

**55th Meeting of the NOAA Science Advisory Board
28-29 April 2016**

Location: Magnolia Ballroom
Sheraton Silver Spring
Silver Spring, Md.

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:

Ms. P. Lynn Scarlett, Managing Director for Public Policy, The Nature Conservancy (Chair); Dr. Susan Avery, President Emeritus, Woods Hole Oceanographic Institution; Dr. Michael Donahue, Vice President, AECOM Corporation; Dr. Jeremy Jackson, Senior Scientist Emeritus, Smithsonian Institution; Dr. Everette Joseph, Director, Atmospheric Science Research Center, University at Albany, State University of New York (SUNY); Dr. Eugenia Kalnay; Professor, University of Maryland; Dr. Peter Kareiva, Institute for the Environment and Sustainability, UCLA; Dr. David Lodge, Professor University of Notre Dame; Dr. Molly Maucauley, Vice-President for Research, Resources for the Future; Ms. Jean May- Brett, Retired (STEM Partnership Coordinator, Louisiana Department of Education); Dr. Denise Reed, Chief Scientist, Water Institute of the Gulf; Mr. Robert S. Winokur, Retired (NOAA, Navy); and Dr. Dawn Wright, Chief Scientist, Environmental Systems Research Institute.

NOAA senior management and Line Office representatives in attendance:

Dr. Kathryn Sullivan, Under Secretary of Commerce for Oceans and Atmosphere; Dr. Rick Spinrad, NOAA Chief Scientist; VADM Manson Brown (USCG, ret.), Assistant Secretary for Environmental Observation and Prediction; Dr. Chris Blackburn, Assistant Secretary for Conservation and Management; Mr. Ben Friedman, Deputy Under Secretary for Operations; Dr. Russell Callender, Assistant Administrator, NOAA National Ocean Service; Mr. Craig McLean Assistant Administrator, NOAA Office of Oceanic and Atmospheric Research; Dr. Louis Uccellini Assistant Administrator, NOAA National Weather Service; Ms. Eileen Sobek, Assistant Administrator, NOAA National Marine Fisheries Service; Dr. Stephen Volz, Assistant Administrator, NOAA National Environmental Satellite and Data Information Service; and RADM David Score, Director, NOAA Office of Marine and Aircraft Operations

Staff for the Science Advisory Board in attendance:

Dr. Elizabeth Turner, Acting Executive Director, Dr. Laura Newcomb and Ms. Mary Anne Whitcomb

Thursday April 28, 2016

Opening Statement of the Chair and Self-Introductions by Science Advisory Board (SAB) Members;

Lynn Scarlett, The Nature Conservancy and Chair, NOAA SAB

Lynn Scarlett welcomed everyone to the meeting. She discussed the SAB focus to invite outside speakers to give insight on issues to help the SAB help NOAA in terms of new needs—human capacities and, new technologies. The speakers will help NOAA think strategically about the next 3-5 years. The Board has also spent some time thinking about the Working Groups and how to better communicate their operations and interface with the Board and get the best value; this will emerge with the agenda.

SAB Consent Calendar

Lynn Scarlett, The Nature Conservancy and Chair, NOAA SAB

- January 2016 SAB Meeting Minutes
- CWG Membership Roster
- Working Group Status Reports

A motion was made to approve the three consent calendar items and passed unanimously.

NOAA Update

Kathryn Sullivan, Under Secretary of Commerce for Oceans and Atmosphere

Summary

Personnel Updates

Dr. Sullivan welcomed the four new SAB members: Everette Joseph (University at Albany, SUNY), Atmospheric Sciences Research Center); Eugenia Kalnay (University of Maryland, Department of Atmospheric and Ocean Science); Richard Moss (University of Maryland/Pacific Northwest National Laboratory/Joint Global Change Research Institute); and Denise Reed (The Water Institute of the Gulf, Chief Scientist). Richard Moss was not able to attend this meeting. Rob Hicks resigned from the NOAA SAB in January. Cynthia Decker has resumed her job as SAB Executive Director and this is Beth Turner's last meeting as Acting SAB Executive Director. Chris Blackburn is now the Assistant Secretary for Conservation and Management. Mike Devany retired as Deputy Under Secretary for Operations and Ben Friedman has taken this position. Mr. Friedman had been working on the Secretary's General Counsel staff and knows the agency well. Steve Fine who was the Deputy Assistant Administrator, OAR has taken a job in the EPA and Mike Farrar, NWS, is acting in that position. VADM Score has been selected as a member of the Board of Visitors to the U.S. Merchant Marine Academy.

Budget

FY 17 budget has been released and Dr. Sullivan highlighted a few points. There is a mission support line item that supports the people who do grants, personnel and other back of house

functions. There is increasing demand for the front line services the agency does but funding has not increased. This funding shortfall has resulted in a vacancy rate of 7% or 1800 vacant positions. Impacts of these vacant positions include loss of 205 Days at Sea by the Office of Marine and Aircraft Operations due to the inability to fill staff positions; the National Weather Service is barely keeping pace with attrition with 100 unfilled positions in headquarters and over 200 vacancies in field locations. Dr. Sullivan gives the Hill the message that science and services are at risk if NOAA doesn't make progress on mission support.

Ocean Survey Vessel Update-The FY 17 budget proposes a path forward that involves the acquisition of a regional class vessel before an ocean class vessel. Without any new investments, NOAA's current fleet will decrease from 16 to 8 ships by 2028. Given NOAA's urgent need to recapitalize its fleet with regional and ocean class vessels, the best federal procurement at this time is a regional class vessel.

Research Transition Updates

NOAA has substantially streamlined with its transition process, including the codification and use of "Readiness Levels", strengthened the role of Line Office Transition Managers, and clarified the role of the Technology Partnerships Office. NOAA requested \$10M in the FY 17 budget to start a Research Transition Acceleration Program (RTAP), which selects projects focused on accelerating the transition. NOAA initially identified 100+ potential projects through an internal competition that were then narrowed down to 21 projects with 16 identified as tier one that will be first to get any new money.

NOAA Water Initiative

There is a new focus in NOAA and in the interagency arena on water. With support from Congress in FY 17 and beyond, the NOAA water initiative, which is cross-Line Office and transdisciplinary, will make NOAA the focal point for practical prediction. There will be a significant change in how NOAA forecasts water. Moving from 4000 data collection points to 2.7M forecast points, the forecasting framework will be over 700x more spatially dense than the current NWS hydrological forecast system. Information from this forecasting framework will deliver from 15-hour- regional to 7-day national water forecasts as well as a 30-day outlook for the entire nation. The forecasts will cover water flows the along the reach of rivers, linking terrestrial and coastal processes. In Louisiana, for example, this brings the forecasts to a neighborhood level. Forecasts are integrated with precipitation to show flow that moves down the river in a time continuous sense.

The NOAA Water Center in Tuscaloosa will synthesize stream forecasts and provide daily situational awareness of flood and drought emergencies. It will deliver a daily geophysical soil moisture map for the U.S. that will dramatically enhance the U.S. Drought Monitor and act as a key indicator for plant growth in agriculture.

Water has been in the news - March 22 was World Water Day. NOAA participated in the White House Water Summit and made announcements including a Presidential Drought Memorandum and release of the National Drought Resilience Partnership Long-Term Drought Resilience Federal Action Plan that focused on building national capabilities for long-term drought resilience. Finally, NOAA will hold three water conversations in May and June over eight weeks to make sure the agency is aware of partner needs and what key stakeholders want to see in enhanced water services. In these efforts NOAA will draw on lessons learned in previous national conversations on tornado outbreaks. From these conversations, NOAA will determine what actions it needs to take and will have a more partnership point of view for the National Water Center.

NOAA Priorities

During the last SAB meeting, Dr. Sullivan provided an overview of the NOAA strategy to develop priorities that are outcome-oriented and aligned with the four NOAA priorities: make communities more resilient; invest in observational infrastructure; evolve the weather service and achieve organizational excellence.

Resilience

El Nino Rapid Response Wrap Up

Between January and March NOAA collected data across the Pacific to accelerate understanding of El Nino events and impacts. The long term impact is that NOAA obtained unprecedented observational records to support research into processes linking weather events originating in the deep tropical Pacific to the West Coast during a strong El Nino. There were several surprising findings. Dropsondes and radiosondes revealed complex moisture features which are not well represented in operational models and in satellite measurements, and may contribute to significant forecast errors affecting both the tropics and mid-latitudes. Extratropical disturbances played a direct role in exciting and suppressing local convection in the equatorial Pacific during February. Findings included that strong upper-level westerly flow extended across the equator, allowing frequent intrusions of extratropical energy into the central and eastern Pacific. These disturbances may reveal forecast errors if included in the models.

Magnuson-Stevens Fishery Conservation and Management Act 40th Anniversary

The Magnuson Stevens Act put the U.S. on forefront of sustainable fisheries management globally. In 2015, eight fish stocks came off the overfished list. Total number of stocks rebuilt since 2000 is 39; and while there is more work to do this is a significant effort. In a recent trip to the West Coast, Dr. Sullivan noted the signing of the Klamath River agreement including the

removal of four dams; talking to businesses on innovative bycatch reduction techniques; and cleaning up a beach with marine debris staff.

