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**56th Meeting of the NOAA Science Advisory Board  
2-3 August 2016**

Location: Bryant Conference Center  
Rast Conference Room  
University of Alabama at Tuscaloosa  
240 Paul W. Bryant Dr.  
Tuscaloosa, AL

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; Walter Faulconer, Vice President, SGT, Inc; 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, Cornell University; Dr. Jennifer Logan, Harvard University (ret.); Ms. Jean May- Brett, STEM Partnership Coordinator, Louisiana Department of Education (ret.); Dr. Richard Moss, Senior Scientist, Joint Global Change Research Institute, Pacific Northwest National Laboratory; Dr. Denise Reed, Chief Scientist, Water Institute of the Gulf; Dr. Stephen Polasky, Professor, University of Minnesota; and Mr. Robert S. Winokur, Consultant (ret. NOAA, Navy)

**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; Ms. Mary Erickson, Director, National Centers for Coastal Ocean Science, NOAA National Ocean Service; Mr. Craig McLean, Assistant Administrator, NOAA Office of Oceanic and Atmospheric Research; Ms. Laura Furgione, Deputy Assistant Administrator, NOAA National Weather Service; Dr. Richard Merrick, Chief Scientist, 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. Cynthia Decker, Executive Director, Dr. Laura Newcomb and Ms. Mary Anne Whitcomb

DRAFT

**August 2, 2016**

**Commemoration of our Colleague Molly Macauley**

Lynn Scarlett, The Nature Conservancy and Chair, NOAA SAB Chair

Kathryn Sullivan, Under Secretary of Commerce for Oceans and Atmosphere

SAB Members

On July 8 our colleague Molly Macauley was murdered. We have held her in high esteem as a colleague and a friend. Lynn Scarlett highlighted some things that came to her mind and recur in tributes to Molly. The first is Molly was an incredibly bright person who applied this intellect to thinking of so many topics from her work on space economics and space exploration to environmental economics at Resources for the Future. Here at the SAB the work of NOAA, she contributed to discussions on coastal resilience, earth observations and other topics. Lynn Scarlett said she also knew Molly as a person of incredible kindness and graciousness. Lynn worked with her at Resources for the Future for four years and Molly cared about her work and what was happening in her life. Molly provided guidance to young people and mentoring. As a public servant, everything was driven by making the world a better place. Molly always said NOAA work was incredible and we have to elevate the visibility of the work. Her public service championed the work of agencies and always she thought of how to address challenging problems and bringing substantive analysis to problems and helping to inform solutions. Molly was a friend and colleague and will be much missed. There are some blog opportunities through RFF and NASA if any SAB members would like to express their feelings.

Kathy Sullivan echoed Lynn Scarlett's sentiments and shares them fully. She said reading the blogs encouraged her to see how Molly's work will live on through work of others. Resources for the Future is hosting a memorial to Molly on September 23 and will provide details to SAB members. She will give a lecture at Resources for the Future in October and will encourage them to make this an annual lecture for Molly.

There was a moment of silence in memory of Molly Macauley.

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

Lynn Scarlett, The Nature Conservancy and Chair, NOAA SAB Chair

Lynn asked new member Richard Moss to introduce himself. Richard Moss said he is senior scientist at Joint Center for Global Change, collaboration between Pacific Northwest National Laboratory and the University of Maryland. Work at the Center is in the interface between natural and social sciences focusing on climate change.

Lynn Scarlett reminded the group that there is a continuation of strategy sessions started 18 months ago with speakers from various areas. Today we will have some of the first efforts to pull all of that together through discussions of issue papers written by the SAB members. These issue papers are a terrific basis for taking this thought process in a direction for impact and import for NOAA and Lynn Scarlett thanked the authors.

DRAFT

### **SAB Consent Calendar**

Lynn Scarlett, The Nature Conservancy and Chair, NOAA SAB

- April 2016 SAB Meeting Minutes
- Working Group Status Reports

Lynn Scarlett asked for approval of the consent calendar items. Jean May-Brett made a motion to approve; Michael Donahue seconded the motion, which was approved unanimously.

### **NOAA Update**

Kathryn Sullivan, Under Secretary of Commerce for Oceans and Atmosphere

#### Summary

Kathy Sullivan said the NOAA Update will begin with personnel updates and then will provide some “deep dives” on coral and status of water, Arctic and marine conservation and conclude with updates on the four NOAA priorities.

#### Personnel Updates

Tom Karl, Director of NESDIS, retired after 41 years as the Director of the National Centers for Environmental Information (NCEI). At his retirement celebration representatives from Ashville and NCEI emphasized that the system of innovation at NCEI was due to Tom Karl’s vision to create innovative structures and mechanisms to link public data to non-public and private sector partnerships.

The New Sea Grant Director, Jonathan Pennock, has started as well as the NOAA Chief Economic Advisor, Monica Grasso.

#### Corals

In June NOAA announced that higher-than-normal sea temperatures will increase coral bleaching for the third straight year - the longest global bleaching event on record. Worldwide over the last two years, 40% of reefs internationally and 72% of reefs in the U.S. have experienced thermal stress conditions that may have caused bleaching and mortality of corals.

In the Great Barrier Reef half of corals in upper third of the 2,300 km reef in Lizard Island died; in the entire Great Barrier Reef 22% of the corals were killed and 93% were impacted. Further, severe bleaching is likely in Micronesia, Palau, and the Marshall Islands, Hawaii and the Caribbean. NOAA’s role in addressing the response to coral bleaching in the U.S. is through the place-based Coral Reef Conservation Program. The goal of the program is to restore US coral reefs focusing on three threats- climate change, land based pollution, and unsustainable fishing practices.

On the science side, NOAA’s National Coral Reef Monitoring Program provides a strategic framework for conducting observations of biological, climatic and socioeconomic indicators while the Coral Reef Watch incorporates polar and geostationary satellite data to monitor thermal stress on coral reefs in near-

DRAFT

real time. Emerging areas of science focus includes coral genomics to understand species genetics associated with resilience and directed interventions to protect corals from stressful temperatures.

#### Water Update

Three national water “conversations” between NOAA and stakeholders were completed this year in Tuscaloosa, Sacramento and Washington DC. One key message heard overall was to start with the decisions where water information is needed and work backwards for science and modeling needs. Another message was to sharpen focus on keeping things simple; often detailed science papers are not what are needed. For example, for service, NOAA should tune its service delivery to working needs of real decision-makers. The meetings highlighted the high value of case studies as learning vehicles. Stakeholders also called on NOAA to sustain engagement on water across partners and to remove boundaries to collaboration. There were requests to make data and metadata discoverable and accessible and to grow boundary-spanning partnerships that foster wider engagement. NOAA was encouraged to develop further connections with urban and land use planners who have little hydrology background so that urban plans take hydrology into account from the beginning.

