Meeting of the NOAA Science Advisory Board
August 30-31, 2022

Location: DoubleTree Silver Spring
8777 Georgia Avenue
Silver Spring, Maryland

Presentations for this meeting have been posted on the Science Advisory Board (SAB) website: http://www.sab.noaa.gov/SABMeetings.aspx

SAB members in attendance:
Mr. John Kreider, President, Kreider Consulting LLC (Chair); Mr. Jon Allan, Senior Advisor, Senior Academic and Research Program Officer, School for Environment and Sustainability, University of Michigan; Mr. Jesse Ausubel, Director, Program for the Human Environment, The Rockefeller University; Dr. Ilene Carpenter, Earth Sciences Segment Manager, Hewlett Packard Enterprise; Dr. Chelle Gentemann, Program Scientist, Transform to Open Science, National Aeronautics and Space Administration; Mr. David Grimes, President and CEO, Grimes Consulting; Dr. Robert Grossman, Frederick H. Rawson Distinguished Service Professor in Medicine and Computer Science and Jim and Karen Frank Director, Center for Translational Data Science, University of Chicago; Mr. W. Chris Lenhardt, Domain Scientist, Renaissance Computing Institute, University of North Carolina at Chapel Hill; Dr. Ruth Perry, Marine Scientist and Regulatory Policy Specialist, Shell Exploration and Production Company; Dr. Zhaoxia Pu, Professor, Department of Atmospheric Sciences, University of Utah; Dr. Denise Reed, Professor Gratis, Pontchartrain Institute for Environmental Sciences, University of New Orleans; Dr. Elizabeth Weatherhead, Senior Scientist, U.S. Geological Survey; Dr. Steve Weisberg, Executive Director, Southern California Coastal Water Research Project; Dr. Anthony Wu, Executive Director, AeroMarine LLC; Dr. Donald Wuebbles, The Harry E. Preble Professor of Atmospheric Sciences, University of Illinois.

NOAA senior management and Line Office representatives in attendance:
Dr. Rick Spinrad, Under Secretary of Commerce for Oceans and Atmosphere and NOAA Administrator; Dr. Michael Morgan, NOAA Assistant Secretary of Commerce for Environmental Observation and Prediction; Dr. Sarah Kapnick, NOAA Chief Scientist; Dr. Cisco Werner, Acting OAR Assistant Administrator; Mr. Ken Graham, Assistant Administrator, National Weather Service; Dr. Steve Volz, Assistant Administrator, National Environmental Satellite Data and Information Service; Ms. Mary Erickson, Acting Assistant Administrator and Director, National Weather Service; Dr. Gary Matlock, Deputy Assistant Administrator for Science, Oceanic and Atmospheric Research; National Marine Fisheries Service; Evan Howell, Director, Office of Science and Technology, National Marine Fisheries Service; Dr. Mitch Goldberg, Chief Scientist, National Environmental Satellite, Data, and Information Service

Staff for the Science Advisory Board in attendance:
Dr. Cynthia Decker, Executive Director and Designated Federal Officer; Ms. Courtney Edwards; Ms. Katherine Longmire; and Mr. Andrew Peck.

Opening Statement of the Chair
John Kreider, Kreider Consulting and Chair, NOAA SAB
John Kreider welcomed the attendees to the meeting and reviewed the agenda. He welcomed two new members of NOAA leadership: Sarah Kapnick, NOAA's new Chief Scientist, and Michael Morgan, NOAA's new Assistant Secretary for Environmental Observations and Prediction, who both gave brief introductions. Chair Kreider called for introductions from SAB members.

SAB Consent Calendar
John Kreider, Kreider Consulting and Chair, NOAA SAB

- April 2022 SAB Meeting Minutes
- Working Group status reports

Denise Reed made a motion to accept the consent calendar. The motion was seconded by Jon Allan and was passed unanimously.

Environmental Information Services Working Group Report: Review of NOAA Sub-seasonal to Seasonal (S2S) Report to Congress
Jon White, U.S. Navy (retired) and EISWG Member

Admiral White discussed some of the highlights of EISWG's work on the S2S Report. The Weather Research and Forecasting Innovation Act of 2017 called for a report that includes three specific things: how information is used, specific plans and goals, and what the research and monitoring requirements are to meet those plans and goals. NOAA answered those questions and also provided a longer supplement that included the details that guided their thinking, actions of the S2S program, and efforts within NOAA. For the present report, the team focused on what new insights and observations they could make about the NOAA report and its supplement to provide an external take. The review found that the report is responsive to the tasking from Congress and NOAA continues to make progress on its plans. There has been some response from Congress in their appropriations and other efforts. There is a level of urgency on this topic. Given what has happened over the last couple years on seasonal regional scales, there is urgency for more information and there has been a higher demand signal for these types of products and services. It is critical that this program advance and the plans and programs described in the report should be given a level of importance going forward. The team concurred with the summary statement provided in the report that this is a critical component to enable decision making at various levels. The reviewers felt the report should include a strategic goal that is time-bound along the lines of what was mentioned in the report from the Academy originally, which was that in the next decade these types of products and services should be looked at by the public just as much as daily weather forecasts. S2S is a key enabler of the earth system approach. S2S does, however, have multiple definitions which creates confusion on what timescales are under consideration; this should be clarified going forward. The interagency and international collaboration that NOAA has within its role as a co-leader of the Interagency Council for Advancing Meteorological Services (ICAMS) provides leverage to advance these efforts. The decadal plan for advancing meteorological services from the White House Office of Science and Technology Policy (OSTP) under ICAMS is critically important and should include many of the things mentioned in the S2S report. They are currently soliciting public input on the plan.

<u>Discussion</u>

Denise Reed said the review suggests additional specificity would help the agency moving forward. She asked if there was anything the SAB should be picking up from the review to help NOAA develop a more strategic plan. She also asked if the team thought the pilots chosen for the report were the right ones. Admiral White said there are varying levels of specificity in the supplement, especially in terms of timelines. Roadmaps and timelines could be very important for outlining what NOAA wants to focus on. Advancing ocean observations and ocean coupled data assimilation will be critical to advancing the seasonal-to-interannual scales and the accuracy of their products in the future. Heightened focus of the Earth Prediction Innovation Center (EPIC) would be a key enabler to advancing a lot of this research. On pilot projects, the Arctic is one that remains important for many reasons. Pilot projects should be coordinated more with regional efforts, which should help inform prioritization of pilots, as should consideration of which projects would get the attention of appropriators.

Jon Allan said some of the recommendations to NOAA should be more explicit on exactly what they should do, particularly for Recommendation 21. Admiral White said they discussed the social and behavioral science aspects extensively. NOAA has made efforts to bring on social and behavioral scientists to look specifically at S2S. Underserved populations tend to be the most heavily impacted by catastrophic S2S events and better understanding what types of information would help them make decisions would be helpful. Mr. Allan said this is a good answer, but the recommendation in the review seems tepid.

Elizabeth Weatherhead asked if they were leaving enough room for the private sector to fill its role, particularly in the recommendations on marketing, education, and outreach. She asked how their thinking on S2S takes this into account. Admiral White said they discussed this but did not include it in their review because the report does not address it since Congress directed them to deal with the governmental functions. S2S is an area where the private sector is starting to show more and more skill. A conversation on where NOAA's skills are and how the private sector factors in would be valuable and is an area where the SAB's input might be especially useful. John Kreider said it is appropriate in these early stages of S2S forecasting that NOAA at least be aware of efforts in other sectors and play a role of enabling and encouraging as opposed to doing everything internally. Admiral White said there is economic value in the private sector being able to provide tailored weather services, but underserved communities need to be able to get what they need to make informed decisions without having to pay for it.

Brad Colman said this is why pilot projects are so important, because they get at what the work is enabling and what needs are being meeting. He also said that in addition to specificity, NOAA needs transparency on what their plans are.

Steve Volz asked if the team evaluated the degree to which NOAA is collaborating with other agencies and sectors in basic research in the area of earth system predictability. Admiral White said NOAA can do better on this. There is a lot of duplication of effort and redundancy in the field of national earth system prediction capabilities. ICAMS' forthcoming decadal strategy will hopefully bring those research partners together. There is also room for better coordination and more inclusion. There was little mention of international coordination in the report at all.

Denise Reed made a motion to accept the report as written with the SAB's comments on urgency included in the transmittal letter. Jon Allan seconded the motion and it passed unanimously.