Cuba Update

At the November meeting, Dr. Sullivan briefed the SAB about the first Memorandum of Understanding (MOU) with Cuba. Since that time MOUs have been signed with Cuba on navigational products and services designed to improve navigation safety through cooperation on hydrographic data and products. Cuba announced it will be the 24th nation to join the Port State Measures Agreement to combat illegal, unreported and unregulated fishing; NOAA is prepared to consult with Cuba on strategies for effective implementation once the agreement becomes binding after the 25th country joins. Finally NOAA scientists from the Southeast Fisheries Science Center and the Atlantic Oceanographic and Meteorological Laboratory collaborated on a blue fin tuna cruise and survey in the Gulf of Mexico with Cuba and Mexico.

Evolve the NWS

“No more shouting” - previously, forecasts were issued in all capital letters and this has stopped. Two new supercomputers, Luna and Surge, have boosted capability by nearly four-fold; installations have been completed in Reston, Virginia and Orlando Florida. There is a University Corporation for Atmospheric Research (UCAR) computer advisory group that advises NCEP and recommended the need to bolster the U.S. potential for world leadership across the full suite of its environmental prediction capabilities. There is a Presidential Executive Order on a National Strategic Computing Initiative looking at exascale computing from science computing to national security and names NOAA as a deploying agency. This gives NOAA full participation as the Nation develops a viable path forward on high performance computing. The current way computing is done, from large scale computing to global scale at greater density and frequency, will need to go through a phase change to identify the architecture, software and talent needs.

New operational products

There is a national blend of models that contains guidance based on a blend of global model inputs for ten weather elements; AWIPS workstations can display this guidance at all field sites. A high resolution suite of models went operational on March 8; this suite provides higher spatial and temporal resolution than other models, allowing for more specific and detailed guidance for forecasters to use when analyzing the potential for hazardous weather. On the observation side Japan launched an operational satellite, Himarwara-8 and users in the Pacific and Alaska region, in addition to the national centers are pulling down the data at spatial and temporal resolutions similar to GOES- R. The Weather Prediction Center made the experimental Days 4-7 winter weather outlook available to the public on December 1; survey results through mid-March indicate extremely positive feedback as people think the product is useful and easy to use.

NWS Operations and Workforce Analysis (OWA) update

At the last meeting Dr. Sullivan provided an update on completion of an analysis of NWS operations, workforce and organization and identification of gaps in meeting user needs. Key findings were that NWS excelled with technological advancements that now allow our modeling and computing capabilities to handle the majority of forecast production, allowing staff more time to provide decision support to public safety partners. Now the OWA is in the most important phase, identifying options for organizational change recommendations, which should be ready in June. OWA is still working through the fully integrated field structure to determine how the field offices should be staffed and the roles of the staff.

Observational infrastructure

Commercial Space Policy

Dr. Sullivan described a proposed space policy bill from Representative Bridenstine (R-OK-1) that would change the management and regulation of space activities by pushing the government to rely more on commercial capabilities. NOAA's views are that while the agency will engage the emerging weather observations companies in the space sector just as it's done with commercial providers of ground-based weather data, the mission assurance obligation will remain paramount.

NOAA released the Commercial Space Policy in January to establish broad principles for the use of commercial space-based approaches for NOAA's observational requirements and potentially open a pathway for new industry to join the space-based Earth observation process. NESDIS is launching architecture studies to explore possible future approaches to meeting NOAA's space-based observing needs. An Office of Space Commerce has been launched in NOAA to better streamline and strengthen engagement with industry and to be a one-stop shop to learn about specific business opportunities with NOAA.

Organizational Excellence

Sea Grant 50th anniversary

For half a century, Sea Grant research, education and outreach activities have spanned healthy coastal ecosystems, resilient communities and economies, sustainable fisheries and aquaculture, and environmental literacy and workforce development. Dr. Sullivan highlighted Sea Grant success stories, including the example of how \$50K of funding from Virginia Sea Grant to college students to complete a coastal resilience plan led to a \$120M Housing and Urban Development (HUD) grant for resiliency infrastructure in Norfolk neighborhoods.

NOAA's Presidential Early Career Awards

Dr. Sullivan reported that NOAA has three winners of the President's Early Career Awards for scientists. The winners are: Dr. Gijss de Boer, Cooperative Institutes for Research in the Environmental Sciences; Dr. James Thorson from the Northwest Fisheries Science Center and Dr. Nate Bacheler from the Southeast Fisheries Science Center.

Dr. Sullivan gave the William D Carey Lecture on the compact between science and society that provides challenges and opportunity for the future; Dr. Sullivan was also elected to the National Academy of Engineering.

Discussion

Jean May-Brett congratulated NOAA on its educational accomplishment award.

Susan Avery complemented NOAA on technology transition work and the number of projects at the high level of readiness project. Dr. Sullivan said the budget marks are the first step forward and NOAA will ask for more funding for this project.

Eugenia Kalnay said she was interested in what she heard on the integrated water project and wondered if it is possible to influence the Tuscaloosa Water Center to both work closely with National Centers for Environmental Prediction (NCEP) and to prepare verification of the forecasts. Louis Uccellini agreed that the water system must be integrated with forecast suite; he added that they use the community model, Weather Research and Forecasting (WRF) Hydro so they worked with other agencies on this system. NCEP is also involved with land process and verification.

Lynn Scarlett commended NOAA on integrated water initiative. She noted it is an ambitious effort and wondered what it will take to build it out. Dr. Sullivan said the 2015-2017 budget detail was provided on the SAB website. The goal is impact-based decision support; making sure that the impact of the forecast is understood in your area. She emphasized what NOAA envisions to make sure the smartest and most important pieces of the practical prediction work that others will take off from. The water discussions will see if NOAA is missing anything. The Water Center is could be a test bed for what is possible. Louis Uccellini said NWS is operationalizing this effort. There will be five employees from the U.S. Geological Survey (USGS) and one from the Federal Emergency Management Agency (FEMA), all focused on the mapping activity of the Impact-based Decision Support Services (IDSS).

Everette Joseph said he is looking forward to seeing how to bring the university community in through proposed programs and would like to see these details. Molly Macauley said at their heart these are information processes and products; she asked in the program design if social science can evaluate the impact of the information. Louis Uccellini said yes, they are hiring a Chief Economist but NOAA has a long way to go. The plan is to have social science as part of the outreach to the research community; the intrinsic value of the forecast is how it is used.

Rick Spinrad added that they signed a Memorandum of Understanding (MOU) with all directorates of National Science Foundation (NSF) and the focus is to bring in the social sciences expertise. Kathy Sullivan said the social science staff at NSF was key to their energy and food web programs.

Susan Avery asked if snowpack was part of the data flow. Kathy Sullivan said yes it will be included. Louis Uccellini said the model will revolutionize the way NWS does hydrology modeling and they have modelers coming in from the university community. Susan Avery asked if by integrating the water prediction system with the coastal environment could the system address water quality. Louis Uccellini said they are looking at this in coastal waters and in Great Lakes. This cross-LO effort also involves other agencies such as the Environmental Protection Agency and Food and Drug Administration.

NOAA Chief Scientist Update

Richard Spinrad, NOAA Chief Scientist

Dr. Rick Spinrad provided the SAB with an update on various activities since the last meeting. He reminded the group the statement of task for NOAA's Chief Scientist is to "build a robust portfolio logic for NOAA's research enterprise as reflected in clear strategic guidance that defines critical mission-optimized operational and organizational principles and alignment of capabilities."

Strategic Research Guidance Memorandum (SRGM)

The purpose of the Strategic Research Guidance Memorandum (SRGM) is to give clear, unequivocal guidance for the agency's research portfolio. The first such document was issued on August 22, 2015 and is being used to guide FY18 priorities. This is envisioned to be an annual project with the SRGM FY19 being drafted now and open for input. The FY18 SRGM highlights integrated Earth system processes and predictions, observing system optimization, decision science, risk assessment, and risk communication, data science, water prediction, and arctic as research priorities. These priorities reflect strategic discussions with the SAB.

Research to Operations/ Commercialization/ Application (R2X)

The Research Transition Acceleration Program (RTAP) was created to completely re-engineer the process by which NOAA can accelerate research into practical use. RTAP was established using best practices in other Federal agencies including the Department of Defense budget system and NASA's Technology Readiness Levels concept. NOAA conducted an internal call for proposals for possible RTAP support. The initial response was 101 ideas for \$190M. These were winnowed down to 16 projects totaling \$9M that will be funded if RTAP is appropriated as requested in the President's Budget request (current FY17 Senate Appropriations mark at \$2M). Two RTAP tier 1 projects have already been started (total of around ~\$825K in year 1) under

NOAA's Joint Technology Transfer Initiative (JTII), a program that supports the transition of OAR research into NWS operations.

NOAA has revised the NOAA Administrative Order (NAO) that defines agency policy on transition and broadly describes key concepts of the process. NAO 216-105A, "Policy on Research and Development Transitions" (NAO 216-105A) went into effect in December 2015. The Handbook to guide everyday application of NAO 216-105A is currently in development, and will be released in a few months. Transitions take many different forms with many end uses, and NAO 216-105A supports a wide range of possible pathways and outcomes.

