAR), NWS, and the National Center for Atmospheric Research (NCAR) signed an agreement for developing the infrastructure for coupled modeling, which includes putting everything on GitHub. There is a lot available on GitHub already and by February, user support will be in place for the first FV3 Global Forecast System (GFS) version of the Unified Forecast System (UFS).

Dr. Russell said the Modular Ocean Model version 6 (MOM6) development has been extraordinary, but that the issue is how to bring the code back into NOAA. Dr. Colman asked what the right business model for this could be and how NOAA could support it in a way that it would be better protected for private industries that are growing dependencies upon it. Dr. Gentemann pointed to a section in the National Academies report on open sourced software it wrote for NASA that describes the different ways to support open sourced libraries. She recommended following that guidance, which includes allowing employees to contribute to open source projects and/or have funding for open source library development. There are nonprofits set up to help support these libraries in an organized way. Dr. Tolman said the biggest issue is not how to do this technically, but getting people to buy into it. Dr. Gentemann said that she counted 14 different groups in the satellite algorithm development community all independently developing the same algorithms, each with a closed code model. Sharing their work on GitHub or even collaborating or talking about their work could jeopardize their funding model.

Dr. Uccellini said that from a data perspective there is a difference between working with archived data and realizing its intrinsic value and real time data. People won't release data in real time unless the user is paying for it and from an operational perspective, NWS has a two-hour window for its data. He stated that there will be different categories of use that need to be brought to bear on code development - from a research perspective (which can handle some chaos), from a research-to-operations (R2O) perspective (which needs more structure), and from an operational perspective (which needs to be hands off). Each of these categories will require different security parameters. Some of NOAA's partners will not use an operational code if universities from other countries have been involved in it. Dr. Gentemann said they spent a lot of time discussing near-real time data versus archive data and decided not to include a recommendation on one or the other because they felt each of those communities would have different priorities. This is the start of a long process of prioritization and culture shift that has to balance and consider all these different communities and nuances.

Dr. Michaud asked if DAARWG had given any thought to who they see in this recommendation as being responsible for curating and making available ARDs and where they see NOAA sitting in the process. Dr. Gentemann said they had discussed it extensively and thought the best approach would be having a Tiger Team help whoever has the training dataset to create the ARD. Once you have tutorials and data recipes then the data providers will transition themselves into providing this. Mr. Levenbach asked if there is a reason this competency should not lay outside the federal government. Dr. Gentemann said it could, as long as it is closely tied with the scientists that prepared the dataset, otherwise you'll end up with datasets that have been compressed or chunked in ways that are not scientifically appropriate. Mr. Levenbach said it would be useful to include in the report the federal role and the extent to which they could support partnerships.

Dr. Weatherhead was in favor of accepting the report as is, acknowledging that this is not the only word on the topic and NOAA can take it as part of their advisement while acknowledging that there are other issues. She encouraged the working group to continue to address some of these multifaceted aspects because their advice is incredibly valuable.

Mr. Lenhardt moved to accept the report and transmit it with a cover letter stating there are additional issues for the working group to address; the motion was seconded by Dr. Weatherhead and passed unanimously.

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

Charles Alexander, Office of Marine and Aviation Operations

Dr. Alexander presented an update on NOAA's UxS Strategy. He provided background on efforts towards a NOAA UxS program and the legislation that provides the foundation for collaborations. A UxS strategy underpins NOAA's goal to increase the economic contributions of the blue economy. RDML Gallaudet has been the main sponsor of this effort. A NOAA UxS Strategy Paper and a NOAA UxS Implementation Plan were both originally targeted for completion by September 30, 2019. A draft was published November 14 and the implementation plan is on the brink of moving forward. As the team was working on this, they connected three other NOAA technology initiatives to move forward on the same timescale (omics, AI, and cloud computing) and then presented all four draft strategies at the White House S&T Summit. The draft strategy comment period was open for input from November 14 through December 16 and the 50-60 comments contain interesting input from various sectors that will be useful going forward. The strategy includes five goals and their three supporting objectives. The goals are: (1) Coordinate and support UxS operations at an enterprise level; (2) Expand UxS applications across NOAA's mission portfolio; (3) Accelerate transition of UxS R2O; (4) Strengthen and expand UxS partnership; and (5) Promote workforce proficiency in UxS use and operations. Dr. Alexander discussed each of these in detail. Remotely operated vehicles are still included in the definition of UxS for strategic reasons.