NOAA is providing feedback from meetings to stakeholders and using this to inform NOAA’s integrated water strategy and the National Water Center agenda.

#### Arctic Update

David Kennedy is serving as the senior Arctic team captain, which will now be housed in NOS. There is a steering council with an organizational home in NOS but the program will continue to function across NOAA Line Offices.

The White House is hosting an Arctic Science ministerial meeting in September to expand collaborations focused on science, research, observations, monitoring and data sharing.

#### Marine Conservation

The International Union for Conservation of Nature (IUCN) World Conservation Congress is meeting in Hawaii in September, the largest conservation meeting to date in the US. NOAA will capitalize on the IUCN’s convening power of 6,000-10,000 people to foster collective commitments, forge new partnerships and relay NOAA’s conservation successes at the 50+ events at the Congress. NOAA also plans to announce 4-5 exciting new efforts that highlight the culmination of marine conservation and living marine resource protection work. Kathy Sullivan will attend.

Kathy Sullivan will lead NOAA’s participation at the Our Ocean’s Conference in September. Secretary Kerry will host the conference with the intent to use the meeting to catalyze international action to protect our shared oceans and resources. At the 2015 conference NOAA announced a Memorandum of Understanding with Cuba on Marine Protected Areas (MPAs). Top issues for this year’s conference include blue carbon, ocean acidification and climate change, marine pollution and MPAs and sustainable fisheries and fighting illegal, unreported and unregulated fishing.

## Updates on NOAA Priorities

As a reminder the NOAA priorities are:

1. Make communities more resilient
2. Evolve the National Weather Service
3. Invest in observational infrastructure
4. Achieve organizational excellence

## Resilience

Harmful Algal Blooms (HAB) are increasing along the coastline in the US due to runoff of nutrients into coastal waters and warmer water temperatures. In southeastern Florida, Governor Rick Scott declared a state of emergency as a result of freshwater HABs in that area. The Environmental Protection Agency (EPA) is leading the Federal response to HABs in freshwater and NOAA leads the response in coastal waters and the Great Lakes. In NOAA the National Centers for Coastal Ocean Science (NCCOS) are coordinating with federal and state agencies to provide imagery for monitoring in Lake Okeechobee and has issued condition reports. The Office of Protected Resources in NMFS is coordinating with Florida officials to monitor the bloom and its impact on resident populations of dolphins and manatees. In terms of research, the Great Lakes Environmental Research Laboratory (GLERL) is sampling and conducting field experiments to better understand the drivers of this particular bloom in Florida.

In July NOAA predicted that western Lake Erie will see a smaller bloom than in 2015. NOAA will deploy an Environmental Sample Processor (“lab in a can”) in Lake Erie in September, the first use of this technology in freshwater, to collect water samples and analyze them for algal toxins.

In June NOAA announced the appointment of 15 members to the new Advisory Committee for the National Climate Assessment. The committee will advise NOAA on sustained climate activities and products, including stakeholder engagement, on an ongoing basis.

## Evolve the National Weather Service

### Forecasting Model Updates

NOAA recently completed a significant step toward building the Next Generation Global Prediction System (NGGPS) by selecting the dynamic core, the engine of the numerical weather prediction model that will enhance resolution of forecasts. To ensure impartiality in the selection of a new core, a Dynamic Core Test Group was formed and completed their selection in an open and transparent process. After thorough testing and evaluation, results showed the FV3 dynamic core developed by the Geophysical Dynamics Laboratory performed best.

At the last meeting, NOAA reported that the National Blend of Models (NBM) version 1.0 was implemented into production by the National Centers for Environmental Prediction in January. The second version, v.2.0, will be implemented in September and will expand the NBM coverage to Alaska,

DRAFT

Hawaii, and Puerto Rico. The NBM creates a seamless starting point for the national forecast picture by blending models using advanced calibration and computing techniques to create more accurate and consistent forecasts and free up time forecasters to devote to adding in local-level detail.

Other important model improvements were made possible due to increased supercomputing power acquired earlier this year. The Global Forecasting System (GFS) model was upgraded to 4D data assimilation, taking into account how weather systems evolve on a 3D spatial grid over time. The GFS model is run four times a day with each update forecasting out to 16 days. With the new GFS, the model delivers hourly forecast guidance out to five days, instead of every three hours as before. Hourly forecasts will help forecasters better predict the onset of a storm and critical details of its evolution, which will be particularly helpful to decision-makers, emergency managers and commuters in preparation for morning and evening rush-hour. The European models went to 4D some time ago in a computationally intense way NOAA could not do with its computers. The NOAA approach, which is different, is still on par with the European capability so the Europeans are looking at the US computational approach.

#### Invest in Observational Infrastructure

The Deep Space Climate Observatory (DSCOVR) satellite became operational July 27 and serves as a distant early-warning sentinel to alert of incoming eruptions from the sun that could disrupt power grids, aviation, telecommunications, and GPS systems on Earth.

The Geostationary Operational Environmental Satellite-R Series (GOES-R) is on track for launch in November and is a big step forward for 0-2 day forecasting with 5x faster scan with 3x more channels and 4x better resolutions. GOES-R also has a lightning detection monitor which should improve tornado lead time.

The *Okeanos Explorer* has been investigating the western Pacific Ocean and broadcasting the journey via live stream with recent discoveries of a ghost-like octopus and a ghost-like eel that had never been seen before.

Human activities over the last century that cause ocean noise are impacting marine life in complex ways. NOAA released a Draft Ocean Noise Roadmap in June to accompany a 10-year Ocean Noise strategy focused on more comprehensive and effective understanding of ocean noise impact. The Ocean Noise Reference Station Network provides the long-term ocean noise data needed for assessments of impacts on marine ecosystems by monitoring ocean noise and the sounds made by whales, dolphins and other marine species. Since April, five small autonomous instruments known as HARPs (High Frequency Acoustic Recording Package) were deployed from Georges Bank to New Jersey, adding to a network of 11 existing noise reference stations.

#### Ocean observing grants

The Tropical Pacific Observing System (TPOS) 2020 project is an international/interagency initiative to develop new technologies to supplement ship-board and mooring efforts for improving El Niño Southern Oscillation (ENSO) forecasts. NOAA investments will support sail drones to measure wind stress and new sensors for Argo floats.