Cooperative Institutes

NOAA has 16 Cooperative Institutes (CIs) that comprise 42 universities and research institutions across 23 states and the District of Columbia. CIs represent two-thirds of NOAA's extramural research; approximately \$1 billion went to the CIs in the last five years. The CIs serve as a powerful tool for addressing research and development needs of the NOAA Line Offices; however, they were not established with common practices and focus. Therefore in 2014, Dr. Sullivan charged the Office of the Chief Scientist to work with the directors of NOAA's CIs, the CI Committee under the NOAA Research Council and other key stakeholders to develop a vision for the Cooperative Institutes in the 21st Century (CI21). The resulting vision is that CIs should serve NOAA's mission needs, be nimble and flexible, provide a complement to NOAA's workforce, and be NOAA's extramural providers of choice.

NOAA and CI staff developed a set of 22 draft recommendations to improve the CI portfolio. These recommendations are categorized in four key areas: mission alignment and enhancement, work force development, finance and management, and private sector engagement. The recommendations span a time scale that includes short- (6-9 months), medium- (1-3 years), and long-term (3-5 years). The following are some examples of these recommendations:

- Mission alignment and enhancement: conduct a review of CI research themes and efforts (medium-term) and develop thematic language that promotes social science (short-term).
- Work force development: establish fair and consistent use of best practices for CI employee career advancement (medium-term), recruit and train a more diverse workforce (long-term), and develop a workforce management plan to ensure flexibility for graduate students and postdocs, and stability for core staff/ faculty (medium term).
- Finance and management: establish a NOAA lead Technical Program Manager (short-term) and conduct a Request for Information (RFI) towards a cost-benefit analysis (medium-term).
- Private sector engagement: develop opportunities for students at their institutions to conduct externships at private companies (medium-term) and create incentives to encourage CIs to identify private sector needs and establish relationships that benefit all parties (long-term).

The SAB is asked to review the CI21 recommendations so that the report can be given to Dr. Sullivan in early summer and be implemented before the end of the fiscal year.

Analytics

The Office of the Chief Scientist is hosting a Sea Grant Fellow (Matthew Womble) this year who is examining the impact of NOAA research. Using analytical approaches such as bibliometrics will enable NOAA to develop credible and repeatable methods for measuring research & development. There are a number of metrics that can be analyzed, including the number of publications, the impact of those publications (NOAA's "H-index"), collaboration networks, and research topics and themes. The next steps are to: (i) determine an appropriate transition metric (i.e. transition of research to operations, applications and other uses); (ii) gauge the impact and future trajectory of NOAA's research investment; and (iii) explore ways to compare NOAA's research performance to that of comparable federal agencies. While Line Offices track metrics for research performance, this is the first time such analysis has been done corporately. Research analytics will be included in the NOAA Chief Scientist's Annual report.

Discussion

Dawn Wright asked for examples of projects that have successfully transitioned research into applications, operations and other uses. Rick Spinrad replied these include Lake Erie harmful algal bloom (HAB) Forecasting, NWS High Resolution Rapid Refresh weather models, Alaska climate impacts on fisheries, and upgrades to Multimission Phased Array Radar (MPAR) at NCEP. These transitions represent a wide spectrum across all lines and partnerships that are cross-agency by design. RTAP focuses on readiness levels 5-7. Dr. Wright also asked for more details on the concept of externships at CIs. Dr. Spinrad indicated that while he was at Oregon State there were students at the University who worked for private companies.

Mike Donahue expressed interest in private sector engagement, and shared his opinion that universities do not take advantage of the capabilities private. He asked if there were incentives beyond externships that could strengthen linkages to the private sector. Dr. Spinrad replied that there are a number of different approaches, and that NOAA should take better advantage of Department of Commerce resources. One approach could be comingling NOAA and private sector support for research in academia. In addition, NOAA has intellectual property that could be licensed for use by private sector. NOAA's SBIR (Small Business Innovative Research) program is not currently coupled with the CI program but could be. The CI21 strategy includes fostering new business development in NOAA-relevant fields. In terms of workforce development, the question is about where students end up – at universities or in the private sector.

Peter Kareiva said that based on a lot of CI reviews including one he ran himself, it strikes him that although there is a real benefit to a university hosting a CI, there is wide variance in matching resources from universities. He wanted to know if there was any attempt in CI21 to

address this issue. Dr. Spinrad replied that NOAA needs to develop a set of best practices on how to interact with partner institutions within applicable legal frameworks. On analytic, Dr. Kareiva asked if social media had been included. Dr. Spinrad said that analyzing social media was a possibility and pointed to an upcoming National Academy workshop on the topic.

Susan Avery raised the conundrum of making CIs nimble and flexible while working within a university system. She stated that universities have money for education and wondered if there has been any work to incorporate this into the vision for the CIs. She mentioned much of the CI diversity is in bringing together disciplines from around the university, not just social science but also engineering and computer science. This is something that could be leveraged beyond what is in NOAA cooperative agreement. She pointed out that there is a difference between a cooperative institute and cooperative agreement. Dr. Spinrad replied that these issues have been addressed in the CI21 report.

Craig McLean also asked about private industry and academia. He has seen the private sector, academia, and government brought together, e.g. Stennis Space Center in the Gulf of Mexico with the Small Business Administration. He asked if any board members know how to pursue this engagement. Dr. Spinrad said overall efforts between engineering colleges and the private sector exceed what has been done in NOAA. The question is whether CIs can be used to engage the private sector.

Louis Uccellini commented there is something bigger happening from a research perspective. The weather community has grown more interested in Research to Operations and in using NOAA infrastructure for the research. He believes NOAA must provide this in an efficient manner. The best example is the Joint Center for Satellite Data Assimilation which was operationalized within six months of launch.

Working Group Issues

Lynn Scarlett, The Nature Conservancy and Chair, NOAA SAB

Lynn Scarlett reminded the group of the status of working groups' issues. The SAB has been having an ongoing discussion on how to best engage the working groups, including the attendance by working group chairs at meetings. As part of the process, the SAB has reexamined the Working Group Concept of Operations document to ensure best practices for group communications with the SAB and vice versa; there was a teleconference meeting on January 28, 2016 to discuss this document. There are common themes with the SAB on positioning for the future - how can the working groups be best positioned to align with NOAA mission and be nimble and responsive to NOAA. There also have been discussions on the composition of working groups, the role of *ad hoc* groups, clarity of work plans, and the body of work that working groups produce.

Kathy Sullivan commented NOAA has a number of Federal Advisory Committees; NOAA wants to make sure all charters are in order, with concepts of operations across all of them. It has

been a long time since this had been done. Secondly as the SAB has thought of different ways of doing business, this should also include ways of doing business for working groups. What other modes might there be for reports to the SAB such as tiger team and letter report versus a longer (18-24- month) detailed studies? Rick Spinrad said he met with the NOAA staff that work with these groups and discussed best practices that could be used. Some of these practices will depend on the larger strategic development of the SAB and changes in SAB operations.

Lynn Scarlett said should consider working group effectiveness, nimbleness, and composition as they relate to the external speakers and strategy work.

Eugenia Kalnay asked how working groups are formed. Cynthia Decker explained that there are now five standing working groups: climate, data archive and access requirements, ecosystem sciences and management, environmental information services and Gulf Coast ecosystem restoration science program. One or more NOAA Line Offices identified the need for each group and supports it. When there has been a specific issue to be addressed there have been *ad hoc* groups identified to develop a report on that issue in 18-24 months. Kathy Sullivan added that the SAB will not have the full mix of expertise for all of NOAA topics and the working groups are the mechanisms to provide expertise beyond the SAB.

Denise Reed said her observations from the ESMWG membership are that the current working group process is not nimble as the groups develop deliberate products for the record and not for immediate use; the SAB also waits one year for the NOAA response to the report. Dr. Reed thought the interactions with the NOAA staff in working group meetings were very useful and added value.

Lynn Scarlett said this discussion relates to the SAB process looking for new ways to get insights rather than through a 2-year report. This is a parallel issue with the working group—are there mechanisms that are quicker and more nimble?

Bob Winokur asked where the work plan for the groups is supposed to come from - top down from the SAB or from the sponsoring LO. He noted the Co-Chairs of the EISWG have been aggressive in developing work plans.

Peter Kareiva said a task force has the advantage of urgency; the Working Groups are not that. One solution is to make them smaller; perhaps a group of 3-4 can provide sustained outside advice on particular topics.

Michael Donahue said the Concept of Operations comments paper they reviewed was helpful but it may be better to get a subset of board members and working group chairs to develop a list of specific recommendations that can be acted on.

Susan Avery agreed that task forces have urgency and that the SAB should move from long reports to letter reports that do not have a long process of approval by the SAB before transmission to NOAA

Kathy Sullivan agreed that some reports are more lengthy than needed; some reports are audits and analysis of functions, not needed as much as analysis of trends and emerging science. A task force from the SAB could look at this based on speaker input, e.g. going from a presentation and discussion to useful input.

Lynn Scarlett suggested that there may not need to be a single approach; in some cases NOAA may want a longer report but a shorter report could be useful for other issues. Maybe a sub-group of the SAB should look at this issue and provide specific recommendations. The group should consider if working groups are a vehicle to follow up on strategic presentations. Working groups could have additional presentations on the same topics to get more information on topics. Another issue to consider is who drives the work plan and whether there should be both bottom-up and top-down development of these.