The report includes vignettes of what NOAA has been doing operationally and experimentally in order to give context to the strategy. As with all of the four strategies, the UxS Strategic Plan includes a two-page face sheet summarizing the key points of the document. The draft strategy next has to travel back through the NOAA review process before being finalized. In parallel, a Tiger Team will be put in motion to look at a five-year Implementation Plan that uses the structure of the strategy to define milestones, products, and outcomes over the next 3-5 years. How to do external engagement following public review will be part of the implementation process. Recent related activities include RDML Gallaudet's keynote presentation at Oceans in Action 2019, a new annex to the Commercial Engagement Through Ocean Technology Act of 2018 (CENOTE) defining how NOAA and the Navy will collaborate, working with the Navy on their Advanced Naval Technology Exercise for 2020, and several upcoming meetings and events on the strategy. The University of Southern Mississippi's (USM) Center for Ocean Enterprise broke ground in Gulfport on November 8 and it will be a big step forward for NOAA plans to do significant collaborative efforts on the Gulf Coast with USM, the Navy, and many others.

Discussion

Chair Scarlett asked for some examples of the vignettes included in the plan and where NOAA sees some of the greatest use opportunities. Dr. Alexander discussed the Atlantic Oceanographic and Meteorological Laboratory (AOML), Integrated Ocean Observing System (IOOS), and Navy

collaboration using Slocum gliders as a data collection tool for hurricane forecasting as an excellent example of ongoing UxS work. There is also great potential in UxS assets for airborne data collection, hydrographic and bathymetric mapping, acoustics work, endangered and protected species surveys, and deep ocean exploration. Dr. Uccellini further discussed the data flow for the gliders which are now automatically included in NOAA's operational systems and provide the backbone of the real time ocean forecast system. This all came together through the NOAA-Navy NOPP.

Dr. Russell asked if there is a table somewhere that displays the opportunities for deployment that would reduce risk, improve skill, or cut costs. Mr. McLean said it would be a good idea to put together a table in order to sell the proposition. One of the components they have to work out is that the plan identifies the importance of R2O, but NOAA is not a good customer for many of the partners that have pursued this work under CRADAs. NOAA will partner to develop a capability and then not be able to buy that capability. This program is trying to move money into a column where the agency can procure the technology and use it operationally. Many of these deployments won't save money, but will improve the quality of the observations. Dr. Russell said she would like to see the observing system simulation experiments (OSSEs) done to determine the value proposition for each and every thing they deploy. Dr. Alexander said these comments were anticipated and they intend to produce a cost-benefit analysis.

Mr. Winokur said the Navy produced a value proposition for purchasing gliders, which included a very extensive OSSE.

Dr. Perry said the problem here is that the system is driving the strategy rather than the problem driving the system need. Shell has partnered with IOOS in the Gulf of Mexico where they can't nail down hurricane intensity. After a partnership with NOAA and the Navy was built around addressing the problem, they started to bring in UxS and modeling. This strategy doesn't have a good vision for how the systems are going to help solve their problems. The value of UxS is really about how these systems are going to help solve grand challenges, not just those that NOAA is facing but major issues communities are facing. NOAA should focus on bringing together the skill sets as opposed to figuring out how to buy 200 gliders. There is a lot of private industry available that can be leveraged.

Mr. Kreider said the report mentions how critical private sector partnerships are, but then the vignettes are of NOAA acquiring systems and the agency or labs operating them. There is a lot of capability, experience, and success in the private sector with these systems. Things change very quickly and government procurement is a long process. This is also an opportunity to outsource and build partnerships. He asked for comment on the alternative of buying either data or a service as opposed to spending a lot of time and effort acquiring hardware. Mr. Levenbach said this question is very much on their minds even if it's not shown in the document. One of the advantages of setting this up as a program is that it makes the conversation much more efficient than if it was done across various programs. NOAA has every intention of exploring all acquisition models for how to use UxS.

Dr. Uccellini said the reason NOAA became interested in this area was the idea that gliders could augment or replace buoys. There is less glider data going through the National Data Buoy

Center (NDBC) today than in 2013. He did not know if that is because there are fewer deployed or because more are not sharing their data. Dr. Perry said that unless the glider data is perfectly packaged, NDBC is not the one that is going to help them get the data into the Global Telecommunication System (GTS). This is why IOOS has taken this over from a data management perspective. There have been challenges with getting information from gliders and other systems from academic institutions or private industry through the system. Unless data providers are aware of who is available from NOAA to help them, it is not easy.

Mr. McLean said NOAA has had commercial sector engagements and the challenge is in finding the right contractor. It would be a mistake for NOAA to acquire the internal capacity to be operating every one of these different systems. Often the best thing would be to write a check and have oversight in implementing the contract. The only way they will get operational is to have a dedicated group that is funding the operational enterprise.