DRAFT

In June the Integrated Ocean Observing System (IOOS) program announced \$31M in grants to support investments in new observing capabilities including upgrading of the high frequency radar network to include real-time wave height and current tracking and to expand the Deep Ocean Assessment and Reporting of Tsunamis (DART) network with high frequency radar observations to increase tsunami detection area and decrease detection time.

NOAA runs a baseline observation site at the South Pole and in June announced that carbon dioxide surpassed 400 parts per million at the South Pole site (the last place on earth to reach this mark) for the first time in 4 million years.

#### Achieve Organizational Excellence

In July NOAA announced the launch of its Diversity and Inclusion Toolkit, a part of the NOAA commitment to create a more diverse and inclusive workforce.

Cooperative Institutes (CIs) for the 21<sup>st</sup> Century (CI21) is an effort to review CIs and update policies as appropriate. This program provides a model to ensure that CIs are effectively run while focusing on NOAA's mission.

In terms of research portfolio logic, NOAA has been putting into place new institutional mechanisms to improve the caliber of research enterprise and partnerships. These mechanisms include:

1. Research Strategic Guidance Memorandum - a forward-looking document for NOAA with guidance about future research priorities and needs of the agency and provides guidelines for reviewing evaluating and rebalancing NOAA's research and development enterprise.
2. Chief Scientist's Annual Report – this will be released in October and will provide a corporate overview of the agency research and development performance as well as provide detailed analytics of the research portfolio and highlights of impactful work.

#### Service to America Medal

Two NOAA staff members are finalists for the Service to America medal award: Christopher Doley for his work on a comprehensive plan to repair damage caused by the Deepwater Horizon oil spill and James McFadden for his work with the hurricane hunter program.

#### Discussion

Lynn Scarlett asked if the information from the Water Conservations will be publicly available. Kathy Sullivan said yes. NOAA partnered with the University Corporation for Atmospheric Research (UCAR) and the U.S. Water Partnership so information will be on their websites as well as the National Water Center website in the near future.

Lynn Scarlett asked about NOAA's ability to conduct climate science given continued Congressional concerns and whether there have been resource challenges. Kathy Sullivan said looking at the House and Senate marks; NOAA has seen preference by the House of Representatives to fund core federal functions only. Over the years between chambers there has been some reduction in funding for climate but the

DRAFT

Senate has kept some funding in place. NOAA's role is the measurements and data to help understand how earth system works and also helps with weather forecasting. NOAA has heard about unmet needs on seasonal forecasts up to 1-3 year timeframe from city managers and others and is working to meet those needs.

Susan Avery said the richness and diversity of model development is important; models serve different purposes and have different accesses and that diversity is needed. Kathy Sullivan agreed and, calling it pluralism, but added that, absent some inability to share coding standards, pluralism lacks the ability to converge. There is an art form to sustain pluralism and link and harmonize and put some coherence and a momentum factor in model development. The United Kingdom Meteorological Office has some pluralism with commonality in platforms so any development can spread. In the US model pluralism is anarchy and there needs to be more commonality to share improvements across the modeling community.

Craig McLean said as a result of the analyses completed during the selection of the NGGPS Dynamical Core models, NOAA has ceased production of three models.

### **NOAA Chief Scientist Update**

Richard Spinrad, NOAA Chief Scientist

#### Summary

The NOAA Chief Scientist, Dr. Rick Spinrad, began by presenting a framework for how the Office of Chief Scientist (OCS) prioritizes its work. The OCS is focused on strategic and tactical issues with both internal and external applicability, many of which have involved direct collaboration with the SAB. The Chief Scientist has assigned highest priority to strategic internal activities (e.g., 2016 Strategic Research Guidance Memorandum [SRGM], and Research to Applications and Operations [R2X]). The next priority has been strategic external activities, primarily at the White House level, including various subcommittees of the National Science and Technology Council (NSTC), and also various boards of the National Academy of Sciences. Finally, at the tactical external level, the OCS is producing the first ever Chief Scientist's annual report (CSAR) and will issue that report in the fall.

The first ever SRGM was issued in August 2015 and included a lot of input from the NOAA SAB. For example, within the definition of priority research areas, the SAB emphasized the importance of focusing on earth system processes, and this was captured in the final version. This year, a lot of discussion has occurred in the NOAA Research Council to incorporate some new thinking into the focus of the SRGM research priorities. Ultimately, the 2016 SRGM has very similar priorities, but includes some changes in emphasis and focus. NOAA will be sharing the draft of the 2016 SRGM with the SAB immediately after this meeting with a request for comments and intends to share it with public in late August – early September timeframe.

NOAA has worked to develop a more robust, comprehensive, and disciplined approach for transitioning research to operations, applications, commercialization and other uses (“R2X”). This transition process and approach has been codified in a NOAA Administrative Order which establishes, among other things,



a “Readiness Level” spectrum adapted from NASA’s Technology Readiness Levels. Program managers throughout NOAA’s Line Offices are now characterizing their investments in terms of Readiness Levels. The FY 2017 President’s Budget Request to Congress includes a new NOAA program called Research Transition Acceleration Program (RTAP), RTAP is primarily focused on moving projects through Readiness Levels 5-7 and will take advantage of the work we have done to define the appropriate process and structures for transition. As NOAA was developing the RTAP proposal, Congress appropriated \$6 million for a new Joint Technology Transfer Initiative managed by Dr. John Cortinas in the Office of Weather and Air Quality within the Office of Oceanic and Atmospheric Research (OAR). The newly developed processes and approaches for transition were applied to select projects for JTTI support. JTTI focuses on the transition of OAR research into the operations of the National Weather Service, whereas RTAP will have the scope and flexibility to transition research throughout NOAA.

The SRGM and RTAP are examples of the strategic approaches the Chief Scientist is taking to develop the portfolio logic of NOAA’s research investment and make more evident the value of NOAA research. These concepts are being institutionalized in NOAA, as reflected in the FY17 budget request. Updated practices include using the SRGM to shape the FY 17 Small Business Innovative Research (SBIR) call for subtopics, and the establishment of a cross-NOAA Unified Modeling Working Group and the establishment of a NOSC Emerging Technologies Workshop.