Kathy Sullivan asked if it would be difficult to ask the working groups to change direction and jointly define out-year work plans. Are working groups really the right place to do the quick follow-ups on speakers? Peter Kareiva agreed that working groups are the not right place for reacting quickly to speakers. The continuity of the relationship with NOAA is the benefit of working groups. They give insight beyond SAB and are appropriate for longer-range tasks.

Jeremy Jackson said over the first few years on the SAB he thought members just listened to recommendations from working groups; it was hard to elicit any excitement. The standing working groups have a function but he was not sure how they changed things. The change last year in the SAB on the strategic review was very helpful. He would like to know what the working groups have done for NOAA.

Dawn Wright agreed that greater awareness of work plans in formative stages would be helpful. DAARWG is mindful of overlap with EISWG; if there was fore discussion of topics during formative period that would be helpful. At times there is need for groups to merge and separate. For the Big Data Request for Information, there was much overlap; common effort would be helpful. Working groups do a lot but their recommendations must be heard and implemented.

Craig McLean said we might want to think of acceleration for turnaround by NOAA to be meaningful and to help promote effectiveness.

Richard Merrick said ESMWG has been very effective and the discussion may be most important part of their meetings. ESMWG has been very productive and has brought together subject matter experts e.g. native community representatives. Discussions with this group have been most helpful; for NMFS most of value from SAB comes from that committee.

Kathy Sullivan said people not at the meetings don't get the benefit of discussion of what the ESMWG is doing on an ongoing basis. NOAA and SAB could benefit from knowing what the ESMWG had underway; let us understand the agenda that is being worked on. Richard Merrick said they thought that is what the SAB liaison was supposed to do.

David Lodge said he has respect for what the ESMWG has to do but he found it awkward, as a new liaison, to understand how the role worked. It is a process of different timeframes of SAB members and the timeframe of liaisons. He thinks more of a shorter timeframe and shorter reports that can be communicated more effectively to SAB would be helpful. In the end he thought he was a failure as a liaison to the ESMWG but this may be part of difficulty of SAB engagement with the working groups.

Lynn Scarlett said it might be useful to know what is valuable from the working groups and how the value can be enhanced. One of the things she heard was timeliness and how can the richness of the dialogue in working groups be translated for SAB and NOAA to be aware of and act upon. What are ways of doing this? Aside from reports, are there other communication mechanisms? Another focus is work plans — bottom up, top down and the role of SAB liaisons to enhance SAB participation in setting focus. What are the working groups best suited to? Finally the dialogue is valuable and how does one take the dialogue so the SAB and NOAA Administrator and NOAA at large can benefit?

Eugenia Kalnay said she was impressed by the discussions on the working group processes and the explanation that they are the legal way to provide advice to SAB and the discussion about the task forces. She asked if it would be possible for working groups to change to a different structure, to be more like a task force.

Dwayne Porter, RSPAWG Co-Chair, thinks the RSPAWG has made a contribution and is surprised about concerns on nimbleness. RSPAWG was aware of timeframe of process for SAB approval; the member feel fortunate for the support they had from Mary Erickson and restoration science plan group; the SAB liaisons kept them informed. The second year the Co-Chairs attended the SAB meeting. Now they can put their charge into context and are able to communicate the context to the working group.

David Fluharty said he was SAB Chair for four years and he has seen quick responses from *ad hoc* groups (task forces). The standing working groups do take time but work in a deliberative way. The ESMWG meets in person twice a year. Their first topic was how to define Marine Protected Areas, Coastal and Marine Spatial Planning and Ecosystem response. NOAA requested the group to provide advice on ocean color. While the ecosystem- based fisheries management report took two years; during that time there was an ongoing dialogue that was judged useful. They have had difficulty with having active NOAA liaisons. It was a year ago when the SAB changed from working group updates during meetings to quad charts that include information on ongoing activities but may need more SAB input on work plans.

Chris Lenhardt said he welcomes the dialogue and asked how DAARWG can help NOAA as a working group. Working groups are in a unique position to connect outside expertise with a specific Line Office and the SAB. The greatest challenge is on the SAB side. What are right procedures and way to engage? There is also an issue of travel budgets where there should be more clarity. Communication is an issue; quad charts are a good start but he suggests three slides with a five minute discussion.

Walt Dabberdt said there are different functions that EISWG serves. It had discussions with the Line Offices and provides feedback through formal reports. They also serve as a bridge between NOAA and academia and private sector, a listening body for what is going on in the community and translate that into actions and activities and feed information back to community. He doesn't think reporting process is broken; their recent study on partnership policy review - started in April 2015 and sent to the SAB in January 2016 - represents how a working group can work effectively and provide quick turnaround. On work plans they ask Line Offices what issues are important and also use their own expertise on issues of importance to NOAA.

Recap of Strategy Session to Date; Discussion on Documenting and Disseminating Strategy Speaker Input

Lynn Scarlett, The Nature Conservancy and Chair, NOAA SAB
Kathryn Sullivan, Under Secretary of Commerce for Oceans and Atmosphere
Richard Spinrad, NOAA Chief Scientist

Lynn Scarlett started off the discussion, reminding the SAB that these strategy sessions reflect Dr. Sullivan's focus on enhancing NOAA's capacity to fulfill its mission. These sessions aim to help the SAB think about what this means in term of technology, structures, and processes. The goal has been to move the meetings beyond routine reporting and review and to bring in outside thinkers. These thinkers are working on innovation ideas that might have some bearing on NOAA and its future. Steve Polasky and Susan Avery were in charge of the original steering committee that brought in speakers align with the 4 NOAA priorities: coastal resilience, evolving the weather service, observational infrastructure, and organizational excellence.

The SAB's challenge is to help Dr. Sullivan and Dr. Spinrad further reflect on these presentations. It is not to give recommendations on how NOAA does its business, but to provide insights on implications of the presentations in terms of accessing technology or the types of people NOAA needs to be hiring. The SAB members must think about how they want to summarize all of this information. There is a summary of each speaker's presentation but the SAB has not summarized all their thoughts into the original subgroup's document. One approach may be to take the whole composite and come back with some key nuggets to work on and then to group these into topics.

Dr. Sullivan said she has found these presentations as intellectual refreshment. They present an opportunity to widen horizons and think about trends and prospects that are out there. There are a

couple of ways to go from here. One approach is to put together small teams to explore topics and what this could mean for NOAA, to consider how should NOAA think about these issues and redirect resources and frame budgets to get there.

For this meeting, RADM Jon White will address issues of the ocean realm from a different point of view. Dr. Katherine von Stackelberg will discuss risk communication and decision-making. This is an opportunity to think about how well social science is being incorporated into NOAA's work.

Rick Spinrad said part of what NOAA is trying to establish a "new normal" by taking advantage of well-established approaches. The speakers spoke about a variety of issues but the SAB has not discussed them again. After hearing from SAB members quotes like "this is why I wanted to serve", there should be a way forward that exploits these discussions more. Dr. Spinrad asked if members of the board would self-nominate to follow-up on any of these topics. From a leadership perspective, NOAA sees value in having these strategy sessions be a sustained activity, but the board needs to do more than just 15 minutes of discussion after the presentation.

Lynn Scarlett opened up the discussion to the SAB asking what insights from these presentations merit a more thorough discussion.

Molly Macauley thanked NOAA leadership for letting SAB members take this journey. Dr. Macauley said it would be helpful to know moving forward if any of the actions mentioned in the talks would be able to be acted upon by NOAA and to know where NOAA is already acting on them. For example, they are working with drones, which was something speaker Marcia McNutt suggested. It would also be useful to know what constraints exist in bringing these ideas into NOAA.

Dr. Sullivan replied that there are different time frames involved with implementing in NOAA. Some things could take a lot of time, but she encouraged the SAB not to prioritize on that account. For example, the new RTAP (Research Transition Acceleration Program) had no path forward until NOAA established the framework and could make the argument to Congress for the program. If compressive sensing could revolutionize NOAA, NOAA should know so they can make the argument to Congress and others of why it should be part of NOAA's portfolio. It might take time to get there but well-crafted input from the SAB can establish a basis for moving in that direction. That is an important starting point and trigger in the federal arena.

Rick Spinrad said we have been asked by Congress where the technology development leading edge is for ocean and atmosphere technology. He would like input from the SAB on this.

Molly Macauley asked for those external opportunities and constraints to be identified because that could help the focus of the SAB going forward.

Susan Avery talked about Rowan Douglas's talk about risk in the climate arena on how you quantify risk and take action when it is quantified. The dilemma in the climate arena is with scientific uncertainty and risk. Based on this thinking, what does that say about the next IPCC, for USGCRP, how does that go into risks with ecosystems? That one presentation stimulated a whole set of interesting questions. There are direct applications to NOAA in the priorities of making communities more resilient, and where to put observing infrastructure to look at extremes. She would have loved to dig deeper into these areas to see where the pay offs could be in communication, messaging, and the time put into these huge climate assessments to make them more valuable for future decision makers. It is a new way to capture climate discussion that could move forward.

Peter Kareiva said NOAA connects environmental intelligence to people in a way that matters to them. Risk matters to everything NOAA does. Risk uncertainty is an active area of scholarship; it is an area ripe to be harvested. NOAA needs to invest more in risk communication. The website is a huge improvement, but it is not well branded – NOAA is the leader and yet people do not recognize that. If NOAA puts an effort into harvesting intellectual work on risk and applied that information for its own uses that would be huge.