Chair Scarlett commented that ordinarily a strategy would state upfront what it hopes to accomplish. She suggested that even in this abbreviated section it may be useful to identify the kinds of partnering that NOAA might envision. Resource allocation and whether there is the prospect for increased funding links to the value proposition. It would be a valuable undertaking to make a case for appropriators, whether in a table or another format, what the value propositions for various UxS are.

Public Comment

There was no public comment.

December 17, 2019

Welcome

Lynn Scarlett, The Nature Conservancy and Chair, NOAA SAB

Chair Scarlett welcomed everyone to the second day of the meeting and reviewed the day's agenda. This will be her last meeting as Chair of the SAB after nearly six years. She thanked NOAA staff for all of their support and the outstanding work they do, especially thanking Cynthia Decker and her staff.

Climate Working Group S2S2D White Paper

Joellen Russell, CWG Chair and University of Arizona

Dr. Russell presented the working group's white paper on S2S2D. Climate change and earth system prediction on sub seasonal-to-seasonal-to-decadal timescales are essential to saving lives and property and supporting industry. The convergence of climate and weather modeling, occasioned by the implementation of the FV3 GFS model, provides the opportune time for NOAA to leverage earth system observational capabilities to better save lives and property and support the blue economy. The CWG asserts that an orderly prioritization and resourcing of pertinent projects focused on modeling, processes, observations, and communication will define the path to a successful and seamless S2S2D prediction system. The CWG's S2S2D white paper focuses on five areas: (1) hybrid statistical-dynamical models; (2) boundary layer processes; (3) global ocean observations; (4) biogeochemical processes (oceanic and terrestrial); and (5)

improved engagement and communications on S2S2D timescales. Dr. Russell discussed the opportunities and gaps in each of these areas and the CWG recommendations for each. These recommendations included:

- (1) fund hybrid-statistical models (including contribution from machine learning, artificial intelligence, deep learning, etc.) to bridge the gap between the needs of stakeholders and limitations of the dynamic models at regional scales, especially for S2S2D predictions;
- (2) fund boundary layer chemical dynamics research to help weather forecasting and calculations, as well as quantification of emissions for air quality and climate needs;
- (3) work towards realizing an expansion of observations networks into the tropics, deep, and polar oceans; obtain global oceanic biogeochemical observations through the implementation of deep Argo, biogeochemical Argo, and enhancements in Argo beyond the 2020 design;
- (4) restore funding for ship time in support of sustained observations and deployments;
- (5) fund a global biogeochemically-sensored autonomous profiling float array and train the personnel to deploy and calibrate them;
- (6) invest in terrestrial biogeochemical research and modeling, especially collaborations with USDA. Collaboration between the Geophysical Fluid Dynamics Laboratory (GFDL) and CPC would accelerate improvement of terrestrial biogeochemical processes in S2S2D predictions;
- (7) train NOAA's workforce, academics, and commercial enterprises in the use of FV3 and invest in educational outreach and resources;
- (8) invest in the social sciences and human infrastructure for engaging sectors and communities in supporting decision-making and communicating earth system predictions;
- (9) expand capacity to assess the return on science investment using multiple metrics such as economic impacts, diversity and number of people and locations served.

Discussion

Dr. Weatherhead commented that some of what is discussed in the white paper is incredibly expensive, such as biogeochemical floats, and some of it just requires the right people thinking hard about an issue. She asked Dr. Russell what action items she thought would be most easily attainable. Dr. Russell said that very little of this would be inexpensive. Even the peopleware to develop the software to be more effective in capturing the metrics will not be easy. Done collaboratively, float arrays can be much more affordable investments. The CWG was asked to think 5-10 years out in terms of how NOAA could change the world, and they felt seamless earth system prediction from small scales to big, short time scales to longer, are the major pieces that could get the agency to the next level.

Dr. Werner said that for \$60,000 more, biogeochemical Argo floats could provide an extremely valuable measurement. If NOAA wants to couple the biogeochemical to fish there are very simple calculations that go from primary production to fish, assuming certain trophic efficiencies. Biogeochemical measurements would be a great long-term investment for understanding the changes at the bottom of the food web.

Chair Scarlett asked if the CWG has looked at return on investment as a lens for prioritizing the sequencing of the investments. She was also interested in their perspective on organizational impediments to enhancing cross-research and collaboration. Lastly, she asked if the report addresses partnerships at any depth. Dr. Russell said the white paper highlights areas that are all related to improving prediction on different time and space scales and suggests that if NOAA had a defined strategic plan and related metrics for success, that each of these areas could make significant impacts that could be achieved with a reasonable amount of time and effort. Dr. Russell said NOAA would find a lot of support in Congress for these objectives.