NOAA Response to SAB Climate Working Group (CWG) Review of the Coastal Inundation at Climate Timescales White Paper
Mark Osler, Senior Advisor for Coastal Inundation and Resilience, NOAA National Ocean Service

The SAB previously approved the Coastal Inundation at Climate Timescales white paper, which identifies critical information gaps and how they can be addressed. The content of the paper has also been approved internally within NOAA through their Weather, Water, and Climate Board and adopted as a suitable and useful vision for NOAA going forward on this topic. The SAB provided 18 specific comments in their review. Mr. Osler highlighted four high level recommendations to make clear NOAA's response and how they were incorporated into the revised draft. NOAA's response to the SAB's recommendation to clearly state the aspirational vision at the beginning of the document was to revamp the executive summary to put the bottom line upfront. The SAB encouraged NOAA to be specific and aggressive in their statement on to what degree of geographic specificity might some of these products be turned out. In response, NOAA updated the text to state that information will be produced at the parcel level if certain criteria can be met. The SAB suggested the white paper be clear about the desire for NOAA to provide a no-cost off-the-shelf resource for this information and this is now reflected in the revised text. The SAB also recommended coordinating across the federal government, with the private and academic sectors, and encouraging NOAA to commit to a leadership role in the interagency space. The text of the white paper was updated to reflect this and it has been happening already. The updated white paper is now publicly posted online and NOAA is currently briefing it across federal agencies. They are also convening discussions on alignment with the White House National Climate Task Force's Coastal Resilience Interagency Working Group on how they can work on these topics in general and, potentially, specific ideas included in the white paper. The Bipartisan Infrastructure Law (BIL) provides some funding to get a head start on two of the twelve action steps outlined in the white paper. NOAA will continue to work with the SAB to align prioritization of the remaining ten steps and attract the resources for their execution. The SAB's review materially improved the white paper and galvanized the community within NOAA that is working on this topic.

Discussion

John Kreider asked what single thing that has made the biggest difference as a result of this and what NOAA has changed. He also asked what key performance indicators (KPIs) NOAA is using to measure progress and success. Mr. Osler said the single biggest thing is that these things ideas are captured, vetted across NOAA, and written down in a place that can be referenced. Socializing the process is instrumental in rounding out the ideas and making sure they stick. Though they are still in the early stages with no KPIs identified and used to measure progress, the ability to track resources will be an important KPI. For the two action steps started with BIL funding, they are on record with Congress in terms of what they are going to execute and there are clear spend plans and milestones associated with those.

Jon Allan said there are interrelated questions related to inundation: Can we stop it? Can we know ahead of time and how much? Can we respond effectively when it does happen? and Can we change behavior after we know that it can happen? He asked how NOAA can build learning into the response in order to change behavior. Mr. Osler said behavioral change and readjusting our coastal endeavors are at the heart of the coastal resilience concept. The SAB has emphasized NOAA's leadership role in coastal resilience, which is a broadening of the aperture in this area and touches on social and economic factors that drive behavior change and decision making. Improving predictions of a certain variable or type of hazard, though necessary, are not sufficient to make ground on larger questions.

Denise Reed asked about the one kilometer resolution mentioned in the report and in what environments NOAA thinks they will be able to provide these predictions. Mr. Osler pointed back to the concept of NOAA as an enabler. This is an effort to push NOAA to be aspirational; where skill develops and from whom will color the actual answer of how this unfolds over the next 5-10 years.

Review of the Cooperative Institute for Modeling the Earth System (CIMES)
Zhaoxia Pu, University of Utah and SAB Member
David Grimes, Grimes Consulting, LLC and SAB Member

CIMES is a collaboration between Princeton University and NOAA's Geophysical Fluid Dynamics Laboratory (GFDL) founded in 1967. Dr. Pu discussed the CI's Science Management Plan and science themes, which are earth system modeling, seamless prediction across time and space scales, and analysis and application of earth system science. The three criteria of success for CIMES are: the contribution of ongoing CIMES research to NOAA's mission; the publication of scientific results in refereed journals, as well as their impact on the field; and the success of CIMES postdocs, associate research scholars, and graduate students in obtaining research, faculty, public policy, or other positions in this field upon completion of their stay at Princeton University. Dr. Pu reviewed the methodology the Science Review Panel followed in coming to its conclusions and drafting their report. The panel rated CIMES as outstanding and the key observations and findings in their report included: Well-articulated and defined science objectives; CIMES's science plan closely aligns with GFDL's research interests and meets GFDL's goals and needs; impressive accomplishments in science, particularly in earth system modeling and applications; their science achievements are laudable as evidenced by the quality and quantity of their publications, improved/new modeling capabilities added to the various GFDL model components, and the relevance of the science outcomes to NOAA's priorities; they have strong management with a clear organizational structure, mechanisms for resource distribution, thoughtful attention to the needs of students and postdocs, and staff development/training; their successful research and education efforts are demonstrated by the research alignment and productivity of the CIMES postdocs and students; CIMES produces excellent research and provides training for students and postdocs, creating a pipeline of scientists supporting GFDL, other NOAA laboratories, universities, and beyond; CIMES students and postdocs have successful career paths in universities and national labs; and CIMES has impressive educational outreach and DEI (diversity, equity, and inclusion) efforts, given the limited resources for these activities. Dr. Syukuro Manabe's 2021 Nobel Prize in Physics provides more evidence of CIMES world-class program in climate research and attests to

CIMES scientific leadership. The panel's recommendation on CIMES' science and CI tasks was to realign funding to increase support for principal investigator-led research projects to strengthen multi-disciplinary science contributions to support applications of earth system modeling for important decision-making processes and relevant policy measures, which are essential for NOAA's Climate Ready Nation priorities. The panel's recommendations on education and outreach were to strengthen guidance and mentoring for postdoctoral researchers, strengthen mentoring for graduate students to ensure that mentors for students are responsible and provide high-quality mentorship, and to optimize outreach investments by considering a pipeline approach to get more underrepresented minority students to apply to the Atmospheric and Oceanic Sciences program, to track and foster the development of these students, and provide incentives for them to participate in the CIMES (or other NOAA) postdoctoral scholars programs. Science management recommendations included increasing support for administrative and outreach activities to strengthen these areas and reduce the workload of the CIMES director and adding resources for Princeton's high-performance computing system to improve computational efficiency.

Discussion

Elizabeth Weatherhead said CIMES is a great CI, much appreciated by the climate community. She asked if the CI has a clear plan about allowing other climate scientists, including international scientists, to cycle through and creating visiting scientist capabilities. Dr. Pu said the post-doc programs include long-term international collaboration and they also host some short-term visiting scientists. They recommended further strengthening this educational outreach program. David Grimes said this is part of what they were getting at by recommending fostering broader collaboration from outside scientists rather than the predominate emphasis on using post-docs. There is currently not sufficient funding in this area to necessarily attract visiting scientists.

Chelle Gentemann commented on the closed cycle between privileged institutions that perpetuates inequalities in research infrastructure. She would like to see the report come out stronger in this area. She was disappointed that the report did not include a DEI dashboard. This program presents a tremendous opportunity to expand who is participating in science and these institutions play a key role. Not seeing any DEIA (diversity, equity, inclusion, and accessibility) metrics in their success criteria was surprising. Dr. Pu said they could add this point into the report. Mr. Grimes said that when they reviewed CIMES' accomplishments it was against a program that was established five years ago and those were the criteria for success they had outlined. Princeton is very active in the DEI area and this can be addressed not only in the outreach components but also make it a criterion for success. Michael Morgan agreed that the review criteria for CIs should include DEIA and the engagement of the researchers in both outreach activities. The dashboard idea might also be a good thing to implement.

Denise Reed said the CI handbook that was in use when she was last involved in a CI review was from 2013 and wondered if it has been updated since then. If the SAB is going to continue with its role reviewing the CIs, NOAA should provide them with good guidance. Dr. Morgan pointed to NOAA Administrative Order 216-107A, which discusses the CI handbook and makes mention of fostering diversity and inclusion and promoting partnerships with minority serving institutions (MSIs). These partnerships could involve providing opportunities for faculty, undergraduates,

graduates, post-doctoral scientists. NOAA also encourages faculty and staff exchanges with MSIs. It is clear that this should be considered in reviews of CIs. Dr. Decker said that reviewers should be working a new CI handbook, but only the 2013 handbook is currently available.