Lynn Scarlett followed up asking to what degree is NOAA already embracing and operationalizing growing insights whether in own practices or communications? Would this be something suitable for a small team to come back with some insights on further leading edge work in this realm?

Dr. Sullivan responded that the Fisheries Service has had a social science part, with regards to economics. There is some aspect of risk communication in the in the weather and coastal hazards domain as well that has come in the last couple of years, but NOAA needs to get better at how we communicate and make risk-based decisions. Tomorrow's discussion on risk communication with Dr. Katherine von Stackelberg will be very illuminating. Dr. Sullivan mentioned a number of different ways the SAB could explore this topic but concluded that the SAB discussion should be specific about what is the scope that NOAA should aim for.

Craig McLean said that in a short cycle, Rowan Douglas provided a clear pathway for OAR to know where to update the climate portfolio. After the United National Convention on Climate Change Council of the Parties (COP21) resolution on climate change, the nation is moving past trying to prove causation of climate change and moving more towards how to evaluate the risk.

Jeremy Jackson mentioned it has been over a year and there have been a lot of presentations. He would like to know what NOAA found most useful, and how the agency is valuing these presentation. He thought the most informative was Simon Levin's talk (April 2015).

Strategy Discussion with Jon White, RADM, USN (Ret.), President and CEO, Consortium for Ocean Leadership

Summary

RADM White began his remarks on the need and importance of science-based decision making at the nexus of oceanic, atmospheric and climate science by providing an update on Consortium for Ocean Leadership (COL). Some of the big programs that were run by the original organization, Joint Oceanographic Institutions (JOI), in the past have diminished. COL is still managing the Gulf of Mexico Research initiative (but money runs out in 2020) and Ocean Observing Initiative (OOI). COL needs to envision what is next. The board of trustees wants to go back to advocacy, education, and communication.

Why does ocean science matter and why is it important to people? First, explaining population growth to people is easy - population growth in poor countries is going up; this increases demands for basic needs. This is then put in the context of how many people live near coastline influenced by sea level rise. It is food, water, energy that could be the crisis of our times. It used to be a nuclear holocaust coming but now the crisis is climate change; and not just climate but major changes in the whole earth system.

How do we as a society reduce the risk associated with this new reality and balance risk with sustainability and security? That is a choice that we as owners of this planet need to figure out. RADM White says he goes back to Bob Winokur and the data-to-decision-to-data value chain. It is this chain: decision, impact, analysis, and data (forming a pyramid with data on the bottom and decision on the top). This is where we as a society need to go with ocean science. The research part is the costly part. We as a society need to invest a lot in data and people to do that research. Then how do the non-scientists use this science to get to a decision, and what is the impact? That is the distillation of consequence based on analysis and data. That is the essence of a weather-ready nation – does NOAA issue a watch or warning, or just pay attention? What is not talked about enough about is the two-way flow of information between the scientists and users of the science. What are the decisions in the future that need to be driving everything else? For example, what should Eastport Chemical be doing? They build materials going into aquaculture plants and they want to be involved in the new ocean economy. What can we as a society do to take advantage of the ocean to make it prosperous? What are the decisions we as a society need to make for national security? What do we as a society need to invest in oceanography to win the next war? If terrorist activities have the basis of climate change, what do we as a society need to do? What are the decisions related to response? The Department of Defense (DoD) just released a sea level rise scenario. DoD is moving ahead but are they putting together the right impact and the right scenarios and; that must be related to the public.

This food-water-energy crisis rests in the foundation of atmosphere-ocean-climate. The Intergovernmental Panel on Climate Change (IPCC) will prepare a special report on the oceans

in the Sixth Assessment Report (AR⁶). This signals a need to take a fresh look at the way that earth system research is represented. What are the big decisions that need to be made? For example, how close to the beach does one build a house? What are the opportunities for partnerships that can help us as a society make better decisions with the scientific data? One example of where this may be useful is for autonomous underwater vehicles (AUV) - what is the code of conduct for multiple AUV? In the European Union (EU) there is a code of conduct. Why doesn't the United States have one? What are other opportunities from other partnerships to be brought together?

The topic of COL priorities comes up every year. COL is working on a transition document about emerging priorities which include personal security, national security, and the Arctic. RADM White talked about the need for ships of different kinds: leadership, ownership, partnerships with people that come from different backgrounds. Most importantly is the need for entrepreneurship. Entrepreneurships out there are amazing: how can the scientific community harness them?

Discussion

Eugenia Kalnay said it is great that RADM White talked about population growth and the consequences to nature. She stated it is even worse because the number he used for maximum growth was from the UN in 2006 and now it is even higher. It is unsustainable that consumption doubles every 17 years.

Lynn Scarlett asked if decision making in the context of the pyramid is science-based or science-informed? Data and analysis are not enough to make decisions on. It is the sociology of science and what turns science into action that should be at the top of the pyramid. There are many impacts; consequently, one needs to make choices of what to put resources behind. That is about value sets, not only the data and analysis.

RADM Jon White replied that sometimes when he shows this pyramid starts from applied research. For example good science drives an accurate prediction that NWS uses to communicate impact before a hazardous weather event happens. That is science-based decision-making. –But someone has to decide how to prioritize and what to invest. The people who make the decisions need to be in the same room as the scientists but scientists need to have open conversation. It is key to have access to understandable information. The other key pieces are the accuracy that leads to confidence and trust in what people use. That is achieved through experience, teaching, and education.

Louis Uccellini said Tim Palmer, who is an AMS award-winning researcher, quotes from a paper by Allan H. Murphy, (Wea.Forecasting, 8, 286) that states: “Forecasts possess no intrinsic value. They acquire value through their ability to influence the decisions made by users of the forecasts.” Dr. Sullivan mentioned the national conversation on the severe storm in 2011. NWS had four-days lead time with 96% accurate projection, but 311 lives were lost. This was the same

amount of lives lost in 1974 that only had one day lead time. The problem was the lack of education by people on the difference between a Watch and a warning. Social scientists knew this and made it clear. The time period of the Warning changes how people react. The mistake in 2011 was that NWS assumed if the Warning was extended by 45 minutes, people were going to shelter in place. What people did was drive to family. NOS had a program examining storm surge along the coast. Social scientists helped NOS define what storm surge is in a way that people could use. NOS needed to map it at a hometown and street level with a color scheme that was understandable. This was tested during Hurricane Arthur during the 4th of July weekend and people evacuated. People had to see the risk to them to perceive it. That is becoming the basis of how we will communicate the surge. One of the reasons people on the coast are reacting to sea level rise is that they are seeing it. They see coastal flood watches and warnings, and see the sea walls being knocked over. One word missing on RADM's chart is the outcome, and to link to that outcome. Outcome will drive recognition of risk so there must be a definition of the outcomes. RADM Jon White responded outcome is the balance on the scale.

Dawn Wright said she is taken by the "ships" statement. Who are the entrepreneurs? Entrepreneurs are the people who invest in things like wave gliders; They are people thinking of things at a greater speed and who may come up with solution to problems. Then the right decision needs to be made about investment and policies.

Susan Avery commented on the importance of getting leadership together in partnerships, taking ownership in a national center. Dr. Avery asked if in creating a new leadership-ownership partnership that is a community partnership, would it open up opportunities that are not presently there, and how would NOAA perceive such an arrangement? RADM White responded NOAA may need to be bold about harnessing those communities and bringing them together.

Dr. Sullivan said that ocean and the atmosphere are linked on the planet so it makes sense to link them in intellectual endeavors. It is comparatively easy to make an administrative merger but harder to make an intellectual merger. NOAA needs to know where the links are that are more critical. She commented on the pyramid diagram. This pyramid can be used in two ways. The first is from a programmatic sense in terms of what NOAA should invest in. The second is for the general public, such as a citizen in tornado-prone area. The second situation is quite different from the first. The decision swings on how vivid and tangible the impact and intended consequences are perceived to be by a person. These are all science based processes, but whatever agenda being sustained must address this.

Susan Avery commented that foundational science is missing in this pyramid. Data often helps form the scientific question and also confirm hypotheses.

Rick Spinrad asked what does NOAA lose if it does not more strongly unify communities. Within three years the Department of Energy will have 600 petaflops of data through exascale computing. A decision is being made on what areas to use that for. There are three areas of

consideration: homeland security, health (NIH, bioinformatics), and fully coupled environmental modeling. NOAA must unite oceans, climate, and atmosphere to successfully be considered in the last category.

Molly Macauley said the land system should be added as well. Clever researchers and policy makers can put an arrow back to data in the pyramid. When a decision was wrong, it informs the data one collects. It is really important it does not stop at the top of the pyramid. There is a context in which people and decision makers act. For example in the Soviet Union, it really mattered what winter harvest would look like? They used data from satellites, ground intelligence, and convergence evidence. NOAA needs to have multiple sources of information in the same way.

RADM Jon White said the pyramid could be three-dimensional or it could be turned upside down. The Earth is the core system. Other communities could be brought together as well.

Louis Uccellini suggested adding in the cryosphere as well.

Discussion on Implications for NOAA

Lynn Scarlett began the discussion by saying there have been a lot of rich presentations, all with the potential to help inform NOAAs thinking and doing in the mid-term. As NOAA looks ahead towards the future, it is helpful to have that informed by the SAB as they build the case for moving in new directions and take advantage of new technology and techniques.