The office of the Chief Scientist is finalizing the “Prospectus for Cooperative Institutes in the 21<sup>st</sup> Century”, or “CI21”. This was work done following a charge from the NOAA Administrator to provide overall direction and recommendations for existing CI programs, as well as guidance and a framework for institutions and/or organizations interested in establishing new programs and CIs. CI21 supports the Administrator’s strategic priority of enhancing NOAA’s organizational excellence. The Office of the Chief Scientist engaged the SAB and CI Directors throughout this work. The goals of CI21 are to reinforce the role of NOAA Cooperative Institutes (CIs) as authoritative brokers of information and knowledge and to advance the connectivity of NOAA science to critical intellectual resources. Dr. Spinrad expressed his recognition of the great value of the rich intellectual capital within the CI’s and expressed the need for NOAA to take best advantage of it. There is also an operational aspect of making sure the CI’s are effectively run. There was a lot of discussion with not just CIs, but also other cooperative science entities, to determine the main areas of emphasis for our CIs. Four areas emerged: Mission Alignment and Enhancement; Workforce Development; Finance and Management, and Private Sector Engagement. The SAB provided comments on a draft of the CI21 prospectus after the last meeting. The outcomes of the CI effort will clarify expectations for both CIs and NOAA, formalize processes for validation of cost-benefit analyses, improve the ways we tap into the intellectual capital of the CI’s, and workforce optimization that will include workforce development plans. The final report should be available in September 2016.

For the first time ever, the OCS has undertaken a corporate analytics approach to assess and measure the productivity and impact of NOAA science for major research areas across the agency as well as to compare these metrics with those of other federal agencies. Productivity was measured based on the number of published articles. Impact was measured using the Hirsch Index as well as normalized citation impact, which is calculated by dividing the actual count of citing items by the expected citation rate for

similar documents in the year of publication and subject area. The first task was to determine what fields NOAA influences. Those fields, or core research areas, include: meteorology and atmospheric sciences, marine and freshwater biology, oceanography, fisheries, environmental sciences, ecology, and geosciences. According to these analyses, which were performed using the web based platform InCites™, based on data from between 2011 and 2015, NOAA has the highest productivity among federal agencies in the fields of meteorology and atmospheric science and marine and freshwater biology. With regard to impact, NOAA has the highest Hirsch Index and the second highest normalized citation index in Meteorology and Atmospheric sciences. In Marine and Freshwater Biology, NOAA is at the top according to both impact metrics. In the five other research fields NOAA ranked near or at the top in all of the metrics. These results demonstrate NOAA's excellence in research. The results of this analysis will be incorporated into the Chief Scientist report for all research areas.

The new Chief Scientist's Annual Report (CSAR), as mentioned above, will be a concise external-facing document and will serve as a place to discuss, and review NOAA progress in research. It will include an introduction that will define, for the first time ever, NOAA's research portfolio logic. This section will cover issues such as what types of research NOAA does and where and how NOAA does research. There will be research and development themed chapters that align with those of the SRGM, and highlight some of the achievements of NOAA's R&D enterprise. The analytics that were presented previously will be spelled out in detail, and there will be a workforce and reviews section that will emphasize recruiting and retaining talent, and will cover scientific integrity, (including what NOAA has done to foster intellectual freedom and capacity of NOAA scientists), accomplishments, awards, noteworthy publications, and program reviews. The CSAR will be published in October 2016; the chief scientist expressed his interest in hearing the SAB reaction to the CSAR at the November meeting.

### Discussion

Michael Donahue asked about the seven research areas for bibliometrics and wondered what was missing. Rick Spinrad said all of the research areas for NOAA have been identified; however, the analyses have been restricted to only the 7 research areas that were highlighted.

Walt Faulconer said he would like to see the metrics continued into the future and also for NOAA to eventually tie them to return on investment. Rick Spinrad agreed that a lot more could be done; the agency will consider what can be done in the future.

Susan Avery asked if the Chief Scientist's Annual Report could include work that will be done in the next year. Dr. Spinrad replied that some of this is captured in the SRGM and will be reflected in the CSAR by using the SRGM priorities as the chapter headings. But he agreed that this was a great suggestion, and mentioned that if he had issued a CSAR last year, it could have included NOAA's El Niño rapid response efforts.

Bob Winokur highlighted that nothing was mentioned about partnerships in the annual report proposal. He asked how partnerships would fit into the structure that was discussed. Rick Spinrad acknowledged that partnerships will be called out. Some examples included the accomplishments of the CIs, numbers of grants and contracts, the balance of intramural and extramural effort, and so on.

Denise Reed asked whether the report will be used to motivate and reward the scientists and if so, who is going to feel left out. Rick Spinrad said OCS had to consider who the audience is and what the message is. The audience is external and the message is that NOAA research is deliberate, impactful and diverse. Beyond that he was not sure how the receiving audiences will respond as there is no example of a Chief Scientist report from another federal agency that is quite what he envisions for the CSAR. On what to include to respect and honor scientists, he is counting on the NOAA Assistant Administrators to identify what to highlight.

### **Arctic Research Review report from the Ecosystem Sciences and Management Working Group (ESMWG)**

Jackie Grebmeier, University of Maryland and Member, ESMWG

#### Summary

The SAB asked the ESMWG to evaluate the quality and direction of the NOAA Arctic research portfolio. Based on their work, including discussion with NOAA and other speakers, a survey of NOAA Line Offices, a bibliographic survey and review of research reports and plans, the ESMWG developed one overarching finding and more specific findings on which they based 15 recommendations. An overall goal of the combined recommendations is to enhance NOAA's High Arctic profile of activities to multiple stakeholders, both nationally and internationally.

**Overarching finding :** While the ESMWG found examples of strong NOAA contributions in atmospheric and sea ice monitoring through coastal bathymetric surveys, ecological surveys and cross-line office (LO) partnerships for field measurements and ship use, an overarching finding is that NOAA's Arctic efforts need improved coordination and enhanced platforms, including fleet replenishments, to fulfill its mission and provide international leadership.

#### **Recommendations:**

Recommendation #1: NOAA needs to develop a clear vision and statement of its strategic role and activities in the Arctic, both nationally and internationally. Focused outreach documents should be developed to highlight NOAA projects in the Arctic, the connection within and among Line Offices and connections with other US government agencies and international groups. There is value in a central Arctic office in NOAA, with staff to facilitate the new Arctic Executive Committee in order to coordinate NOAA's Arctic portfolio to address strategic national needs.

Recommendation #2: NOAA should regularly evaluate its academic partnerships supporting NOAA Arctic activities that occur both through direct competitive calls and Cooperative Institutes (CIs), specifically looking at trends in the level of support, productivity and transparency of effort. Specific to the CIs, NOAA should determine if they are being used for direct capacity for NOAA activities or if NOAA is supporting efforts that could be filled by academic entities directly.