Jon Allan said the SAB should think strategically about how to increase not only diversity in the pipeline from premier institutions, but also how to expand outreach to a broader community, including K-12. Dr. Pu said Princeton has K-12 and DEIA strategies and these are part of the CI, but the panel did not emphasize this since they were focusing on a science review. Mr. Grimes added the panel recognized that they need to increase outreach resources if they want to bring the value of what Princeton was already doing in this area to their collaboration with NOAA. They will review the report to strengthen the statement of this view.

Mitch Goldberg said that NOAA, through its Education Partnership Program (EPP), has Cooperative Science Centers focused on MSI, which could provide a pipeline for connecting MSIs with CIs.

Sarah Kapnick encouraged the panel to be very clear what they mean by outreach, because they seem to use the term differently in different places throughout the review.

The SAB discussed how to move forward, given their concerns over the DEIA component of the review. David Grimes suggested using the outreach and diversity strategy in a transmittal letter and this was agreed to. SAB members wishing to provide input on the letter were instructed to contact Dr. Decker.

Elizabeth Weatherhead made a motion to accept the report with the SAB's comments on DEIA and outreach strategies included in the transmittal letter. Steve Weisberg seconded the motion and it passed unanimously.

NOAA Response to SAB Climate Working Group Report: Advancing Earth System Prediction Report
Eric Bayler, Principle Scientist-Policy, NOAA National Environmental and Satellite Data and Information Service

The SAB CWG Advancing Earth System Prediction report included 22 recommendations to NOAA across several themes, including: land observations, atmospheric chemistry observations, ocean and coastal shelf observations, ice and inundation, operational oceanography and forecasting, decision-maker needs, enhancing coordination, and model technology. NOAA agreed with the CWG's recommendations and felt that the emphasis on land processes and atmospheric chemistry measurements in the context of earth system prediction was timely and speaks to important, yet underexplored, research directions. They noted that within this report there is confusion in distinguishing between the Finite Volume Cubed-Sphere Dynamical Core (FV3), the FV3-based Global Forecast System (FV3-GFS), and the Unified Forecast System (UFS). NOAA agrees with focusing on the MOM6 for appropriate applications. NOAA, however, does not concur with the focus on the single solution of MOM6 for the broad range of ocean applications and challenges. NOAA felt the report lacks focus on verification, evaluation, or overall measuring of model performance. Dr. Bayler went through each of the SAB's

recommendations and NOAA's response in detail. These are available for review along with NOAA's actions to date and intended future actions in the meeting materials on the SAB website.

Discussion

Joellen Russell, CWG Co-Chair, said she was delighted with the detailed response from NOAA.

John Kreider asked for one or two takeaways from the overall response. Dr. Bayler said that focus on the Arctic should be a high priority because of the compounding impacts of atmosphere and ocean. Coupling with the sea ice component is also critical. This directly feeds into issues with the ecosystem and marine fisheries aspects, as well as marine spatial awareness for national security considerations. Another takeaway would be looking at the coupling between land-water components and the coastal regime. This brings in ecological modeling, particularly in large estuaries. This would directly support NOAA's strategic pillars on the blue economy and resilience.

Jon Allan asked if Dr. Bayler expected to see autonomous platforms replace ship days over the next 10-20 years. Dr. Bayler views these platforms as complementary. NOAA needs a more coordinated fleet and oceanography has to move beyond exploiting research and development efforts, which are not operational. Mr. Allan expected that over the next 20 years, we will come to have a very different view on how autonomous systems are deployed and integrated than we have today. He asked how NOAA is planning for that eventuality. Dr. Bayler said he did not have particular insights into how NOAA is thinking about this, but felt they should be coalescing the national operational ocean forecasting enterprise across the ocean observation value chain. Unlike NOAA's weather enterprise, which is housed predominately in one line office, the agency's ocean components are distributed across all line offices. NOAA should consider how to arrange that organizationally so that it is clear and extends down to the local levels.

Mary Erickson said they are looking at the whole portfolio of observations, not just platforms but also data buys and what sorts of platforms those purchases use then trying work that into conceiving what the right operational concept would be. The lack of ocean observations is one of the biggest gaps for the Precipitation Prediction Grand Challenge and where NOAA needs to head for S2S prediction. They are pushing forward on trying to set a new paradigm for autonomous platforms.

Tsunami Science & Technology Advisory Panel Strategic Plan
Rocky Lopes, Co-Chair, TSTAP
Rick Wilson, California Geological Survey and Co-Chair, TSTAP

TSTAP's Strategic Plan includes five strategic goals each with associated objectives. These goals are: (1) Review the activities of the administration, and other federal activities as appropriate, relating to tsunami research, detection, forecasting, warning, mitigation, resilience, and preparedness; (2) on an annual basis, review activities of the administration and other federal activities as appropriate to prepare an update for the SAB on matters relating to tsunami research, detection, forecasting, warning, mitigation, resilience, and preparedness not addressed by previous reviews or reports; (3) respond to all NOAA responses to TSTAP reviews and reports

within one year of receipt; (4) when a tsunami event causes impacts and/or responses on any U.S. coastline, review administration and other appropriate federal agency responses and impacts on states and territories; and (5) administer the TSTAP per guidance provided by the SAB and the TSTAP terms of reference. The first two goals are directly derived from the TSTAP's terms of reference. For the fourth goal, the TSTAP does not do an after-action report, since NWS already does those. Instead, they are providing their own observations and findings related to how an event corresponds to recommendations they have made. These point out where there is alignment or gaps/misses, as well as strategic alignments with activities that have been done. TSTAP filled two vacancies at the beginning of this year and now has eight members. TSTAP feels this strategic plan will enable them to provide a framework for the ongoing sustainability of the panel.

Discussion

Jon Allan asked what did not make it into the strategic plan that the TSTAP had extensive discussions about or wanted to include. Dr. Lopes said there wasn't anything else the TSTAP felt should be included as this was mostly an exercise in getting down in writing how they already operate given their terms of reference. They did take the opportunity in Goal 4 to explain the intention not to duplicate NWS' efforts following events. Chair Kreider thought this approach was valuable as it allowed them to step back and review with a critical eye. Mary Erickson commented on NOAA's role in evaluating NWS' performance and reporting to their overseers and Congress when there has been a major event. They want to ensure going forward that these reviews are complementary. It is always valuable to have an external review, particularly one focused on the science challenges.

Denise Reed made a motion to accept the TSTAP Strategic Plan as written. Jon Allan seconded the motion and it passed unanimously.

Other Business

Elizabeth Weatherhead commented on some themes that come up repeatedly when reviewing NOAA programs. She asked that future presenters be instructed to include DEIA topics in their briefs to the SAB. Related to this, she also asked that NOAA send more female presenters to brief the SAB. Another theme that comes up in many of the SAB's responses to NOAA reports is engagement, both interagency and internationally. She stated she is not hearing emphasis from presenters on which agencies NOAA is engaged with and how on larger initiatives, such as tsunami relief research or climate and weather.

NOAA Response to SAB Climate Working Group Review of the Climate and Fisheries Initiative (CEFI) Implementation Approach
Jon Hare, Chair, Interim Executive Council, Climate, Ecosystem, and Fisheries Initiative, NOAA

The SAB previously reviewed NOAA's CEFI Implementation Approach and provided five recommendations. NOAA formed a steering committee in response to the SAB's recommendations and Dr. Hare presented on their behalf. CEFI is a cross-NOAA effort to provide advice and capacity for climate-informed resource management and community

adaptation leveraging existing NOAA investments in research, modeling, observations, and decision making. CEFI aims to build the end-to-end decision support system needed to increase resilience and adaptation, while also reducing risks to the nation's marine resources and the many people, businesses, and communities that depend on them. CEFI is an interactive group of three components: (1) a science and development component that provides validation and drives innovation; (2) an operations and infrastructure component that will produce actionable advice; and (3) an extensions and management component which will help to provide sustainable management and resilient communities. In its report, the SAB recognized the urgent need for reliable and timely information about climate change impacts on oceans & coasts. They commended NOAA for recognizing that the agency lacks the nationally integrated observing, modeling, and decision support system needed to deliver the climate information required to meet NOAA's living marine resource (LMR) mandates in the face of these rapid changes and the challenges they present. The SAB recommended NOAA accelerate implementation of the CEFI integrated modeling and decision support system and stressed the need to coordinate efforts to accelerate the transition to an integrated modeling system. Their five recommendations were: (1) Accelerate implementation of an integrated modeling system; (2) Expand stakeholder engagement in products and process; (3) Strengthen trust in products and process; (4) Upgrade the ocean observing system; and (5) Advance multi-stressor predictions at multiple scales. NOAA agreed with these recommendations and has taken action to address Recommendation 1. Recommendations 2-5 provided useful guidance on important topics, and will be used to inform development of the CEFI system. Though Recommendations 4 and 5 were deemed beyond the scope of the CEFI and will require further consideration by NOAA, they will work with NOAA leadership and the Weather, Water, and Climate Board to enact them at a broader level. Dr. Hare went through NOAA's response to each recommendation in detail, which is available for review in the meeting materials on the SAB website.