Bob Winokur brought up RADM Jon White's pyramid. The bottom line of the pyramid is data in the context of the technology to get the data. NESDIS is considering cubesats and minisats; OMAO is considering ship-based technology. Now UAV (unnamed autonomous vehicles), AUV (autonomous underwater vehicles) and satellites can complement ship-based and other traditional measurements. He suggested the SAB have a discussion on the future of autonomous systems in the context of ships and other platforms.

Lynn Scarlett summarized the previous discussion that the five areas the SAB has flagged were (1) compressive sensing, (2) remote sensing and cubesats, (3) autonomous systems and relationship with existing observation systems, (4) risk, risk thresholds, and communications, and (5) micro miniaturization.

Bob Winokur said that he had just seen the movie Eye in the Sky. The movie is grounded in technology surrounding modern warfare and use of unmanned aerial systems (UAS) that observe and kill people. There is a large ethical aspect to the movie working its way all from Global Hawk to micro UAS. This is where technology is going.

Susan Avery said unmanned systems are much more difficult in the ocean. Just having the platforms is not adequate enough. There needs to be miniaturization of sensors and new types of

sensors that can read biophysical actions. Miniaturization of sensors will give throughputs that get to commercialization beyond the research field.

Rick Spinrad wants to clarify platform issues versus cubesats. The exciting thing about cubesat is the point Marcia McNutt made about being in a golden age with cross calibration.

Everette Joseph said data science is important to consider. As these new platforms create more data, we need a way to manage all of this information. What are the innovations in data science that can be important to NOAA?

Craig McLean said he got to visit the first Nanolab. A larger question is what are the suites of technology that can answer scientific questions. NOAA should be contemporary enough to know what technology is being provided and give input to the manufacturer for other uses. Dr. Sullivan wanted to know how to address these questions further. NOAA could use the SAB, visits to places with cutting-edge technology, synthesizing existing information. How would NOAA keep track of opportunities and decide what to do? She suggested brief papers on topics of interest. Lynn Scarlett directed the conversation to what is next and who will be working on these reports.

Eugenia Kalnay said there are new instruments to be used for data simulation that weren't conceived of 5-10 years ago. Accuracy versus quantity of observations also has to be considered.

Peter Kareiva mentioned the idea that the SAB go out and investigate these areas, and comes back with one of four answers, (1) okay to ignore, (2) pay attention, (3) need to explore this in more depth immediately, and (4) urgent to change research portfolio. He also noted that machine learning is a new enterprise now on which NOAA should focus.

Lynn Scarlett said there are several needs. . Three areas that have come up repeatedly: (1) sensing technology, linkages to existing technologies (2) data science, incl. machine learning (3) risk module.

Kathy Sullivan said one other to add is global environmental modeling in the exascale computing era.

Jeremy Jackson said there is grave uncertainty about the biological health of the oceans, which relates to atmospheric chemistry and ocean chemistry. If one considers only physical and chemical issues and biology related to just fisheries, something big is being missed. He noted that Simon Levin in his discussion with the SAB talked about the serious uncertainty about the future biological health of the ocean

Dave Fluharty said ESMWG is considering the linkage of these things and would circulate the terms of reference for that idea to the SAB.

David Lodge said there are a lot of emerging genetic technologies, new tools, 'omics, eDNA that are increasingly information-rich that relate to biodiversity - monitoring in ways that where the

benefits are unclear but may be useful to pursue. The National Academy of Science is just finishing a study on this.

Susan Avery added the omics revolution getting at the biological functioning of the ocean. There are huge data issues associated with this as well.

Kathy Sullivan replied that we need to have something biological in the first set of topics to be considered, especially with regard to NOAA ecosystem-based management work.

Jeremy Jackson added that NOAA must understand ecosystems to protect them. There needs to be consideration of the whether boundaries of biology in the ocean are well understood and if there is a danger those biological boundaries are being surpassed. The role of climate change in this should also be factored in.

NOAA and the SAB agreed to move forward with some brief issue papers for the next meeting that would provide background and an assessment in the context of the four categories Peter Kareiva suggested. Members agreed to address the following topics. NOAA will provide background papers to get these started.

Exascale Computing – Eugenia Kalnay

Risk Communication – Peter Kareiva

Compressive Sensing – Everett Joseph and Susan Avery

Data Science - Dawn Wright

Ecosystem science and ‘omics – David Lodge, Susan Avery, Jeremy Jackson

Friday, 29 April

Recap of Thursday Strategy Session

Lynn Scarlett, The Nature Conservancy and Chair, NOAA SAB

Kathryn Sullivan, Under Secretary of Commerce for Oceans and Atmosphere

Richard Spinrad, NOAA Chief Scientist

Lynn Scarlett started by summarizing the history and situation as it exists now with the strategy discussions. First, over the past two years, the SAB has brought in a variety of speakers with the knowledge to help the NOAA Administrator and Chief Scientist. This has been an effort to transform the way SAB operates. The SAB now needs to translate this information into something meaningful. Based on yesterday’s discussion there is now a path forward that will provide more a more intensive look at some critical topics and leave this Administration with ways to answer important emerging science and technology questions.

Second the SAB discussed its working groups. That is part of the larger orientation of the SAB and will help this Administration and future administrations use working groups to drive towards information, science insights, and technological insights. Ms. Scarlett was not sure where discussion of working groups is headed, but she appreciated candid comments from working group chairs and from NOAA leadership.

Kathy Sullivan largely echoed Ms. Scarlett's comments. These speakers have been valuable for NOAA and it is good institutional hygiene to look at and think deeply about any entity such as the SAB. She has been appreciative of the spirit, energy and wisdom with which the SAB has participated in these discussions. The individuals who are going to explore five of these topics for the next meeting will make the best use of the SAB talent around the table.

Dr. Sullivan also mentioned that the NOAA Office of the General Counsel has been taking a comprehensive look at all NOAA federal advisory committees making sure they are running smoothly. NOAA leadership will bring all of that together into a synthesis and come back to SAB to rethink how to move forward.

Rick Spinrad said we live in a world of indicators, whether it is health of ocean or improved weather forecasts; it is the same thing for the SAB. The level of engagement and excitement on the part of the SAB and NOAA leadership is very high right now, and that is exciting.

Lynn Scarlett said listening to both Dr. Sullivan and Dr. Spinrad leads her to think about the elements of institutional hygiene. Ms. Scarlett highlighted a few that inform how the SAB operates: (1) multi-directional communication flows, (2) people and technical capacities aligning to fulfill NOAA's mission, (3) mechanisms to help hone and focus priorities, (4) innovation in the context of a changing world, (5) adaptive management, (6) transparency, and (7) the ability to identify, generate, and distribute relevant knowledge in all of its forms.

Strategy Discussion with Invited Speaker

Katherine von Stackelberg, Harvard University

Dr. Sullivan introduced Katherine von Stackelberg, a research scientist at Harvard University, T.H. Chan School of Public Health, Center for Health and the Global Environment. Dr. von Stackelberg studies human health and risk analysis, working at the intersection of science and decision making. Dr. Katherine von Stackelberg started off explaining the Center for Global Health and the environment at Harvard operates under the goal of helping people understand our health and the health of our children depends on the health of the environment. She noted that protecting the environment improves lives, and biodiversity informs all health on earth. From the Microbiome to ecosystems, there is no context where biodiversity is not important. The World Health Organization (WHO) recently came out with a report that all human well-being depends on biodiversity. Food choices are another subtopic at the Center under human health and the environment.

Risk assessment has been around since the mid-1980s. Risk assessment had been used in engineering, and when its use was shifted to natural and biological systems, stochasticity and uncertainty came into play. The field was focused and reductionist, chemical by chemical, at the start. Now there is a toxicity piece that is much broader and more cumulative. Toxicity is incorporated into outcome pathways.

Dr. von Stackelberg mostly looks at ecological risk using Bayesian networks to construct contaminants and other stressors, ultimately looking at risk to the fish population. Risk analysis is more qualitative, and Dr. von Stackelberg is looking for new tools to make it more quantitative. The AOP (adverse outcome pathway) is useful. This is used by the US Army Corp of Engineers (AOPexplorer.org) and USEPA.

Dr. von Stackelberg's other affiliation is the Harvard Center for Risk Analysis. This center focuses on making better decisions, knowing that decisions involve tradeoffs. Risk is the probability of an adverse outcome. Dr. von Stackelberg works with the technique of willingness-to-pay to understand the decisions people make about their choices. She also has developed multi-decision framework using objective findings, different criteria, and many pieces of information about the entire system that enables a mathematical analysis. This gives a quantitative basis for decision making.

Another project is on the biogeochemistry of global contaminants. The overall goal is to understand how biogeochemical processes affect the fate, transport and food-web bioaccumulation of trace metals and organic chemicals in aquatic ecosystems. This will allow scientists to characterize how changes in climate and emissions affect human and ecological health, and the potential impacts of regulatory actions.