Recommendation #3: NOAA considers observing systems to be: “The heart of NOAA’s Environmental Intelligence” (SAB Synthesis Session, April 16-17, 2015), yet NOAA funding of these observatories continues to be inadequate. Continued focused investments are needed in order for NOAA to fulfill its identified responsibilities within national and international observing programs. These programs are the front line of detecting change in the Arctic ecosystem.

Recommendation #4: It is important to use local and indigenous knowledge systems to contribute to NOAA’s understanding of the Arctic ecosystems and to share results of NOAA scientific endeavors with coastal communities. It is essential that NOAA and its partners assess the needs and importance of social sciences in the Arctic and to increase support for the human component as part of “ecosystem science”.

Recommendation #5: NOAA should strengthen its US interagency efforts through the Interagency Arctic Research and Policy Committee (IARPC), including continued leadership on observing activities (e.g., Observing Collaborative Team and Distributed Biological Observatory Collaborative Team), and their inclusion in the revised format for the next 5-year IARPC plan.

Recommendation #6: NOAA should continue to strengthen its international efforts and leadership through the working groups of the Arctic Council, e.g., Circum-Arctic Biodiversity Monitoring Program (CBMP) and Emergency Prevention, Preparedness & Response Subcommittee (EPPR). In addition, efforts should continue in collaborative observing programs, such as IASAO (International Arctic Systems for Observing the Atmosphere), the Distributed Biological Observatory (DBO), and working toward reinitiating the Russian American Long-term Census of the Arctic (RUSALCA) program. Developing issues, such as fisheries and ecosystem management in the Central Arctic Ocean (CAO), biodiversity topics, and climate change impacts globally, are important topics requiring international leadership. In addition, cross-platform asset use in the Arctic should be encouraged.

Recommendation #7: Linkages between researchers and mid-level management within and among LOs and the NOAA Arctic Executive Committee leadership should be strengthened. There should be a formal link of task force activities to agency planning, programming, execution, and evaluation, along with budget allocations for a common Arctic portfolio goal via cross agency initiatives.

Recommendation #8: NOAA should continue to coordinate and facilitate an open and transparent data archiving protocol that is usable by all components of NOAA-supported science activities in the Arctic. In terms of academic relationships, NOAA could make incentives for collective contributions from both NOAA scientists and academia, along with improved methods for making data available while maintaining QA/QC and publication opportunities.

Recommendation #9: NOAA management should consider developing an explicit budgetary survey to capture the flow of funds for Arctic science activities within each Line Office, with a specific definition as to what “activities” for Arctic information is needed. Both within and cross-LO budget levels for Arctic research should be identified, with an explicit definition of activities as being research and observing activities, as well as operational costs associated with these activities. Such a composite, cross-LO evaluation will form the basis for evaluating LO High Arctic activities within the Congressional funding base across all Line Offices. The budgetary detail would relate to both internally and externally

supported activities, as well as associated full-time effort (FTE) support for the NOAA High Arctic research (including ecosystem) portfolio. NOAA needs to better capture the “metrics of success” from its Arctic research activities.

Recommendation #10: Both NOAA employees and external non-NOAA entities supported through NOAA-funded High Arctic projects (academics, collaborative institute funded projects, NPRB, AOOS, etc.) should be included in a design process in order to develop “metrics of success” from its Arctic research projects for future science planning and budgetary decisions.

Recommendation #11: The NOAA domestic fleet for research is deteriorating and inadequate for undertaking High Arctic marine research. NOAA should take leadership in working through IARPC and other channels to obtain ship support for Arctic research activities.

Recommendation 12: There is a need for NOAA to systematically estimate the impact of partnerships (both in kind efforts and monetary support) through cross Line-Office, US interagency and international partnership supporting its High Arctic program. Findings from such a survey would explicitly show the strengths and vulnerabilities of internal and external decisions that could influence its High Arctic activities portfolio.

Recommendation #13: Continued and expanded coordination efforts with other federal agencies undertaking High Arctic research should be encouraged. We note that NOAA relies greatly on BOEM funding for NOAA High Arctic research activities and some form of evaluation by NOAA management should be considered to make sure that NOAA provides core funding as an agency priority for the nation, along with collaborative support via other US agencies.

Recommendation #14: NOAA needs to continue to expand its capabilities provided through its newly developed bibliographic effort to capture all research products (peer-reviewed and gray literature as well as data sets) from all its funded Arctic projects across Line Offices (both internally by NOAA employees and through its externally funded projects) through a standard reporting of output results.

Recommendation #15: NOAA should initiate and coordinate a comprehensive, 5-year High Arctic research program with interagency collaboration of field and modeling efforts as a national priority. The US needs to enhance its understanding of the High Arctic ecosystem. As such, NOAA needs to enhance its platforms to fill its leadership role for understanding the changing Arctic system. There is an opportunity with new international programs and research programs to augment research currently funded by NOAA if there is some flexibility for coordination.

### Discussion

Mike Donahue liked the practical aspect and sweeping recommendations and asked about prioritizing the recommendations or putting a timeline on them. Jackie Grebmeier said there are some that could be put into a higher priority—a suite of the top four to six with the remaining recommendations being supportive of the higher level recommendations.

Steve Polasky noted that, since the Arctic is rapidly changing, he wanted to know whether this effort was well-situated to capture what would be needed 5-10 years in the future. Jackie Grebmeier said no one agency can do this work alone; NOAA has strengths in many areas but other agencies also have strengths. Steve Polasky asked if NOAA has scientific capability to track key changes and threats in the Arctic. Jackie Grebmeier said the scientific community does have these capabilities though not all are 100%. Weather, climate and atmospheric tracking are the strong parts of NOAA Arctic research while NOAA relies on other agencies to lead in other areas. NOAA needs to decide if it is satisfied with this kind of dependency.

Kathy Sullivan acknowledged the good work and insights in the report. While acknowledging that NOAA developed the charge to the group, she expressed some concern that the recommendations are all about management and infrastructure practices, not science. The SAB has unique capability to look at ecosystem science capabilities and perhaps a bit of management assessment of how we can work better—those would be hugely valuable. She noted that there is a tendency by SAB working groups to provide recommendations on management and budget rather than science and this is not the highest value the groups can bring to the SAB.

Jackie Grebmeier said the report noted that NOAA is weak in the biological observations and biodiversity is one example. Observing system aspects could be strengthened; the report made recommendations on the logistics needs for observations.

Jo-Ann Leong, Co-Chair of the ESMWG, said the charge to the ESMWG for the Arctic work includes organizational and management components. The ESMWG is now working on a report on Indigenous and Local Ecological Knowledge (ILEK) that includes how NOAA looks at and works with local and ecological knowledge. The NOAA guidance today will change the way on the ESMWG will examine this topic.