Evan Howell added that CEFI is one of three formally endorsed projects under the Weather, Water, and Climate Board and has strong NOAA support.

Discussion

John Kreider asked what KPIs NOAA uses to measure the success of CEFI. Dr. Hare said that the leading indicators will be the number of decisions in LMR management that are informed by outputs from CEFI. They now have CEFI pilots in several regions and are starting to track management decisions informed by climate, but are not yet doing this nationally. Another metric will eventually be the quality of advice provided. Steve Thur said that one of the frequent challenges NOAA has is describing the impact of their science on LMR management decisions that are difficult to quantify. He would welcome the SAB's input on KPIs for applications to management as a way to inform not only CEFI but also many other LMR science provision NOAA does. Chair Kreider observed that he never sees KPIs included in presentations on NOAA initiatives. Dr. Weisberg said the State of California is putting together a report card on ocean management which will include KPIs on many different aspects. This effort will be moving forward as part of the West Coast Ocean Alliance and other states will be aligning around these report cards metrics. If the SAB holds a future meeting on the West Coast, he would like to invite the leads on that effort to present. Ruth Perry added she also supports more use of KPIs by NOAA.

Jon Allan asked if CEFI is more about a NOAA culture change or an operational approach. Dr. Hare said the intent is to develop an operational system that can inform LMR management and advice. This is a result of NOAA recognizing that the agency needs to work across line offices and the momentum for that continues to grow. Cultural transition is incremental and this transition has been underway for a number of years. Initiatives like CEFI will help accelerate that transformation.

Cisco Werner said CEFI in some ways has been building over 20+ years. They are finally at a point where the models and assessments are good enough that the questions are answerable. On the issue of KPIs, how well this has been received by the councils and stakeholders is a good indicator of its value. There is also an international effort called SUPREME (SUstainability, Predictability and REsilience of Marine Ecosystems) that is building off of the idea of CEFI.

Updates from SAB 2022 Work Plan Topics

Open Data/Open Science

Chelle Gentemann said that the topics of DEIA and open data/open science (ODOS) are intertwined, as the goal of ODOS is to broaden participation in science. The group came up with a set of discussion questions and asked people within NOAA as well as external people about ODOS via questionnaire and follow-up interviews. The ODOS team is preparing a report that will summarize the survey responses, findings, and recommendations. Dr. Gentemann presented some initial findings to elicit feedback from the SAB to help guide future work on drafting the report. NOAA deserves a lot of credit for putting over 220 of their datasets on the cloud through the NOAA Open Data Dissemination Program. Some of the topics that have percolated up from the working group's discussions include: NOAA's move to open science would benefit from high-level leadership of open science principles that become part of their core messaging; the distributed nature of data access points has created barriers to open science, redundant workflows, and inconsistent adoption of policies; streamlining the policy and procedures to enable ODOS is a high priority; issuing DOIs for NOAA datasets should be made the highest priority and bottlenecks removed; training the workforce on how to do open science in an immersive way is necessary; and external users, especially commercial cloud providers, are a key partner in increasing accessibility of data for unforeseen uses. ODOS is difficult to achieve and NOAA needs to be more agile in order to reap the benefits. NOAA has access to many experts who want to help, they just need a more consistent and coordinated effort. Dr. Gentemann asked the SAB and NOAA how their report can best help the agency move to ODOS and what they need from the working group. They also asked for feedback on gaps and if they have been meeting with the right constituents.

Chris Lenhardt emphasized the challenges they had when talking with NOAA staff. When asked about open science, the conversation would inevitably turn to open data. This demonstrates they are still trying to figure out what open science means and that open science is somewhat antithetical to NOAA's culture of validated algorithms. This is an inherent tension that gets to the cultural piece.

Mitch Goldberg was glad the team mentioned reproducible science. Datasets used to generate bias adjustments should be stored somewhere and should be able to demonstrate reproducibility of tuning coefficients. Dr. Gentemann said they now have the ability to work in reproducible environments and produce executable notebooks and NOAA needs to lean into this as part of the requirements for people they work with. Dr. Goldberg noted that it is also important for when NOAA employees retire to ensure things are well documented.

Ilene Carpenter said we have been in an era when computing seemed pretty standardized and if you do it on the cloud it should run anywhere. She cautioned, however, the diversity of computing platforms in the cloud or on premise is exploding and there are real challenges with reproducibility that they need to be proactive in addressing. As instruction set architectures start to change they need to be very deliberate about what needs to be done to ensure reproducibility.

Jon Allan asked about the typology of the hesitancies as to why ODOS is hard. He also asked which communities are most likely to share and embrace ODOS and where there is the most reluctance. Dr. Gentemann said the question of hardness will be broken down in more detail in the report, but it has to do with how one makes releases on GitHub. To the second question she said that as we move to open science, access is redistributed which redistributes privilege, often to more early career, more diverse, and more traditionally excluded groups. Many of the privileged scientists are reluctant to embrace ODOS, not only out of self-interest, but also because it is a change to how science has been done.

Public-Private Partnerships

Steve Weisberg said this working group is focusing its report particularly on non-monetary public-private partnerships. They have identified six types of non-monetary mechanisms available to NOAA: shared technology development, transition of the technologies NOAA develops, empowering private investors to fill available niches, collaborative data collection, engagement in public decision processes, and workforce development. The group intends to prepare a report describing each of these partnerships and provide three or four high-level recommendations. For each of the mechanisms, they will address four considerations: How is it currently being used? How could it be used better? What are its potential pitfalls? and What impediments are there to using it? The team has started work on the first three mechanisms because they felt they had the greatest promise and they have been interviewing people with some experience using each, including NOAA staff. The group will convene around October to discuss key findings, which they will present at the next SAB meeting. They expect to have a draft written report for SAB's review at the spring meeting. The group asked for the SAB's feedback on whether there were other people the group should be talking to and if any members would like to join the group. They also wanted to hear from NOAA leadership if the group was on the right track towards producing something helpful.

Elizabeth Weatherhead said the SAB has often talked about role identification, with NOAA sticking to their lane and the private sector sticking to theirs. Dr. Kevin Petty of The Weather Company has said a better way forward would be for NOAA to be very transparent about their plans and the private sector can adapt and build from there. Many other people in the weather community have responded favorably to this idea.

Steve Volz asked that some quantification of the value proposition in the near-term and long-term for private partners and for NOAA be included in the summary assessments. NOAA is trying to identify long-term sustained partnerships with commercial entities for shared loads. Dr. Weisberg said they will make that an explicit part of their report. Mr. Allan added that understanding who the likely customers are will be critical for partnerships. The technologies developed through these partnerships are likely to be highly specialized with very specific applications. Therefore, identifying the market potential will be essential to their success.

Steve Thur asked for more information on engagement in public decision processes and if they envisioned for-profit companies filling this niche or other private entities in that regard. Dr. Weisberg provided an example of a project by the State of California developing marine protected areas and working with private foundations to establish a separate science enterprise that provided information to stakeholders.

Ken Graham described some of NWS' engagement with industry and partners in local governments to discuss where they are headed, understand needs, and get feedback. It is all about sharing, enabling, and planning together and there more opportunities for this than ever. He asked if the group is looking at mechanisms for bringing people together to have these conversations. Dr. Weatherhead said that is one of the recommendations they are formulating based on the interviews they have had so far, that there be regular interactive meetings between NOAA leadership and all stakeholders to increase transparency so they can develop relationships and build trust.