The built socioeconomic environment sits within the natural environment. Ecosystem services, defined as benefits derived from natural environment to humans, are the way in which people interact with the natural environment. A few things are problematic. Ecosystem services are an attempt to use language of economics to manage natural environment. Dr. von Stackelberg recommends thinking the other way, using the language of natural environment to manage economics. Ecosystems can degrade as human well-being improves. GDP don't include the idea of a natural capital. Values dictates what ecosystem services are emphasized. The Framework Institute did a survey in the urban environment and asked people their opinion about nature. People in the study saw nature as something to consume. There can be more work with stakeholders to realize the inter-connections. These challenges are just opportunities. This is the best opportunity at being able to make improvements in the natural environment. Biodiversity is the foundation across ecosystem services and it may be important to capture when evaluating ecosystem services. Additionally, contingent valuation analysis fails to work in some cases.

There are opportunities within NOAA vision and mission to engage in risk assessment. Weather is the way people experience climate, there is a way to make that connection in a concrete way.

Resilience and preparedness in coastal fishing communities are another way people are connected. Food is not a commodity; it is a livelihood and in coastal communities fisheries are something beyond that. NOAA can do more with big data. Producing data and constructing a model is not enough. Now we are in an era in which individuals can choose to believe in things or not, making evidence so important. People can interpret evidence in different ways. Relationships and trust are important now that people are much more proactive about absorbing and working with scientific evidence and data (ex. second opinions at the doctor's office). Citizen science and participation will be important in decision making. Additionally, the balance needs to be different – there must be balance social and environment within the larger framework.

There is a localized impact of climate change. One example is temperature induced changes in distribution of commercially fished species. The existing fisheries management structure is unable to address how to manage these shifting stocks. A solution could be to manage in a way that lowers social vulnerability.

There is a large issue with seafood waste in the US. 90% of seafood eaten in the US is not obtained for the US and 40 – 47% of edible seafood was wasted during 2009-2013 (that equals 1 million metric tons lost). The bulk of this loss happens at consumption. How can this be changed?

The incentives to improve fisheries status are based on conventional economic metrics that fail to account for the fact that the natural environment impacts all domains of human well-being and sustainability, including the economy. Community supported fisheries and civic fisheries are emerging to support local economies, reducing dependence on international fish. There are many examples of sustainable and organic fishing, and NOAA is at the cross roads to bridge that gap.

There needs to be a better way to finance the transition to a sustainable blue economy. Sales-based and gross domestic product (GDP) do not capture the true value of fisheries. Citizen science, and for example Fishackathon 2016 (an opportunity for coders to get involved in developing apps for fish management) are tools to use at a local level.

The best way to implement any solution will be at the local scale. Social media is a way to access people and their behaviors, whether it be tweets following an event, or Fitbit data to map green spaces. The goal is to have thriving human communities and the best way is through environmental protection. This needs to be bottom-up where people want to make changes because they understand how it affects their well-being.

Discussion

Dawn Wright said she would add coastal and marine spatial planning to the list of how Dr. von Stackelberg's research aligns with NOAA's mission. There are a lot of GIS-based decision analyses to evaluate trade-offs.

Peter Kareiva said ecosystem services don't reflect entirely how an ecosystem is used. The Natural Capital Project has completed 26 projects where real decisions were changed, involving economists who did the valuation. In the end, the project never asked for dollar figure. In a sense it is to show important stakeholders that you respect their values, but never asked for a dollar summing up. Valuation is a sign of respect for business and economic development community.

Jeremy Jackson asked if are there examples of cases where the perspective Dr. von Stackelberg summed up at the end were acted upon with a positive and desired result. It is valuable when there are tangible examples that communities looked at a problem in a certain way, refocused, and achieve an outcome that made everyone happy. Dr. von Stackelberg replied in Metropolitan area planning, the commission looked at human well-being and how decisions are being made. Local communities are proactive and figuring out ways to navigate climate change.

Eugenia Kalnay explained humans are doubling consumption of natural resources every 17 years. This brings urgency to changing behavior.

Susan Avery asked Dr. von Stackelberg to reflect more on the whole concept and dialogue of the blue economy. Dr. Avery is worried that the European and Asian definition is more resources and assets on the continental shelf which couches it as an extractive industry. Science is also pushing blue economy as an ocean knowledge economy, pharmaceutical, biotech. Ocean health fails in biodiversity health interconnectedness. Dr. Sullivan responded that it is an interesting tension, everything that happens with the coastal environment happens in the coastal communities. Therefore stakeholders need to be educated and be participants in this. All of the pieces are there but the effective integration like the Natural Capital Project has the best chance of educating people making decisions and helping people make the right kind of decisions. It is an opportunity for people to improve their decision making, and use those data in a more efficient way. It all starts with coastal communities and allowing them to enhance well-being and productivity with a more effective working relationship with the environment.

Molly Macaulay said we need to use different approaches in different decisions. The President asked agencies to incorporate ecosystem services into their practices. Dr. Sullivan replied that ecosystem services came into being through natural capital. Dr. Macaulay asked about the use of the word endurance. Dr. Sullivan responded that the definition of sustainability is thriving and not just meeting your own needs while letting the future worry about its needs. The goal is a system that endures in the face of changing climate and complexity.

Discussion on Implications for NOAA

Lynn Scarlett, The Nature Conservancy and Chair, NOAA SAB
NOAA Assistant Administrators and SAB members

The board members and NOAA leadership discussed the implications of this research for NOAA. They agreed that the trade-off between pursuing economic need and social needs should be captured when using the framework of ecosystem services. They discussed when moving beyond ecosystem services, biodiversity is an important metric to consider when assessing ecosystem health, and its impacts on human well-being. Dr. Sullivan concluded the discussion stating that to best connect biodiversity to human well-being and happiness, there needs to be a better understanding of just how much human well-being depends on the natural environment.

Integrating the Social Sciences into NOAA's Mission

Tracy Rouleau, NOAA Deputy Chief Economist

Summary

The purpose of the briefing is to provide an update on in the status of social science in NOAA. Social science includes a host of disciplines and bridges the gap between what NOAA does and human well-being. Social science can help NOAA's mission in a many ways including managing and communicating risk, valuing NOAA's products and services and valuing what is at risk, enhancing and valuing stewardship, linking earth systems to human well-being, and measuring long-term successes and societal impacts. In 2015 NOAA released a social science vision and strategy document that had three goals: understanding, defining and measuring NOAA's impact on society; ensuring that NOAA's products and services strengthen societal decision-making; and institutionalizing social science to further NOAA's mission.

Ms. Rouleau spotlighted activities in support of each of these goals.

Measuring and Defining NOAA's Impact on Society

On the goal of measuring and defining NOAA's impact on society, in March 2016 NOAA and the U.S. Geological Survey hosted a workshop on the value of scientific information, focusing on satellite data. One outcome of this was to establish a community of practice to practically apply what is known on the value of information.

Ensuring NOAA's Products and Services Strengthen Societal Decision-making

For the goal of strengthening societal decision making, Ms. Rouleau highlighted several activities on ecosystem services. On day- to- day work NOAA is working to respond to the Office of Management and Budget (OMB)'s memorandum, "Incorporating Ecosystem Services into Federal Decision-Making", an overarching policy document that includes requirements for identifying what agencies are doing and best practices in the first phase. OMB and The Council

on Environmental Quality (CEQ) are working with agencies to provide more specific guidance and best practices. The guidance will be released later in 2016 at which point agencies will revise their work plans as needed. Ms. Rouleau also highlighted the OSTP report Research Needs for Coastal Green Infrastructure, which was the post- Superstorm Sandy focus for the Administration. NOAA's goals for ecosystem services include:

- Integrate ecosystem services approaches into relevant NOAA priorities
- Strengthen connections between NOAA's ecosystem research and ecosystem services information needs
- Integrate needed support for ecosystem services approaches into existing policies
- Support the development and appropriate use of existing methods and tools
- Effectively communicate, within NOAA and externally, ecosystem services concepts and project outcomes to promote collaboration and deliver management outcomes

Post-OMB guidance NOAA's immediate actions: undertaking a comprehensive review of its policies and programs; providing senior-level direction to integrate ecosystem services. In the NOAA response to OMB, they included a set of principles including tying ecosystem services work to decisions making.

Institutionalizing Social Science to Further NOAA's Mission-Performance metrics

There is a pilot in NWS to pilot societal outcome indicators to track NWS progress on four metrics: become better informed, get prepared, take action, and avoid injuries. A draft report on this project is due soon. Ms. Rouleau also highlighted work with the NSF that could advance social science work with current and potential cooperation areas to include: National Water Center; Activities at NSF and /or NOAA observatories, centers and networks; and at the nexus of food, energy and water systems solicitations.

Next steps on social science-NOAA will work on actions to implement OMB policy, implement social science vision and strategy, develop social science training modules, and complete the risk communication and behavior report.

Discussion

Everette Joseph said it was nice to see a broad overview of social sciences and asked if the work funded existing NSF researchers on existing projects to focus on NOAA issues and how to incentivize researchers. Tracy Rouleau said they contacted researchers but nothing yet has been awarded. Dr. Everette asked if NOAA was leveraging Cooperative Institutes (CIs) and Cooperative Science Centers as well as NSF. Ms. Rouleau said the social science report does not call for that; currently NOAA is taking advantage of ongoing opportunities but the program would like to work with Cooperative Institutes in the future. Rick Spinrad said on the CIs, they

are making a recommendation that the prospectus to establish a CI will formally include more specific language on social science. In the NOAA Strategic Research Guidance Memorandum, decision science was identified as a priority.