Richard Moss said on page 19-20 in the report there is a focus on investment for observations and asked if there was additional detail on which observations needed to be emphasized. Jackie Grebmeier responded that a missing part of the investment is continuity for measurements on time-series sites that are ecosystem-based. There are a number of physics-based sensors but not enough biologically-based sensors. The RUSALCA included time-series observations in the field but that program has been suspended; details could be added to the report. Some of the products could be metrics of what happens if ships transverse in that area. Eugenia Kalnay asked if it was possible, since the Arctic is changing so quickly, for NOAA to provide decadal or multi-decadal forecasts of range or possibility if the system continues to evolve the way it appears to be. Jackie Grebmeier said NOAA is doing model forecasting of physical processes but less on the biological response to proposed physical changes.

Lynn Scarlett thanked the ESMWG for the report. She thinks there is a lot of rich information on kinds of observations being taken, science activities occurring, partners, and potential linkages across topical issues. In thinking about the challenges of the Arctic and the science needed to manage in that context, two issues come to her mind. In the Department of the Interior when it was faced with the decision to list the polar bear under the Endangered Species Act, it used data on sea ice, global circulation and biological information to examine 19 polar bear populations. What was really lacking was anything that connected

DRAFT

the trends in the bear population biology and sea ice trends—the links between physical and biological science were missing. In the second example, one sees changes in the Arctic and more human imprint - transportation and energy development, for example - and a first question on Arctic science and ecosystem science is what is known about the human activities trends, extent and implications and what more needs to be known to manage the system as stewards? This is a question about what the drivers are, how they are evolving, and implications for decisions that have to be made and what this means for science. Other questions could be asked about biodiversity in a highly dynamic and changing environment and about understanding the system dynamics that impact specific trends. These questions were not in the charge for this study but perhaps when looking forward at NOAA challenges and investments these are the sorts of things an arctic ecosystem examination would ask.

Eugenia Kalnay agreed but added NOAA should also be focused on possibility of giving prediction of the range of that can be expected.

Richard Merrick agreed, but stated that NOAA is only one of the players in this area and the issues being discussed are included in the IARPC research plan. The tasking for the ESMWG was to see how well NOAA is organized to do Arctic research. Jackie Grebmeier said the ESMWG looked at the full range of what was needed and what was being done and what could be done better to achieve science goals.

Lynn Scarlett said she commends the ESMWG or doing what they were charged to do.

A question was asked about accepting the report. Cynthia Decker provided the range of options for the SAB on the report: the SAB can accept the report or change or revise the report. The SAB can also ask the Working Group to make changes in the report; they can also accept the report and raise other issues.

Jackie said if the SAB accepts the report with a caveat you can get more information from the NOAA Line Offices. The SAB could also ask the ESMWG to include additional information such as case studies to highlight issues. Lynn Scarlett asked if the SAB accepted the report; the SAB can then have a subsequent discussion on whether to give the WG additional queries or ask for other work.

Eugenia Kalnay liked report but would like the group to prioritize the recommendations.

Laura Furgione said there is too much to do in the Arctic and NOAA is not necessarily organized and managed properly to cover it all. There are observations and modeling in Arctic that don't have a baseline in modeling and reanalysis. If NOAA focuses on sea ice and looks at water flow, that could be a path forward.

Kathy Sullivan said the Working Group is a fresh look on what NOAA should be doing on the science and how to focus. If the group looks at the resources NOAA has, geography and measurements NOAA can make, what would be the most productive strategy moving forward? Given what has been done with RUSALCA, for example, could there be a plan to focus on that effort to get the time series right rather than a scattered approach? What is best scientific strategy? If NOAA's goal is to be as far down the road five years from now to couple biological information with sea ice data, how best could this be done? What type of advice would be most helpful and provide NOAA with the credibility of coming from a high

DRAFT

visibility external group? Kathy Sullivan suggested that the SAB ask the Working Group to prioritize the recommendations in the report provided. For other Arctic science issues, perhaps a subset of the SAB could frame different questions and ask the Working Group for different recommendations.

Lynn Scarlett made a motion to accept the existing report with the provision that the ESMWG return in three weeks with a prioritization of the recommendations. Eugenia Kalnay seconded the motion and it passed unanimously.

Lynn Scarlett added that the SAB will come back to the Working Group with an additional task that builds from the Arctic science tasking.

Denise Reed suggested that the additional tasking does not have to be sent back to the ESMWG; there could be another solution that is quicker and nimbler. Lynn Scarlett agreed and said there will be a further discussion on any additional tasking.

### **Public Comment**

There were no comments from the public.

### **National Water Center Presentations**

#### **Transforming NOAA Water Prediction**

Tom Graziano, Director, Office of Water Prediction

#### Summary

The U.S. faces a growing number of water challenges. These include (1) population growth and economic development that stress water supplies and increase vulnerability, (2) water availability and quality in a changing climate, (3) an aging water infrastructure, and (4) socio-economic risks of floods and droughts. The NOAA Water Initiative was formed to develop a new use-inspired, agile and nimble water model, the National Water Model (NWM). NOAA engaged with stakeholders, using their input to inform future development activities and the delivery and evolution of new services. This new water model will deliver comprehensive, integrated, and actionable water intelligence. The NWM transforms NOAA water prediction, increasing forecast locations from 4,000 to 2,700,000 locals using high resolution Earth System modeling. The predictions are linked with detailed local infrastructure to provide enhanced impact-based decision support services. The NWM also adds more data by orders of magnitude; predictions are made at the street level with a 250m grid size compared to a 1 km grid size in the old model. This level of detail is made possible through high performance computing. NOAA's water services are currently transforming and evolving making it a very exciting time to be in this topic at NOAA. There has been tremendous support and opportunities to grow the program that has not been previously seen.



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## Discussion

Susan Avery asked about how the model deals with human influences on flow and also pointed out the greater importance of the ocean than the atmosphere in the forecast. Dr. Graziano replied the group is currently working on modeling flow. Right now they use stream gauge data. To model human influence on flow, the model needs to predict how humans will operate dams, for example. In response to the importance of the ocean, NOAA is moving towards earth system modeling capabilities with Navy and Air Force.

Craig McLean highlighted the importance of high performance computing resources to the NWM, and pointed out this request is in the President's budget for FY17. Dr. Sullivan added that in addition to making the case for more cycles on high performance computing, NOAA also needs to be efficient with its use of existing high performance computing resources.