Diversity, Equity, and Inclusion (DEI)

Ruth Perry said the working group expanded beyond DEI to include not only accessibility, but also justice and belonging (DEIAJB+). They have had a series of engagements across the NOAA Employee Resource Groups (ERGs) and affinity groups and got a lot of important feedback on DEIAJB+ activities and needs. Some of this input are directly related to the group's deliverables but other parts were deemed worthy of bringing to NOAA leadership's awareness. The report is focused primarily on non-operational aspects and the group expects to deliver it for the SAB's consideration by their spring meeting. It will include a description of agency activities and staff needs, recommendations and consideration, and guidance going forward. The report itself will be brief but will include an appendix to highlight some of the findings that have arisen from interviews and follow-ups. This topic is not only about talent management but equally about fairness and social justice within the organization. It is important not only internally, but in how NOAA presents itself externally to the communities that it works with. Dr. Perry presented the list of ERG and affinity groups they have engaged with and the script they worked from, which was identical for each. The group's focus is not to be prescriptive and fix NOAA's hiring processes, but rather to connect this topic to the science and to the communities that NOAA engages with internally and externally. The engagement summary will present a collection of all of the feedback they received from their engagements, which they think it is important for NOAA and the SAB to hear. The group found that the ERG and affinity group communities are strong and valuable resources for their members. The ERGs connect and engage with each other and the top NOAA leadership has been active in supporting them. Recommendations and areas

for growth included: a need for transparency in the hiring process; targeting middle management for DEIAJB+ training; considering changes in the Human Resources (HR) process; sustained and dedicated funding; data accessibility; addressing the lack of ERG resource awareness in NOAA generally; addressing employees' isolation at work; and an all-of-NOAA commitment to DEIAJB+ efforts. Over the coming months, the group will continue delving into the areas of supporting internal people, external DEIAJB+ activities, and how to break the glass ceilings within NOAA.

Chris Lenhardt said the working group hopes to bring back representatives from each of the groups they have interviewed in a town hall format. From the discussions around open data, they were sensitized to accessibility issues with data and information products for people with various kinds of disabilities. By engaging with these groups these kinds of things are being highlighted.

Jon Allan asked if statistics are available on demographics of employees that NOAA has lost and why. Dr. Perry said they have been trying to figure out how best to engage with NOAA HR and this is something they have heard from ERGs as well. Some of the groups felt that NOAA may not be able to change in certain areas, such as promotions. There are many issues here that the SAB may not be able to address, but they think are important for NOAA to tackle, such as hiring and data metrics. Mr. Lenhardt said they may have an opportunity to get more insight into these issues when they meet with Ben Friedman, NOAA's Deputy Under Secretary for Operations. Dr. Decker encouraged the group to talk with Louisa Koch, NOAA's Director of Education, about the EPP program, as well as HR representatives.

Chelle Gentemann said there may be some survivor bias in the discussions the group is having with current employees, so it might be useful to try and get ahold of people who have left the agency. NOAA's DEI dashboard shows some hard problems and very little change over the last decade. While there have been some slight increases in some areas, there have been decreases in leadership diversity.

Discussion of SAB Future Roles

The SAB took up the issue of recurring themes they have noticed during their meetings and possibly documenting those in a letter to NOAA. Dr. Kapnick said a letter from the SAB outlining the recurring themes and how addressing them might help in achieving science objectives would be helpful. Mr. Allan said a letter would be timely even if the working groups are still engaged in the work. A letter would be as much an indication of the SAB's intentions and as a recognition of some ongoing things they want to ensure are on the table. Members interested in contributing to this letter were encouraged to contact Cynthia Decker and they will set up a meeting to draft something for the SAB's review. Members discussed the scoping of the letter and potential themes to be included. Mr. Allan suggested keeping it fairly narrow and framing them in a way that can be responded to as opposed to open-ended. In order to make the letter more impactful, the Board decided to stick to the one topic of the diversity of presenters appearing before the SAB.

At the SAB's last meeting, Dr. Spinrad challenged the SAB consider playing a greater role in looking ahead to disruptive technologies and potential game changers for the agency. David

Grimes drafted a document following the last SAB meeting trying to capture ideas put forward by the SAB on playing a greater role in looking ahead. These fell under three categories: to collaborating with NOAA in envisioning and realizing its future; informing NOAA's evolving concept of operations; and identifying opportunity through foresight on future trends in science, systems, and operations. Dr. Weisberg said the document accurately captures what came out of the previous meeting but does not meet the transformative challenge that Dr. Spinrad charged the Board with. He proposed that the SAB explore what new science is on the horizon that might change the way that NOAA operates and suggested that NOAA look at the kinds changes they want to provide information on and what decisions they are trying to influence. Dr. Colman said this is a good opportunity to incorporate impact and value statements, along with how is it transforming the science and transforming NOAA's impact. Mr. Allan said that understanding the techniques necessary for managing a system that is changing so quickly is going to be critical to NOAA's mission. He added that the world is valuing science less and less and so a science organization has to consider its relevance when thinking about transformative changes. Dr. Carpenter said rapid change is at the heart of this matter and NOAA needs to look into how well situated they are to deal with extreme conditions unfolding rapidly. Dr. Weatherhead said NOAA could be a leader in focusing the country and world on a finite number of large and inevitable questions and should be upfront about their current observing and predicting capabilities. Mr. Graham said that NOAA's ability to remain relevant will hinge on it being indispensable to other communities and missions. There are many unpredictable changes that will take place in the coming years and it is incumbent upon NOAA to figure out how to become nimble as an agency in order to adapt. A few SAB members will work on drafting something for consideration later in this meeting. Mr. Allan said the SAB needs to hear from more people that see the world in different ways. Dr. Grossman said that the way in which the SAB intends to deliver on this could in part inform how they conceive of the task. Possible ways could include: devoting time in SAB meetings to presentations on each of the items on the list, create a yearly report on them, help organize a workshop that address them, or specific reports on different topics.

Update on SAB Working Group Reviews
John Kreider, Kreider Consulting, LLC and Chair, NOAA SAB

The SAB concept of operations (CONOPS) indicates they should conduct working group reviews every two years. The last one was completed in 2017. At their last meeting, the SAB agreed on a review process and notional timeline and met with the working group co-chairs in June. Chair Kreider provided an overview of the review process. Many different perspectives were brought forward in the meeting with the working group co-chairs, but the general consensus was that reviews should not be a check-the-box exercise, 2-4 years is too frequent, reviews should address needed updates to the terms of reference, reviews should be forward-looking, NOAA and SAB members must be strong participants, a review structure that has the working groups reviewing themselves should be avoided, and that the frequency and participation of the working groups in the reviews add to the workload of working group. Chair Kreider highlighted one comment he felt was particularly valuable, which was “I see value in feedback from NOAA liaisons on effectiveness – we want to ensure our work has impact.”

Jon Allan asked if the SAB felt something is broken or if they feel that the working groups are precluded from doing something they need to do. The SAB is doing a lot and unless there is a good reason for the reviews, they should not feel obligated to do them.

Denise Reed asked for the process document that the SAB approved to be provided. She can see the need for the reviews because they need to make sure their structure can be responsive to changing needs. She asked if the process includes potential outcomes of the review or if are there ratings in place. This will become a check-the-box exercise unless they have a structured way to identify what the implications of a review will be. The CONOPS the SAB works under may be old and they have several activities that are not self-generated but in response to the Weather Act or other legislative directives.

Rocky Lopes pointed to a parallel with the National Tsunami Hazard Mitigation Program (NTHMP). Those reviews proved invaluable as they developed their strategic plan and enabled them to dedicate resources and attention, as well as command attention from leadership within NOAA. They have helped guide working groups, subcommittees, as well as overall operations of the NTHMP and it would be valuable to the SAB to do the same.

John Kreider said he thought there would be value in doing a working group review if it is focused on reviewing their obligations, customer feedback, and what activities they can stop doing. The people on these working groups are looking to make a contribution and should feel rewarded by their work.

Brad Colman said reviews should avoid performance, but rather help the working groups step back and look at how the landscape is changing.

Denise Reed said two years seemed too frequent, but they should look at how often it makes sense to reframe what a working group is doing to ensure the working groups are meeting a need. They need to ensure the reviews are structured so that they provide value.

Joellen Russell suggested thinking about how much of the SAB's and the working groups' valuable volunteer time should be spent on process and review rather than the heavy lift of outside expert advice. Reviews would seem to be counterproductive rather than helpful unless there is a clear, measurable, and specific update required, and she did not hear that in the discussion.

Chelle Gentemann said she wanted to hear some feedback from NOAA, which could save the SAB a lot of time. Dr. Kapnick said that the specific reports presented at this meeting were very useful and always needed. If the SAB identified specific things they want comments on in terms of committees or specific reports, NOAA's Science Council can do a usefulness review and report back.