Russell Callender thanked the social science team and said he encouraged the strategy to engage with community through the Sea Grant, Coastal Zone Management and National Estuarine Research Reserve programs.

Ecosystem Services Valuation Report from the Ecosystem Sciences and Management Working Group

Robert Johnston, Clark University and Member, ESMWG

Summary

NOAA requested a review of its use of Ecosystem Service Valuation (ESV) from the Science Advisory Board. The SAB's Ecosystem Sciences and Management Working Group (ESMWG) took on this task. The ESMWG reviewed the use of ESV in NOAA using a number of methods including semi-structured interviews with NOAA staff; literature reviews of NOAA documents that describe the decision-making contexts within which ESV might play a role; scientific literature describing ESV methods, applications and use of ESV by federal agencies; and extant federal guidance.

The report identifies a number of findings and recommendations; some key ones are listed below.

The practical impact of recent federal mandates to incorporate ecosystem services information “where appropriate and practicable” is reduced by individual agency and line office decision-making contexts which, as currently established, often restrict the role of ESV.

- Constraints in the capacity to conduct ESV imply that the direct relevance of these estimates—or the capacity to use ecosystem service valuation to meet line office mandates—will be an important determining factor in the use of ESV.
- There is a need to clarify exactly when and how ESV is relevant to specific decisions made by NOAA, including how the scale of ESV matches the scale at which decisions are made. This requires a move away from general, vague mandates to “consider ecosystem services.”
- There is a need to reconcile management mandates with ESV—such that ESV has an impact on decisions.
- Ideally, ESV should be implemented in a way that is organic and central to NOAA's mission and the context of agency decisions, and that helps inform and enhance decision-making. Given the constraints facing the agency, however (e.g., current structure of the line offices, decision-making contexts, resource constraints, lack of social science capacity), there is a concern that ESV will be conducted *pro forma* in order to meet new mandates.

NOAA has the capacity to conduct high-quality ESV, particularly in a few targeted areas (e.g., fisheries). However, NOAA currently lacks the internal capacity (particularly in social science) to apply high-quality ecosystem service valuation broadly across the Agency, and to significantly expand applications of ESV.

- Although there is increasing discussion of ESV across the agency, a large proportion of direct applications are to recreational and commercial fisheries.
- The frequent highlighting of individual ESV success stories across the agency can obscure the fact that comprehensive ESV (outside of a few targeted services) is rarely implemented.
- Reliance on “one-off,” isolated studies of individual ecosystem services—while useful to inform (or highlight the value of) NOAA activities in specific cases—is unlikely to have a meaningful influence on the way NOAA approaches its mission.

Greater attention is needed to the assessment of the validity of different methods for ESV, as related to the need for accuracy in different decision contexts. The *perceived* validity of some methods within the agency does not reconcile with the *objective* validity of these methods as evaluated by the scientific community. The distinction between perceived and objective validity/accuracy is particularly relevant for methods such as stated preference valuation, different methods for benefit transfer, and the use of off-the-shelf decision-support tools.

There is a need to distinguish better measures that may be interpreted as appropriate measures of economic value, versus other economic or monetary measures (e.g., jobs, economic impacts) that do not reflect economic values.

There is a concern that too much emphasis is placed on off-the-shelf decision support tools that rely on some of the least accurate methods for ESV, particularly with regard for economic aspects of valuation.

- Given current practice in these tools, even the best developed should be used when more accurate methods are infeasible, and when inaccurate estimates of value are acceptable.
- Care is needed to distinguish tools and methods that generate valid and consistent measures of ecosystem service value, versus methods that generate monetary and non-monetary metrics that are not meaningful as economic value measures.

Valid and accurate ESV requires the direct involvement of natural science and economic experts from the outset, to ensure that integrated methods are applied from initial scoping through data collection and analysis.

- Valuation is about human behavior (trade-offs / responses). It is important to incorporate the human behavioral responses as part of the overall context of the ecosystem services assessment and decision-making approach.
- The construction of the “ecological production function” in various contexts (Ecosystem-Based Fisheries Management, Integrated Ecosystem Assessments, policy analysis, etc.) is among the most challenging issues limiting the application of economic analysis including valuation.

It is often reported that accurate measurement of ESV can inform and improve decision making. A corollary to this statement is that in certain cases incorrect or suboptimal decisions may be made if ESV is not used. Without incorporation of the most significant market and non-market values into decision making it is possible to select options or policies that are not the best for society.

- In general there is a risk of making the incorrect decision regarding investments (e.g., restoration investments), policy decisions or regulatory actions if significant ecosystem service values are excluded.

Among the most important steps that can be taken by the agency is development of careful and clear recognition—across the whole of NOAA—of:

- Whether and how ESV is relevant to different types of decision contexts that occur at different spatial and temporal scales,
- How ESV can be integrated as an organic and core part of NOAA's mission, and in what areas this makes sense,
- The types of methods suitable to measuring different types of values, and the true advantages and disadvantages of these methods,
- What additional capacity—at a minimum—is required to address new mandates for ecosystem services research within the agency?

Discussion

Peter Kareiva asked if the Federal Resource Management and Ecosystem Services Guidebook (a training manual to help resource managers integrate ecosystem services concepts and methods into management and planning) was useful, and whether having a NOAA-wide workshop or other training could be first steps toward education?

In response, Robert Johnston said the guidebook is useful as a place to start, as an overview of ecosystem service methods at the 30,000 foot level, but is not sufficient alone. Workshops are useful, but require follow-through to put these ideas into action.

Molly Macauley liked the concept of ecosystem services but valuation made her nervous; did the group discuss how to determine if the value is right and what you do if it is found to be wrong? The social cost of carbon is agreed-upon valuation; it is an interagency value all agencies use but are there examples agencies agreed on that could be illustrative? Robert Johnston said the goal of ESV is to quantify changes in social welfare caused by actions that affect ecosystem services. To assess the reliability of different valuation methods (for evidence of whether these methods provide correct answers), one option is to use convergent validity in multiple ways to see if one gets same answer. Another option is to look at human behaviors corresponding to ESV changes, to see how well the calculated values correspond to behaviors that we can observe. In terms of

getting it wrong, for different decision contexts, different levels of accuracy are needed, and the literature provides information on the type of accuracy provided by various tools. The report does not consider the social cost of carbon. This is a relatively standardized approximation of social values associated with changes in carbon emissions that may play a role in some types of ESV, but has little to do with the primary challenges of ESV at NOAA.

Kathy Sullivan the report states that NOAA should include detailed guidance and asked if there are any exemplars to consider. Robert Johnston responded that the Environmental Protection Agency (EPA), for example, provides specific guidance for economic valuation and benefit transfer methods that are used for ESV, as well as reports addressing ESV at the Agency. EPA supports the National Center for Environmental Economics to oversee guidance for economics, including ESV.

Dawn Wright said there is a parallel effort with work on earth observations for global ecosystem mapping for ESV; it is led by USGS and NOAA is involved. Is it possible to share the insights from the SAB working groups with agencies that are working on this issue? Kathy Sullivan said the big Global Earth Observing (GEO) effort, will be presented with various methods will have to determine what to use

Eugenia Kalnay asked if the evaluation of the state of health of biodiversity is included in the valuation. Rob Johnston said there a lot of work on ESV in relation to biodiversity; ESV tries to determine why and how biodiversity benefits people. It is critical to recognize that this is only one aspect of the ecosystem; it is hard to measure biodiversity itself and harder to trace it through all systems to human benefit. In many cases it is not biodiversity itself that is beneficial to people, but rather other things that are “produced” by or related to biodiversity.

Lynn Scarlett thanked the ESMWG for the report and noted the field is changing and the way the report linked it to NOAA applications is commendable. What should be done with ESV is to enhance understanding of the value of ecosystem services in decision-making: it is not typically the case that there is a single right answer.

A motion was made by Jean May-Brett to accept the report, seconded by Everette Joseph. The report passed unanimously and will be transmitted to NOAA.

Review of Actions

Cynthia Decker, Executive Director, SAB

Action 1: SAB members will provide brief papers on five issues for discussion at the August 2016 SAB meeting.

Responsible Party: SAB

Point of Contact: Eugenia Kalnay (exascale computing); Everette Joseph/Susan Avery (compressive sensing); Peter Kareiva (risk communication); David Lodge/Susan Avery/Jeremy Jackson (ecosystem science and 'omics); Dawn Wright (data science)

Due Date: July 15, 2016

Action 2: NOAA will provide a memo on the issue paper deliverables and five issue papers.

Responsible Party: NOAA Chief Scientist Office/SAB Office

Point of Contact: Rick Spinrad/ Cynthia Decker

Due Date: May 2016

Action 3: SAB members will provide comments to NOAA on the Cooperative Institutes in the 21st Century document.

Responsible Party: SAB to NOAA Chief Scientist Office

Point of Contact: Lindsey Kraatz

Due Date: May 15, 2016

Action 4: SAB will transmit the report on Ecosystem Service Evaluation to NOAA.

Responsible Party: SAB

Point of Contact: Lynn Scarlett

Due Date: May 31, 2016

Action 5: NOAA and SAB will discuss the SAB Concept of Operations and SAB Working Group Concept of Operations prior to a more general discussion at the August 2016 meeting.

Responsible Party: SAB/Chief Scientist Office

Point of Contact: Lynne Scarlett/ Rick Spinrad

Due Date: July 2016