Walt Faulconer asked about the challenges for short time scales and if there is any thought for blending national water model with severe convective events in the future. Dr. Faulconer highlighted this as an opportunity for the National Water Center to reach out and partner with other groups. Dr. Graziano replied the Water Center has spoken with NOAA's National Severe Storms Lab (NSSL) on this matter.

Everette Joseph built on Dr. Faulconer's question, asking how NOAA is integrating these tools and how others outside of NOAA can be involved. For example, he asked if there a Request for Proposals (RFP) for work in the proposed hydrologic prediction testbed. Dr. Sullivan replied that the pieces have been put into place by working with other agencies such as NSF. The water initiative is less than a year old, and NOAA is still working on an outreach and education plan.

Richard Moss asked what work is being implemented in the demand side of water. Dr. Graziano replied this side has been evolving with those stakeholders a part of the conversation.

### **National Water Model: Deep Dive**

Ed Clark, Director, Geo-Intelligence Division, Office of Water Prediction

## Summary

National Water Model (NWM) v1.0 establishes a foundation for sustained improvement in water prediction as the first ever model with a nationally-consistent operational hydrologic forecasting capability. The goals for NWM v1.0 are to: (1) provide forecast streamflow guidance for underserved locations, (2) produce spatially continuous national estimates of hydrological states (solid moisture, snow pack, etc.), (3) implement a modeling architecture that permits rapid infusion of new data and science, and (4) establish a foundational framework for cross-NOAA Water Science. These goals are being met in the current NWM v1.0 output. The model predicts river channel discharge and velocity at 2.7 million river reaches and incorporates soil and snow-pack states. Several groups (including River Forecast Centers, private companies, National Center for Environmental Prediction (NCEP), and National Center for Atmospheric Research (NCAR)) are currently evaluating the NWM. This initial feedback has identified flash flooding and river forecasting as strengths of the model while improvements could be made dealing with reservoirs and water diversions. The 30-day test of the NWM v1.0 ends on August 5<sup>th</sup>. Planning for NWM v2.0 has already begun to assimilate relevant data and explicitly represent managed flows (reservoirs and diversions) with input from partners collected by Regional Forecast Centers.

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### Discussion

Everette Joseph and Denise Reed asked, with respect to the August 5 deadline, what data will be used for the “go/ no go” decision. Dr. Clark replied that this decision will be based on the correlation coefficients of the model with observations. He acknowledges the areas the model does not work well are with hydropower regulations, water supply diversions, and groundwater interactions.

David Lodge asked if water quality was included in the model. Dr. Clark replied that the NWM v1.0 does not currently evaluate water quality, but a new addition in NWM v2.0 will be a parcel by parcel tracker of where water is coming from, which will be a start to have water quality incorporated in later versions. v2.0 may also include a module for water temperature.

### **Partnering with Academia to Accelerate R2O: Inundation Mapping and Data Services**

Fernando Sala, UCAR Visiting Scientist

### Summary

The Office of Water Prediction Innovators Program is a partnership between the National Weather Service and the academic community made possible by an interagency agreement between the National Science Foundation (NSF) and NOAA. Through this agreement there is a pathway for transitioning innovative research into operational water prediction. One example is the National Water Center Summer Institute. Focusing on a different theme each year since its start in 2015, students spend seven weeks at the National Water Center with their advisors. Following a 2 week boot camp on water models, the students spend the remaining 5 weeks focused on capstone projects. The goal of the Summer Institute has been to close the gap between national flood forecasting and local flood emergency response. Projects use modeling and social science to focus on the forecast of flood impacts at the stream and street level. The Summer Institute has served as an opportunity to build partnerships across a wide range of stakeholders and emergency managers while drawing in the academic community.

Following Dr. Sala’s presentation, two of the Summer Institute students presented their work.

Ryan McGehee from Auburn University presented his project, “Flood Inundation Mapping with the Modified HAND method.” Mr. McGehee’s team project focused on making a modification to the HAND (Height Above Nearest Drainage) method to allow for better flood area prediction in the National Water Model. Mr. McGehee noted that he and his team members are bringing this idea back to their universities for further work.

Whitney Henson from Jacksonville State University presented her Summer Institute project “Translator – TTX” focused on bridging the gap between physical sciences and emergency management. Ms. Henson developed tabletop exercises (TTX) to simulate emergency situations. These tabletop exercises are run using ArcGIS (Geographic Information Software) as a platform to run simulations that can be used by emergency managers for pre-planning as well as in real time during events.

DRAFT

## Discussion

Following the presentation there was a brief discussion on ethnic diversity in student participants in the Summer Institute. Everette Joseph suggested Summer Institute may be an opportunity to work with the NOAA Office of Education and involve the Education Partnership Program.

**August 3, 2016**

### **Recap of Strategy Discussion to Date**

Lynn Scarlett, The Nature Conservancy and Chair, NOAA SAB

Lynn Scarlett provided a recap on the strategy discussions that have been occupying the past SAB meetings. The SAB has brought in speakers whose work links to NOAA's mission and how NOAA thinks about technology, knowledge, and fulfilling the agency mission. Last meeting, members clustered these presentations into five categories, compressive sensing, exascale computing, risk, 'omics, and data science and prepared brief issue papers for discussion at this meeting. The next speaker is Dr. Pavan Sukhdev whose work focuses on the green economy.

### **Strategy Discussion with Invited Speaker**

Pavan Sukhdev, CEO and Founder, GIST Advisory

Pavan Sukhdev began his presentation explaining his background. He started in the field of physics, and moved to a career in finance. One thing that struck him about the economy was unlike his studies in physics, external drivers were ignored. This led him from a hobby in the green economy, to the founding of GIST (Green Initiatives for a Sustainable Tomorrow) Advisory, a private company that advises governments and private organizations on how to measure, value and manage natural, social and human capital.

### Sustainable Development Goals

The United Nations (UN) has developed a list of 17 Sustainable Development Goals (SDG). These goals each have targets, but they do not give any insight how to achieve those targets. Instead of viewing these goals as a list, they can be viewed in the context of "a periodic table of sustainability development". Dr. Sukhdev worked with Johan Rockstrom from the Stockholm Resilience Center to frame these goals into tiers, which he illustrated like a cake. The four biosphere goals are foundational, then the societal goals, then economic efficiency. Under this structure, the bottom layer of the tiered cake needs to be addressed before moving onto the top layers. The biosphere goals focus on resilience, the societal goals equity and access, and the economic goals productivity and efficiency. Dr. Sukhdev used the example of zero hunger (society tier) to explain the cake tiers in practice. To achieve zero hunger, the health of the ocean and fisheries (biosphere tier) protecting the terrestrial ecosystems (biosphere tier) for livestock, forest cover for rainfall for crops must first be achieved. Climate (biosphere tier) is also important because climate change could have negative implications for certain food sources. Lastly, clean water and sanitation (biosphere tier) are needed for food security. Clean water highlights that there are no national boundaries

DRAFT

for a public good. Dr. Sukhdev showed a satellite image of evapotranspiration that drives home how water evaporates over one continent and precipitates on another.