Denise Reed asked what the problem was at the time that this particular concept of operations was created. Dr. Decker said there was a concern from NOAA leadership at the time that they were not clear on how the working groups were functioning and how they were getting their mandates. Part of their reaction was the development of the CONOPS and this particular

requirement. At the very least, it would be useful to revisit the working groups' terms of reference to see if they need to be reworked.

Steve Weisberg said he heard three things that are part of the review: are the working groups working on the right questions, are they composed of the right people to answer those questions, and are they working on the appropriate timescales. Most of the discussion has been focused on the first part. It would seem to be pretty easy to set aside an hour of an SAB meeting every couple years to address this, get feedback, and provide the SAB's review.

Denise Reed moved to table the vote until the next day of this meeting to provide SAB members a chance to review the approved review procedures. Steve Weisberg seconded the motion and it passed unanimously.

Working Group Updates

ESMWG

Molly McCammon said the ESMWG has added a number of new members this year, so much of their recent work has been mostly focused on onboarding. They are currently working on a report on how NOAA could better respond to a rapidly changing marine environment. They have hosted mini-workshops on this topic and identified next steps for three different components: modeling, adding the human dimension more deliberatively in aspects of NOAA science, and looking at incorporating more indigenous/traditional knowledge to NOAA's work. Their goal is to finalize a draft of this paper and present it to the SAB at their December meeting. ESMWG hopes to have an in-person meeting in December/January and want to work closely with the line office liaisons to scope out where the working group needs to go in the future.

CWG

Joellen Russell said the CWG has had their new members approved and now has a total membership of 17. They have had a Climate Ready Nation briefing and discussion with Ko Barrett as well as a briefing on the Water, Weather, and Climate Board and continued biweekly working sessions of three subcommittees working on CWG white paper topics. For the one on organizing civilian operational ocean forecasting, the CWG has had a briefing and discussion with a representatives from the European Centre for Medium-Range Weather Forecasting on how they use coupled models for earth system prediction, including ocean prediction, as well as other presenters. They hope to begin socializing their work with NOAA more fully in the fall. Kirstin Dow discussed the CWG's work looking at emerging hazards and vulnerabilities. They have adjusted their focus to be on drought, wildfire, heat, and flood at 5-10 year timescales. The trust issue has come up repeatedly. Stakeholders want to see that the people trying to address these longer timescale kinds of planning problems have solid scientific information that everyone has confidence in. The CWG has been pursuing what those needs are and where the issues are through a variety briefings from stakeholders and people across NOAA. The CWG members working on climate and air quality prediction have done a series of briefings in non-NOAA space and are now working with the Climate Program Office and others to look at what NOAA is currently doing to make sure the CWG is clear on what the needs are versus what is already

being produced or is in process. The CWG hopes to finalize at least one or two of their white papers during their fall meeting and they will continue to provide input to other working groups and on NOAA's climate portfolio as requested.

DAARWG

Ilene Carpenter said that the DAARWG is now at full membership status and they received a briefing from NESDIS on the common cloud framework. The group is being reinvigorated.

EISWG

Brad Colman asked that the SAB find another EISWG liaison after Jason Hickey stepped down. Four members are rotating off the EISWG and they are looking to bring on 5-7 new members given their workload and broad topic area. They have identified the expertise they are looking for and will be sending out a solicitation for nominations, including self-nominations. The EISWG has struggled a bit with social sciences, which they consider a high priority for the working group. They now have a process by which the social science subpanel reviews every project plan the EISWG develops. Hopefully this will give them a better way to manage the resources and ensure that social and behavioral sciences get represented at the level they are seeking. The EISWG's support for the PWR report has continued and has moved into the communications phase. In addition to multiple presentations on the report, the EISWG co-chairs testified at a House Subcommittee on the Environment hearing on the future of weather research. The Ranking Member of the subcommittee said they viewed the PWR report as their roadmap to refreshing the Weather Act. EISWG continues to be pleased with the impact of the report. They will be meeting with Ken Graham later in September to bring him up to date on PWR. In addition to work on the reports presented earlier in this meeting, the EISWG has identified fire weather as an area they would like to focus on in the future, which has been getting a lot of attention lately. They thought this was an area that would benefit from a community perspective on managing fire weather efforts. They are working on a project plan and will be looking for expertise. The EISWG will be holding their next in-person meeting in Seattle in October.

Public Comment

There was no public comment.

NOAA Update
Rick Spinrad, Under Secretary of Commerce for Oceans and Atmosphere and NOAA Administrator

Rick Spinrad said that it is an exciting time for NOAA and now that the political team is almost fully in place, they are looking forward to doing impactful work. Dr. Spinrad's priorities have remained unchanged since taking over as Administrator, though they have been built upon based on what he has heard internally and externally. These top three priorities are: (1) establish that NOAA is the primary authoritative source for climate products and services that can be applied to a diverse range of missions; (2) advance NOAA's complementary work on environmental stewardship and economic development with a particular focus on the New Blue Economy; and

(3) exhibit equity in how NOAA builds and provides services, with an internal as well as an external focus on DEIA. NOAA has conducted Climate and Equity Roundtables around the country that were specifically intended to reach out to communities and sectors NOAA has not traditionally engaged with in order to get a handle on where there are concerns and opportunities. As a result, they have embarked on a series of pilot projects, including some targeted to the Upper Mississippi Basin on flooding issues and to tribal communities in Alaska focused on coastal resilience. They are looking to build sustainability in addressing equitable delivery of products and services across the agency's portfolio. NOAA is also working on a pilot program with the City of New York on automatically translating NWS watches and warnings into 13 languages. Additionally, NOAA is looking at how they can diversify their own workforce. NOAA is committed to the buildout of the New Blue Economy, which is the economy of information and knowledge as a product to support some of the more traditional blue economies. This is where environmental stewardship and economic development come into balance. Similar to other priorities, NOAA has hosted roundtables and listening sessions on the New Blue Economy with a wide variety of participants and will be following up with a workshop with more targeted partners. Dr. Spinrad has been leveraging other agencies within the Department of Commerce to look into ways to spur economic development within the New Blue Economy and find paths forward. The SAB's input in this area would be very useful, as would something along the lines of the PWR Report for the New Blue Economy. The federal government needs to have an authoritative source for climate products and services in a mission-agnostic manner. NOAA wants to do this in close coordination with the private sector and with eyes open about investment opportunities and financial implications. NOAA has extraordinary expertise, a legacy of observations, robust skill base in climate modeling research, and development of operational products with service delivery mechanisms built in to the organization. The NOAA Climate Council has been a very valuable venue for dialogue with external partners as well as getting their internal operations in order. This includes reaching alignment on the vision for Climate Ready Nation in order to position the nation economically and socially to benefit from understanding what climate change is going to mean and prosper as a result. Dr. Spinrad has now had over 160 meetings with a wide variety of external stakeholders who have interest and intersect with NOAA's climate products and services.

The FY23 President's Budget for $6.8 billion represents a 52% increase over FY22 request (30% increase over the enacted FY22 levels), conveying that NOAA has the policy support of the Administration and there is general concurrence in Congress with what NOAA is doing. The Inflation Reduction Act (IRA) is the largest and most substantive climate bill the country has seen and allocates $3.3 billion to NOAA, which will allow the agency to do some exciting things. NOAA will leverage the flexibility of the funding to make further investments in Climate Ready Coasts while also trying to get the funds out the door as quickly as possible. The BIL allocates $2.96 billion over five years to NOAA which will address improving coastal resilience and apply resources towards transformation projects. Dr. Spinrad wants to raise the agency's level of risk tolerance and ensure that some of these investments go towards high risk/high pay-off projects, spurring economic development, and accelerating research-to-operations/applications/commercialization.

The National Climate Task Force is a cabinet level body that has provided opportunities for Dr. Spinrad to brief many Secretaries on pressing topics. These have included balancing the

Administration's heavy emphasis on mitigation with an emphasis on adaptation and resilience, as well as NOAA's role in permitting and environmental stewardship for offshore wind. The Task Force has allowed Dr. Spinrad to discuss issues and opportunities with the President and the highest levels of the Administration. NOAA is now being asked to represent the Department of Commerce, and even the government's entire climate/ocean portfolio, at the highest levels. NOAA's participation has increased at international conferences and activities in which they previously had minimal engagement. Dr. Spinrad expressed his appreciation for the work of the working groups and the specificity they are including in their work products. These have been enormously helpful in the formulation of policies and budgets. Areas that the SAB could provide further guidance include disruptive technologies, potential new partnerships, and a possible collaborative effort between the National Science Board and SAB. NOAA's role with respect to space commerce has expanded and it might be good for the SAB to get briefed on science and technology issues in this area. Dr. Spinrad sought the SAB's input on the possibility of NOAA transitioning to a net zero fleet, including whether new ships under construction will accommodate next generation power systems. There are many private sector, military, and international partners looking into this issue. The SAB's advice on what a net zero fleet means for NOAA from a science and technology perspective would be valuable (i.e., what is possible, how much should NOAA invent in-house, how much already exists).