Dr. Perry said that cost estimates and gap filling are the types of messaging needed to convince appropriators for funding, which can be a slow and challenging process. She asked if the CWG explored opportunities for private partners to fill in gaps that they could recommend to NOAA. Dr. Russell said that the focus on products on longer time scales are things where public-private partnerships are ripe for opportunity. She would like to see even more support for NOAA at the grassroots level and some of their suggestions are targeted in that direction.

Mr. Kreider said that he wasn't sure how NOAA should act upon this report that looks ten years into the future, because it does not recommend how NOAA should get there. It would be helpful to look at near-term activities that could help the agency move towards the ten-year vision, recognizing that a new large pot of money is not going to be available anytime soon. Dr. Russell said that CWG did not comment directly on NOAA funding or budgets. A proposal is being entertained at NSF at doing a global array at no cost to NOAA. When the agency organizes its priorities, they find there are many other partners that want to step in to help and take advantage of the opportunity.

Dr. Uccellini stated that NOAA is the only agency with the word prediction in its mission statement, but the pie is getting bigger and there is a recognition that they can't do everything. As the demand curve continues to go up on prediction products, observation, and situational awareness, partnerships will become stronger across activities. Stovepipes are being broken down and NOAA will be a stronger agency going forward to meet these challenges. He stated that when he uses the term "collaborative forecast process" he means a co-authored forecast versus a coordinated one. Lastly, he commented that NOAA's seasonal/sub seasonal temperature forecasts have improved dramatically while at the same time their precipitation forecasts have lost skill. Precipitation forecast improvement is mandated by the Weather Act, will require a global research program. They have been discussing how to promote this idea at the ICMSSR (Interdepartmental Committee for Meteorological Services and Supporting Research) and the WMO.

Mr. McLean said that NOAA has experienced incremental funding gains and this is the kind of scale and scope of progress they expect to continue. NOAA has received financial assistance from Vulcan, Inc. in order to deploy 40 deep Argo floats in the equatorial and sub-equatorial region after the company realized that the U.S. government's current pace of funding is

insufficient to meet the societal needs that Vulcan feels compelled to address. Despite this investment, much more is needed to tackle the weather issues the world is facing. NOAA is still wrestling with the role of Regional Climate Advisors and where the program is headed. NOAA needs to be targeting itself along the financial market's need for information, tying climate-scale assessments to those will spell out the cost-benefit return and the agency will see greater support.

Dr. Levenbach asked how the projects the Regional Integrated Science Assessments (RISAs) work differs from climate services in the private sector. Dr. Russell said there isn't much of a difference except in how they serve the underserved communities, since RISAs cover everyone. Mr. Levenbach posited that the reasons they are zeroed out in the FY20 budget is the lack of understanding of how RISAs complement, rather than substitute for what private industry is doing. Dr. Russell said that private sector climate services are often servicing companies that would like the information to remain private and tailored to their needs. The general predictions that RISAs provide use layman's language and are for public interest. Dr. Weatherhead suggested, as someone representing a private sector climate services company, perhaps the private sector could come together and write a common paper that makes clear their support for specific activities.

Dr. Uccellini said that, as they built the Weather Ready Nation paradigm, they learned that the local level public sector is not able to afford private sector firms and they are making decisions with respect to public safety and public preparation with federal information, not just RISAs but also regional climate services.

Dr. Weatherhead suggested approving the report with a clarification of the public and private sector roles on climate services.

Mr. Winokur made a motion to accept the report with a cover letter; Ruth Perry seconded the motion and it passed unanimously.

CWG Report on the Review of the NOAA Ocean Acidification Strategic Plan

Joellen Russell, CWG Chair and University of Arizona

Dr. Russell presented the report. The 2020 NOAA Ocean and Great Lakes Acidification Research Plan is a ten-year research plan that identifies research objectives and actions for NOAA's OA science for the coming decade at both the national and regional levels. NOAA's Ocean Acidification Program invited the CWG to review the Research Plan. Dr. Russell provided background on the current understanding of OA and its projections for oceans, coasts, and the Great Lakes. The Federal Ocean Acidification Research and Monitoring (FOARAM) Act of 2009, requires NOAA to have an OA monitoring and research program to determine the potential consequences for marine organisms and ecosystems, assess the regional and national ecosystems and socioeconomic impacts, and identify adaptation strategies and techniques for conserving affected ecosystems.