Discussion

Jon Allan asked what guides the agency's thinking about the New Blue Economy. Dr. Spinrad said the traditional blue economy (shipping, oil and gas, fisheries, etc.) is robust and has been measured in various ways. The New Blue Economy can best be described through an analogy with what has happened in commercial weather over the last 60 years - building business models around adding value to the information NWS provides. The New Blue Economy is envisioned similarly, but focused on ocean and marine products and services. He described some possible examples of these, including supply chain and logistics insight and ecosystem service valuations. It is about the supporting capabilities and the informational backbone that supports the burgeoning of various aspects of water-related commerce and activity. Expanding this idea out to climate services presents real opportunities. It is important that NOAA take the lessons learned from the development of the commercial weather industry and have public-private partnerships established on principles and terms of reference that are understood and agreed to by all partners.

Denise Reed said $2.6 billion for coasts is good, but it's not a lot given the need. She asked if the approach will be to focus on pilot projects to demonstrate what can be done, creating tools for the nation, or something else. Dr. Spinrad said that through the investments in Alaska, they will be able to establish how to ensure sustainable fisheries, both for economic and cultural reasons. But for other projects, like using the funds to remove abandoned vessels from Hoboken Harbor, it will be one-time investments. Dr. Spinrad would also like to reestablish how coastal development is thought of in the future. In order to get some of the money out, they will utilize existing programs but there will be opportunities for new program development as well.

Chelle Gentemann pointed out that many of the focus areas highlighted in the BIL are areas in which the open science community is very active. For money going out through existing programs, she asked if there is a way to build in advancing impact, broadening participation, and

increasing community development by incorporating new requirements around data, software, and publications that align with open science principles. Dr. Spinrad said yes, there should be that opportunity. Dr. Graham said there is a lot of discussion underway at NOAA around being able to take advantage of open science, particularly within the modeling community. Dr. Volz said they are looking at how they can improve the infrastructure for information sharing to make it more usable and flexible for future uses and applications. A lot of the open science will be enabled by better IT infrastructure, which has the right metadata, data formatting, and the right cloud bases for the integration and interoperability of data. They are looking at how they can invest within the confines of the bill so that it improves the infrastructure and leaves a legacy of impact beyond the initial investment.

NOAA Science Update
Sarah Kapnick, NOAA Chief Scientist

The NOAA Strategic Plan 2022-2026 was released in July and it aligns everything the agency is doing with the Department of Commerce Strategic Plan released in March. The three main priority areas of the plan are (1) building a Climate Ready Nation; (2) integrating equity into core operations; and (3) advancing the New Blue Economy. The goals are achievable due to the agency's deep commitment to organizational and operational excellence. NOAA will make significant operational improvements and invest more in its people, its processes, and its technologies. Since the SAB's last meeting, NOAA has put out the HEAT.gov website, which features heat information across various federal agencies including heat forecasts from NOAA, as well as heat preparation and planning guides. It is a one-stop shop for information on evolving heat events, understanding the future of heat events, and planning for heat resilience. Dr. Kapnick discussed recent NOAA work under their three research and development vision areas of (1) reducing societal impacts from hazardous weather and other environmental phenomena, (2) sustainable use and stewardship of ocean and coastal resources, and (3) robust and effective research, development, and transition enterprise.

NOAA has updated their Billion Dollar Disasters mapping tool to be able to look at community-level hazard risk across more than 100 combinations of weather and climate hazards. NOAA's satellite observations of rapid changes in fire emissions are now feeding NWS' operational air quality forecasting models using NESDIS' RAVE (Regional hourly Advanced Baseline Imager and Visible infrared Imaging Radiometer Suite Emissions) algorithm that generates hourly fire emissions information. This is critical for understanding air quality but also for how air quality links to health impacts. NWS' High Resolution Rapid Refresh model was critical in decisionmaking in real time during the events of the Marshall Fire. 50,000 residents were evacuated thanks to the early warning. The fire destroyed 1,000 homes and damaged another 150, though, despite its rapid spread, there were only two fatalities. Recent revisions in the view of the long-term mean Atlantic Meridional Overturning Circulation (AMOC) structure have shown changes in our understanding of the AMOC. Modeling was brought in to provide deeper insight into what is happening in AMOC in areas without good past observations. The models will allow researchers to be able to reproduce past conditions, understand the structure and what the changes have been, and compare it to current satellite data. This is a key piece to being able to understand the future of climate change. Dr. Kapnick also discussed Hurricane Ida and the high resolution T-SHiELD model's prediction of heavy and extreme rain up to five days in

advance. There has been work on improving peak storm surge forecasts by color coding the graphics to capture varying levels along the coasts. Feedback on these experimental graphics is currently being solicited.

New research of satellite data indicates a 52% decrease in Arctic sea ice from 1982 to 2020. The new understanding, based especially on a new emphasis on sea ice thickness, allows researchers to provide new estimates on when the Arctic may become ice-free in the summer. If the current rate of sea ice changes in extent, concentration, and thickness continue the Arctic is expected to have ice-free summers by the early 2060s. Scientists from the Alaska Fishery Science Center worked with private industry to develop an AI program for noise- and soundscape-tolerant investigation of nonspecific whale call types. They have detected and classified 18 million whale calls taken from 25 mooring sites over a span of 13 years of recordings. The AI has saved more than six years of equivalent manual review efforts. The tool is adaptable for use across all oceans and across multiple species. In July 2022, NOAA Fisheries announced proposed changes to vessel speed regulations to further protect North Atlantic right whales from death and serious injuries resulting from collisions. The changes would expand the current mandatory seasonal speed restrictions of 10 knots or less in designated areas of the ocean, and will extend the restriction to most vessels measuring 35-65' in length. In addition, NOAA is releasing a draft roadmap for public comment about ropeless fishing gear that outlines possible ways to increase the use of this technology in commercial fisheries off the East Coast of the United States. These two efforts are part of NOAA's North Atlantic right whale road to recovery strategy that encapsulates all of the ongoing work across the agency in collaboration with partners and stakeholders to conserve and rebuild the North Atlantic right whale population. The National Centers for Coastal Ocean Science (NCCOS) is expanding the HABscope tool that allows citizen scientists to identify and quantify red tide cell concentrations in the Gulf of Mexico to other red tide forming species in Florida and the Chesapeake Bay. Incorporating AI technologies into the analysis turns days' worth of work into minutes, providing quick results, improved forecasts, and impact mitigation. NCCOS and their partners have also completed predictive habitat models for the Papahānaumokuākea Marine National Monument, mapping potential spatial distributions of 22 genera of deep-sea corals and sponges across the region to support resource protection.

The Fisheries Integrated Modeling System (FIMS) is being developed involving all seven Fisheries regions with a goal of providing a next generation stock assessment platform with linkages to ecosystem, environmental, and human dimension models. FIMS will ultimately serve as a bridge to the next generation of models to help transition them into operational use. The NOAA ship Nancy Foster hosted the 2022 Valor in the Atlantic Telepresence Expedition showcasing the excitement of ocean discovery and research in real time. NOAA and several partners conducted the first in-depth multidisciplinary survey of the Civil War ironclad USS Monitor since 2002, providing access to the public using remotely operated vehicles to be able to witness the exploration. The live-stream webcast showcased these nationally significant historic sites and the surprisingly diverse biological communities and abundance of fish occupying the reef and wreck sites while bringing the excitement of exploration. The importance of being able to provide products and information around heat is growing. NWS has been developing Wet Bulb Global Temperature (WBGT) forecasts and transitioning that to operational status. NWS can now provide a widely used heat stress indicator specific to their Impact-based Decision

Support Service needs across the country and most of its territories. It is already being used around the nation and is especially important for military and athletic communities.