The goals of the research plan include: to advance OA observing systems, modeling, technologies, and data stewardship to improve the understanding and predictive capability of OA trends and processes; enhance the understanding and prediction of OA as a stressor co-occurring with other prominent ocean and Great Lakes changes; improve understanding of the biological response and adaptive capacity of ecologically and economically important species, ecosystems,

and communities; and increase research to understand the vulnerability of communities and stakeholders to OA and to generate useful data that supports adaptation and resilience plans. The CWG report's recommendations included:

- (1) Formally commit to an integrated modeling approach across NOAA line offices;
- (2) Prioritize the linking of regional ecosystem models and biogeochemical frameworks so that OA observations can be utilized to their full potential;
- (3) Increase sampling of nearshore waters in sensitive and economically important areas;
- (4) The co-varying and possibly exacerbating effects of eutrophication and acidification on each other should be studied;
- (5) Highlight centralized access to NOAA's existing data syntheses and products;
- (6) Highlight and or initiate planned communications with stakeholders on the desired data products and syntheses that would be most useful to those communities;
- (7) Include metrics by which NOAA can quantify the success of its OA research and outreach;
- (8) Quantify the economic benefit of NOAA's OA research and products to the Blue Economy.

Discussion

Dr. Rheault said that no one cares about OA until it affects the biological species harvested. The tendency is to conflate upwelling, eutrophication-induced acidification, and anthropogenic acidification. There has been a tremendous proliferation of bad science in this field. The country needs good science with diel variation, sunlight impacts, and phytoplankton and sediments in the system in order to understand the impacts of what an acidified future are going to mean for our biological species, which both the report and the CWG recommendations call out as a need.

Dr. Thur sought clarification on the phrase in recommendation four "should be studied." The co-varying and possibly exacerbating effects of eutrophication and acidification on each other is being studied, so he asked if the recommendation was implying that the amount NOAA is investing in that research is insufficient. Dr. Russell said the way it is addressed in the OA report, it is even less integrated than the rest of the modeling. There are only certain areas of the coast that are actually monitoring both at the same time and studying the co-varying impact on ecosystems. It would require much more effort, but it is worrisome that we're not doing it everywhere along the coasts, given the potential impacts.

Dr. Rheault made a motion to accept the report; Ruth Perry seconded the motion and it passed unanimously.

IPCC Special Report on Oceans and Cryosphere

Ko Barrett, Deputy Assistant Administrator, NOAA Research

Ms. Barrett presented the report. The commissioning of this report responds to government proposals chosen, along with two others, from out of 55 proposals. It built on the completion of two other special reports issued in the last 15 months, one on the effects of global warming at 1.5

degrees and one on climate change inland. Together, these three reports mark the most intensive and ambitious effort in the IPCC's 30 year history. They will build a strong foundation for the main body of the reports to be produced over the next two years. The ocean and cryosphere impact everyone due to their important role in weather and climate, the provision of food and water, energy, trade, transport, health and well-being, and culture and identity. If greenhouse gas emissions continue to increase, global warming will continue to alter the ocean and cryosphere. If we reduce emissions sharply, however, consequences for people and their livelihoods will still be challenging but they will be potentially more manageable, especially for the most vulnerable populations. The report focuses mostly on observed impacts and projected risks, but also addresses benefits of ambitious and effective adaptation for sustainable development, while recognizing that these cannot keep pace with the changes that are projected.

The report finds that human-caused climate change even evident from the highest polar mountains to the deepest oceans, documenting the melting of high mountain glaciers and polar ice sheets, the thawing of permafrost, the ways in which for decades the ocean has been absorbing carbon dioxide and heat to regulate the global temperature , and shines a light on coastal and low-lying areas where sea level rise and associated impacts threaten the lives and livelihoods of large segments of the population. The world's ocean and cryosphere has been "taking the heat" from climate change for decade and the consequences for nature and humanity are sweeping and severe. Ms. Barrett discussed each of the sections of the report, which focus on changes in the mountain cryosphere, changes in the polar regions, sea level rise and coastal extremes, and changes in the ocean. The special report highlights the urgency of prioritizing timely, ambitious, and coordinated action to address the widespread and enduring changes in the ocean and cryosphere. It provides the IPCC's best available scientific knowledge to empower people, communities, and governments to tackle the unprecedented transitions in all aspects of society that would be needed to deliver on international agreements, such as the Paris Agreement.

Ms. Barrett also discussed NOAA's recently released Arctic Report Card. The findings in that report support and amplify many of the messages in the IPCC Special Report with regard to the Arctic. The impact of the two reports was certainly felt at the UN Conference of the Parties (COP) in Madrid. Though the formal negotiations at the COP were widely seen as disappointing, the final negotiation text did note some interesting things: a quarter of it emphasized the role of science in informing action to strengthen the global response to climate change and it recognized the role of non-party actors. Science issues broadly are now a centerpiece of the entire COP experience.

Discussion

Dr. Russell asked about the next steps after the Special Report. Good estimates are not available for feedback on climate or the rate of sea level rise in a dynamical sense because ice sheets are not included in models or parameterizations for scenarios. Ms. Barrett said this is disturbing to hear because IPCC can only assess the literature that is available in the public. Dr. Russell said this and the impact of more freshwater entering the Arctic are not included and asked if there is a plan is for addressing this and if CMIP7 will include these scenarios. Ms. Barrett said she would have to speak with GFDL personnel to find out what their plan is.

Dr. Uccellini discussed the Arctic Ministerial he attended, where he heard about the lives and livelihoods of Arctic peoples being totally upended as the connection with nature and the animal cycles have been destroyed, villages have had to be relocated due to increased vulnerability to storms after the disappearance of shorefast ice and coastal erosion, and the thawing of the permafrost is creating many new challenges. He asked if there has been any action on going back to see what was forecasted by earlier models compared to what is actually happening for oceans and the atmosphere. He wondered if it would have been better to report out on 20-30 year predictions rather than 100-year to make the message more urgent. Ms. Barrett was not familiar enough with the analysis of previous predictions to say definitively, but her sense is that it has been done continuously. This report increases the estimates for the acceleration of sea level rise even since the previous report from 2013. The report on the impact of 1.5 degrees of warming has made this issue very real and present for people and stresses the need for significant near-term action. Dr. Weatherhead said previous reports did not predict as strong of an impact as we have now. A lot of the research going on in the Arctic now is in trying to assess how much of the impact is from carbon dioxide.

Dr. Weatherhead asked what NOAA will do with these results and if they have found them useful in the past. Dr. Uccellini noted that in the short-term NESDIS has ensured that the Day-Night Band of their new satellite systems were moved up a notch in terms of their importance, mainly because of Alaska's need for assessing where the ice is. One of the drivers for the weather-water-climate linkage is factoring ice forecasts into not only strategic aspects of moving forward, but also tactical. Mr. McLean said the reports guide NOAA's climate investments and ever-evolving understanding of the situation. NOAA will continue to provide the information so that policy makers can make informed decisions. The reports help to focus attention on the most relevant issues and the most appropriate ways to address them. They are particularly useful as a convenient distillation of an entire body of global science. Ms. Barrett added that what is important about these reports from a NOAA perspective is that they are populated with the science that the agency undertakes and provide a very visible platform for demonstrating NOAA's investments in its science and for the need for information. Mr. Wheeler said that NOAA also has protected species mandates and climate reports that look ahead 50-100 years help determine in courts the foreseeable future for species.

Dr. Kalnay said that current climate change models do not include feedbacks from the human system, which is doubling the impact on the earth every 20 years. She compared this to the need for coupling the atmosphere and the ocean in order to predict El Nino. Ms. Barrett agreed and stated that if you look at the different projected impacts for the future, the role of humans in the system is key to future conditions, whether we will experience high or low impacts.

Mr. Kreider asked about engaging philanthropists that want to make an impact on big ocean questions and if there is a focused effort to engage philanthropists in order to increase public awareness and get funding for things NOAA wouldn't be able to do otherwise. Mr. McLean said the White House summit was the most productive exchange of information NOAA has had with the philanthropic community. The subjects that have emerged so far with philanthropy are global climate modeling, coral bleaching, and ocean exploration. This is a developing engagement and will be productive for the agency in the future.

Topic 9: New Technologies for Fisheries Stock Assessment Final Report

Mike Castellini, University of Alaska-Fairbanks and ESMWG Co-Chair

Dr. Castellini presented the report on emerging technologies for fish stock assessments. He discussed the context out of which SAB's work plan topic 9 emerged. Topic 9 instructed the group to evaluate fisheries monitoring technologies to improve stock assessments and consider how to optimally balance electronic monitoring, environmental DNA (eDNA), and other technologies. This builds on the 2018 Stock Assessment Improvement Plan and ESMWG's 2016 report on emerging technologies. The structure of the final report presents technologies categorized by their Technical Readiness Level (TRL). These three sections are: (1) TRL 7-8, near term and currently field verified technologies (e.g., modern spectroscopy methods for fish aging); (2) TRL 5-6, medium term technologies at field testing stages (e.g., UxS surface vehicles); and (3) TRL 2-3, technologies in longer term development in laboratory and in the field (e.g., omics and molecular methods). All of these technologies have tremendous potential for enhancing current stock assessment methods. Some are more applicable to particular fisheries than others, but the potential for new directions and strategic utilization is high. They should be considered synergistic with ongoing stock assessment methods and processes, and cannot serve as stand-alone replacements or provide immediate solutions to time, effort, funding and ship-use constraints.