Discussion

Zhaoxia Pu said NOAA seems to have shifted from Weather Ready Nation to Climate Ready Nation and, in doing so, expanded their science. She asked how NOAA, in this transition, has balanced investments between science, operations, and service to society. Dr. Kapnick said that even within Climate Ready Nation, they still need to be adaptive to the new changes that are happening. NOAA needs to make sure they have the investments for the dissemination of the climate information at a scale they have never had before. It will always be a balance to make sure they have and continue to develop further capabilities.

Elizabeth Weatherhead asked how Dr. Kapnick viewed NOAA's communication about their science in terms of achieving some of the results they are seeking. Dr. Kapnick said one of her priorities as Chief of Science is to improve the communications of the science NOAA does and what resources they have available, as well as ensuring that the public trusts the information they provide. In addition to producing all this science, NOAA need to ensure people, governments, and organizations have access to it, are using it, believe it, and act on it.

Discussion of Proposed Work Plan Topics

John Kreider led the discussion of two potential topics for the SAB to take up: the net zero fleet and disruptive technologies. Dr. Spinrad provided some guiding principles on the net zero fleet. His intention is to do something truly meaningful, a technological change of operational activity which needs to be reasonably comprehensive to a broad understanding of what fleet means. He wanted to see what NOAA can learn from the SAB as to what the art of the possible is, including the possibility of the SAB saying it is not viable. He also sought their input on the kinds of technologies NOAA should be incorporating or avoiding. Dr. Weatherhead asked for more information on the motivation for bringing this forward. Dr. Spinrad said federal agencies have been directed by Executive Order to do what they can to be carbon neutral and address challenges associated with climate change, but it is also the right thing to do. This could also be a catalyst for thinking about how NOAA does its job differently, particularly in regards to how they are utilizing autonomous vehicles. Chair Kreider asked if it would be within the context of the study to say something along the lines of "AUVs can be used more and it would reduce the need by one ship," or if the fleet plan as proposed is a given. Dr. Spinrad said the fleet plan is what NOAA is going forward with in terms of long term planning, he is looking for the parallelism in taking a net zero approach. If there are economies of scale or of operation that the SAB identifies in doing this, that would be great to know, but it is a secondary question. He is more interested in a feasibility analysis. Transitions to net zero fleets are happening elsewhere in the world, so it can be done. Mr. Allan asked about the availability of data on the current fleet, not only emissions but also its mission basis, which will determine what kinds of technologies can be applied. Dr. Spinrad said this is part of it and if the SAB chooses to take this on, NOAA will ensure they have access to the fleet plan so they know what the mission definition looks like. Dr. Reed said she did not know if the SAB had the capacity or specific skillsets to address the question, but there may be a couple options for how this could play out for the CONOPS: an ad

hoc group could do the work and transmit it through the SAB; it could be assigned to a working group, but they may not have the capacity to be able to handle it and might not be appropriately aligned; or the SAB could organize a workshop and then generate a report from that. The SAB would have to bring in experts to help, but it is an area that is of interest to many. Mr. Allan asked if there might be NOAA staff that could pull the data together or if some of that could be done through the CIs. Chair Kreider said the PWR study relied on a number of NOAA people and a team that was put together to provide input into the study. There could be a great growth opportunity on both sides. Dr. Spinrad said Adena Liebman is already assigned responsibility within NOAA.

Denise Reed made a motion to have the Chair, along with one or two members, work over the next two weeks to develop an approach on the net zero fleet to be shared with NOAA personnel. The motion was seconded by Jon Allan and passed unanimously.

The next item for discussion was the SAB assisting with pursuing innovative ideas and disruptive technologies to address compelling societal issues. This topic fits very well with the Administrator's three top priorities. It is focused on assisting with fleshing out strategies to achieve step changes and to help effectively employ some of the new resources that are now available and apply them to focused objectives. Dr. Weatherhead said they had several ideas from the last meeting, but none of them have been vetted as being the priorities. The three classes of scientific advances they are talking about are: addressing societal needs (e.g., new ideas getting at regional carbon flux issues, being able to identify issues with the health of ecosystems in real time, ocean acidification), developing and evaluating the next generation of observing systems and tools (e.g., AI/ML, real time monitoring systems, game changing ways of communicating), and being prepared for unknown unknowns, (e.g., coastal resilience if a major event happens, how NOAA would respond if climate change accelerates more rapidly than expected). Cultural changes are needed to be able to address some of the big challenges, shifting from a culture of internal development to one in which NOAA enables solutions and empowers personnel for increased risk tolerance. Dr. Spinrad said this is going in the right direction, but still seemed more constrained than what the SAB could be doing. He agreed fully with the themes identified and said that the SAB should not worry too much about connectivity to NOAA's mission. The SAB used to bring in presenters from other sectors to discuss topics like compressed sensing, surface manufacturing, molecular computing, and other subjects on the horizons of new science and technology. He asked what emerging science and technological areas may have some connectivity in pushing forward NOAA's capabilities associated with things like understanding carbon in the environment or measuring biomass. Mr. Allan said the SAB is interested in exploring the subset of the venture capital community that is purpose-driven and highly interested in emergent technologies, looking to them to vet ideas that have some potential marketability. They are also interested in how the inherent stress and disruption that a climate-induced future will cause translates into deep senses of social disruption. Dr. Kapnick said her ideas about dialogue with the venture capital community are part of why she was brought on, they are constantly reaching out to find out how they can get involved in advancing NOAA's science and technology. This is part of NOAA's private sector strategy, thinking through how they are going to engage with all those different communities to make sure ideas and technologies can advance as rapidly as possible. Societal consequences are part of NOAA's long term thinking, stepping back to assess whether they are developing a science portfolio that

will meet the needs of the future. Dr. Reed commented on the type of SAB presenters they used to have who focused not on identifying new problems, but on discussing new approaches and solutions being developed to support work in other fields entirely. The SAB's job was then, through the conversation, to link what they were hearing with what they knew of NOAA. With the current workload of the Board and the working groups, it could add an interesting dimension to future meetings. Joellen Russell suggested that, rather than grabbing at a particular technology or process, NOAA should be extending what they are already doing. NOAA has the sole mandate for federal prediction and there are several predictions they don't do well or don't do at all, such as the carbon cycle and full prediction of the ocean. NOAA is not taking advantage of all the prediction science that they have pioneered. Steve Volz said that NOAA does a great job at decision support services for immediate actions by emergency managers, but they fall short on the impacts of slow burning activities, including climate change and carbon buildup. If they had a way to incorporate simulations of the response to communities and economies of a major event or slow burning event that would put a lot more power into their forecasts and would be a tool for emergency managers making short and long term decisions. Dr. Carpenter noted that this sounds a lot like the Destination Earth project in Europe and the SAB might want to look at what they are doing to see if it is something that NOAA should take up. Dr. Grossman echoed the importance of looking at how other sectors approach data and compute. For NOAA, data and compute is a cost used to support the mission, but for other sectors, like health care, it has a return on investment, which has pretty important consequences in regards to how they think about moonshots. Mr. Allan suggested creating a list of a few organizations they want to hear from that could seed their thinking. Dr. Decker will solicit ideas from SAB members on who they want to hear from and a general topic. The SAB will continue to work with NOAA leadership to identify what the grand challenges are that the SAB wants to ensure are on NOAA's radar.

Plans for Next Meeting
Cynthia Decker, Executive Director, SAB and Designated Federal Official
The next SAB meeting will be on November 30 and December 1, 2022, in the Washington, D.C. area.

Review of Actions
Cynthia Decker, Executive Director, SAB and Designated Federal Official
Dr. Decker reviewed the actions from the meeting, including:

- Approval of the consent calendar.
- The SAB accepted the S2S report and will transmit it to NOAA.
- The SAB accepted the CI CIMES report and will transmit it to NOAA.
- Independent of the CI CIMES report, the SAB will work with Dr. Decker to draft a letter to NOAA concerning their desire to see more DEIA considerations from the CIs and how their ranking system might be improved.
- The SAB accepted the TSTAP Strategic Plan, which will be transmitted to NOAA.
- SAB staff will explore having a presentation at their California meeting by the West Coast Ocean Alliance on their report cards and what KPIs NOAA could be using. Dr. Weisberg offered to help arrange the presentation.
- The SAB will create a small team to scope the Board's approach to considering a Net Zero Fleet.

- Dr. Decker will solicit ideas from SAB members on speakers and topics they would like to hear about for future meetings.

Adjourn

The meeting was adjourned at 12:32 p.m.