Data created by some of these new techniques produce information that is substantially different from current data inputs to stock assessment and may have distinct biases that will need to be evaluated before they can be used. These and other new methods will require dedicated studies comparing their results to NOAA's current best practices to ensure a high degree of integrity, reliability and credibility in stock assessments for fisheries management. These techniques can expand the options, efficiency and accuracy of some existing NOAA research tools and may eventually enable new questions to be addressed. The technologies require specialized personnel training to maximize their use. These methods will likely provide information that goes beyond stock assessment and into areas of environmental assessment, ecosystem-based fisheries management, natural history and core biological information about the target species. The recommendations in the report include:

- 1) Although new technologies may lead to efficiencies in the medium to long-term time frames, they should not be viewed primarily as cost-saving approaches, but rather as a means to improve stock assessments and ecological monitoring moving forward.
- 2) NOAA will need to examine whether and how the new technologies can be linked to current stock assessment models and supporting analyses.
- 3) New technologies can be advanced by holding workshops with diverse experts to develop ideas for how to apply these new technologies to stock assessment.
- 4) Side-by-side dedicated comparisons between new technologies and ongoing stock assessment analyses will be needed to advance these new techniques.
- 5) NOAA will need to invest in laboratory and field testing of these methods...and should consider Public-Private-Partnerships (P3) to develop support for these methods in areas where the agency does not have primary responsibility.
- 6) NOAA should explore the potential for workforce development, cooperative institutes, postdoctoral programs and training classes to provide current and prospective NOAA scientists training for these methods.
- 7) NOAA should consider how artificial intelligence, cloud computing and other approaches can be applied to process the large volumes of data that will be generated, and should consider implications for data access and ownership.

Discussion

Mr. Levenbach said NOAA will be receiving significantly increased funding for UxS in FY20 and asked for the SAB's input on how best to structure that funding, specifically where it should reside in NOAA and what it should go towards. He would also like the SAB to weigh in on the issue of vendor lock and how the agency can encourage a competitive marketplace among contractors for this type of work.

Dr. Weatherhead said the goal of UxS implementation is to expand capabilities, reduce costs, and improve skill. For aerial missions, there is a fourth reason to use UxS which is to ensure they do no harm. This is an argument for NOAA developing internal expertise, because once you get accustomed to a system you really understand how to operate it safely. A further case for developing in-house expertise would be if NOAA could find ways to do things better, faster, and cheaper. Mr. Levenbach said he was also asking about how to structure the initiative to ensure there is not duplication of effort across the agency and that it is set up to succeed.

Dr. Werner said that thus far much of the development has happened in the various NOAA labs and there remains a lot of research that still needs to happen in-house at the various labs and science centers. There needs to be some assurance that that research will continue going forward in the laboratories that have developed these techniques.

Mr. Winokur said that many of the report's findings are similar to those of the Independent Review Team that looked at the recapitalization of NOAA's fleet. They concluded that UxS, whether underwater, aerial, or surface vessels, do not replace ships but are critical force multipliers. He would advocate for a centrally managed UxS program that distributes funds to other programs. This would help ensure that these technologies are developed with several applications in mind. Regarding vendor lock, NOAA needs to refine the requirements for what it is they want in the context of capability and capacity in order to determine which vendors can provide the best value.

Dr. Perry said this has to come from a Program Office that can look across all of the Regional Offices to see what they're doing and how they might integrate the technology, what TRL they are at, and where they need to go to solve their particular challenges. A program office would be needed to can look at the entire spectrum and evaluate NOAA's needs at different levels in order to allocate accordingly. A more programmatic approach that includes tactics and research will allow NOAA to bypass many of their vendor issues, because then they can segregate based on what they are trying to achieve with the program as a whole.

Mr. McLean encouraged the board to remember that this is not only relevant to the unique application of fisheries stock assessments, but also ecosystem characterization. Eventually, NOAA will also have to consider how to get the regulated public to trust this technology. Lastly, he warned against the possibility of NOAA putting all their effort into operations at the expense of research and innovation.

Dr. Rheault made a motion to accept the final report; John Kreider seconded the motion and it passed unanimously.

NOAA Response to the SAB Citizen Science Report

Laura Oremland, NOAA Fisheries Office of Science and Technology

Ms. Oremland discussed NOAA's response to the SAB's recommendations in their report on citizen science. She provided updates since the report was issued, including a National Academies of Science report on citizen science, record high participation at the March Citizen Science Association meeting, the first report to Congress on crowdsourcing and citizen science, and the growth in NOAA's citizen science community.

Ms. Oremland reviewed the SAB's four recommendations and NOAA's responses.

SAB Recommendation 1: Citizen Science is likely an underutilized tool for environmental data collection and monitoring in coastal systems, and well-designed programs have potential to contribute cost-effective information that can be used in scientific investigation.

NOAA's Response:

- Data call is in progress to identify research projects, programs where citizen science may be integrated
- NOAA directive on R&D has been revised to bolster inclusion of citizen science
- Planning NOAA "All-Hands" email

SAB Recommendation 2: Further review of existing programs that already have valuable data for ecosystem monitoring is warranted, and additional support, standardization of data storage and sharing, and enhancement of data collection protocols or trainings in those programs may improve their utility.

NOAA Response:

- Host NOAA citizen science workshop that will address: (1) Best practices; (2) Data management; and (3) Citizen science resources
- Facilitate the ongoing exchange of best practices between NOAA programs

SAB Recommendation 3: Citizen science doesn't just happen – it requires intention, consideration of community and participant needs, interests and abilities, and careful planning to ensure data quality and control. For programs to contribute meaningful data for NOAA ecosystem science and management, they need to be built over time and receive ongoing support for multi-entity collaborations.

NOAA Response:

- Stand up an Advisory Committee with representation from across the agency
- Adopt or adapt EPA Handbook for Citizen Science Quality Assurance and Documentation

SAB Recommendation 4: Commitment of resources and expertise from NOAA Regional and Science Centers can improve the quality and integration of data generated by citizen science and contribute to participatory research that enhances public awareness of science and its value to coastal communities.

NOAA Response:

- Data call is in progress to identify funding opportunities that either currently do, or potentially could, call out citizen science as a tool for proposed projects to consider using.

Many of these responses are in progress and NOAA would be happy to keep the SAB updated on how they are doing. She asked that the board let NOAA know how best to keep the SAB informed. The citizen science workshop in April will result in a report that they intend to share with the SAB.

Discussion

RDML Gallaudet invited SAB members to attend the workshop. They will address the possibility of creating a strategy for citizen science similar to the S&T strategy.

Dr. Weatherhead said that Dr. Rheault had previously shared information on this topic that would be relevant to NOAA's planning, which is the misuse of citizen science, particularly within the regulatory context. Two well-documented cases should serve as a warning call to NOAA to ensure that their science is not put in with efforts that can be easily corrupted. This effort requires thoughtful oversight, rather than seeing what sticks. A board may be helpful to review any citizen science that goes onto citizenscience.gov or receives a NOAA imprint.

Chair Scarlett discussed Cornell Lab of Ornithology's eBird project, which is the world's largest citizen science endeavor. They would be a highly valuable source of lessons learned on quality control and other issues. They have also merged some of their work with social sciences to look at what motivates participation, what enhances good participation, among other topics. Ms. Oremland said she has worked very closely with the eBird team and they were extremely helpful in guiding this enterprise.

Mr. Kreider said that the importance of this area makes it worthy of a full-time dedication of effort to provide the oversight on quality.

Plans for Next Meeting

Lynn Scarlett, The Nature Conservancy and Chair, NOAA SAB

Chair Scarlett led the discussion. She made some overarching comments reflecting on her time as Chair of the SAB. The SAB has covered a lot over those six years and contributed significantly to NOAA. She will work with the incoming Chair to make the transition as seamless as possible. Looking ahead, she cited key considerations for science in the future, which include: integrating various science pieces to gain a better understanding of the whole, enhancing coordination across agencies and with the larger world, as well as near-term and long-term considerations and how they affect mission delivery, how the agency is organized, and what technologies NOAA deploys. Finally, she stressed the importance of outcomes and communicating what these efforts are all about.

Review of Actions

Cynthia J. Decker, Executive Director, SAB and Designated Federal Official

Dr. Decker reviewed the actions from the meeting, including:

- Approval of the consent calendar

- SAB staff will ensure members have links to the strategy plans for the four focus areas
- Dr. Decker will work with Chair Scarlett on next steps for the four work plan items the board agreed to and the SAB staff will begin drafting language to move this forward
- SAB staff will work with Dr. Gentemann to put together a transmittal letter for the DAARWG's white paper that captures the board's comments
- SAB staff will work with Dr. Russell on transmitting the two CWG reports, capturing the board's comments on the S2S2D paper
- SAB staff will transmit the ESMWG report to NOAA without any changes

The next SAB meeting will be in February 2020, via teleconference. Mr. Levenbach said this meeting would be a good opportunity to get the SAB's views on FY22 and the S&T strategies. RDML Gallaudet asked that they emphasize the converging applications for the technologies.

Adjourn

The meeting was adjourned at 12:04 p.m.

Minutes Certification



Lynn Scarlett, SAB Chair

2.14.2020

Date