The tiered-cake approach puts the SDG in a new context. They are not a menu or a set of choices, but a path to follow to achieve sustainability. Achieving sustainability is a daunting task: the goals have 170 targets and 270 indicators but governments do not have the resources to organize around so many of these. Dr. Sukhdev examines the question of whether there are simpler ways of addressing these metrics.

### Food System Sustainability

The visible flow of agriculture is seeds→crops→yield. This is quite simple compared to the invisible costs of biodiversity, ecosystem benefits, and impacts on human systems. To go into more detail on the human costs, one of the current challenges is dealing with the transition from small farms to industrial large farms. Another problem has to do with policy decisions being based on productivity. Productivity misses other drivers of labor, climate and human health (for example, pesticide use).

The entire value chain of production can be considered by looking at the invisible costs. The economic costs and the social costs can then be factored into a decision. The last piece is to add in risk and resiliency, for example, making sure food systems will be resilient against climate change. In this example, food system sustainability depends on the bottom climate cake tier in the SDG. To put this into practice, there needs to be a universal evaluation framework addressing the visible and invisible parts.

Kathy Sullivan asked about moving this framework forward into practice. Dr. Sukhdev replied the European Union (EU), Kenya, and Sri Lanka are all interested. However, present interest from policy makers is patchy and scattered. Dr. Sukhdev notes sustainable development is not just about the developing world.

Susan Avery asked what the measurable metrics are to know when success has been met. Dr. Sukhdev replied there are three studies underway exploring this question.

### *Private Sector and Sustainability*

In the US, the private sector comprises 75% of the economy, thus the US will not have a green economy without a green private sector. In particular, the private economy uses the externalities of greenhouse gases, water abstraction, and natural resources. These externalities drive six of the nine planetary boundaries identified by the Stockholm resiliency center. These externalities must be built in to the economic system. This could be achieved by taxing those externalities to better reflect the true cost (carbon, natural resource), and injecting ethics in advertising. There also needs to be a way to limit leverage to an appropriate level so no corporation is ever too big to fail.

Kathy Sullivan asked if the Sustainability Accounting Standard Board (SASB) is an approach to move towards this framework. Dr. Sukhdev replied the SASB has brought companies to the table. However, SASB functions more like a checklist. The ultimate goal is to move towards a social and human capital protocol to help companies go on other realms.

*Four Capitals, Green Economy, Circular Economy*

In the final section of his presentation, Dr. Sukhdev addressed how progress on SDG can be tracked. The four types of assets, or capitals, are physical, human, social and natural; these can all be measured to understand how well sustainability goals of resilience, equity and productivity are being met. Currently the business world already reports on physical capital, they can add in the other capitals to fully assess progress on sustainability. This approach can also be used to measure a country's capital and assess dependency on natural capital. These four capitals are easier to measure than the 170 targets in the SDG.

The Inclusive Green Economy (IGE) is one that improves human and social capital while not hurting natural capital. The circular economy eliminates waste. These are both ways to achieve the four capitals above.

Discussion

Several members discussed the feasibility of the framework Dr. Sukhdev presented. Steve Polasky agreed with the presentation that as a society we do not currently pay for what we value. He asked how well positioned businesses and countries are to enact these principle with regards to political will and the ability to measure the four capitals. Denise Reed built upon these comments using the example of small versus large farms. Dr. Reed mentioned the circular economy is one way for small farms to get value out of waste. Peter Kareiva suggested that while it is hard to get traction for these efforts on the national level, cities may be a better place to start. Some cities already have mayors that have set sustainability goals. Lynn Scarlet built on this comment by stating that some of the things that need to be done to achieve sustainability are not amenable to implementation at the city level. There also needs to be an engagement process with communities to define what constitutes equity. Susan Avery asked if some of things that need to be done are easier in new economies (such as the blue economy) rather than older more established economies. Lynn Scarlett added that while the blue economy adds opportunities, it also adds challenges. Everette Joseph asked how the theory of change is being accepted in academia. Dr. Sukhdev replied it is in the early phases, but Corporation 202 launched in Rio in 2012 is part of some business school's syllabi. Eugenia Kalnay added to the conversation explaining she is part of a group that is coupling human systems with earth system adding feedback from the earth system onto human population growth.

The discussion then turned to the NOAA colleagues and their thoughts on the presentation in the context of NOAA's mission. Kathy Sullivan asked if better quality science or more appropriately translated science could help increase the public acceptance of the sustainability goals, to which Dr. Sukhdev replied it is important to find the right economic framing for the science to present to policy makers. It is also important to invest in communication. Richard Merrick added that for IEAs (Integrated Ecosystem Assessments) for the California Current, human wellbeing is viewed as a key part of the ecosystem. Additionally, the Atlantic ecosystem model is expanding to have a strong element in the human side.

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## **SAB Concept of Operations**

Kathryn Sullivan, Under Secretary of Commerce for Oceans and Atmosphere

### Summary

At the last meeting there was a discussion about the operation of the SAB and the working groups and changes NOAA needed to make sure these operations are institutionalized before the transition of the new Administration. The SAB Concept of Operations (ConOps) resulted from this review; it does not replace the SAB Charter but complements and enhances it. The latest draft of the SAB Concept of Operations is provided at this meeting for the SAB's information.

As shown in the presentation, the goal is to institutionalize best practices, provide guidance on the Federal Advisory Committee Act (FACA) and ethics information, identify the requirement for a biennial work plan for the SAB and Working Groups (WGs) and clarify expectations, including roles, responsibilities and work products.

The SAB Charter defines the "what" for the SAB; the ConOps defines the "who" and "how". Additional information in the document includes FACA and ethics compliance guidance that defines how advice is transmitted to NOAA and information on ethics and conflicts of interest. There will be a biennial work plan required, that will be updated each year. The document also defines expectations for the Chair, Working Group liaisons, and SAB responsibilities for Cooperative Institute reviews.

Rick Spinrad noted there will be two ConOps documents: SAB ConOps and a revision of the Working Group Concept of Operations that will be ready for the November 2016 meeting. Both documents are intended to be living documents that can be changed when needed. The SAB ConOps document will inform what changes may be made to the charter in a year when it is revised. In terms of roles and responsibilities, NOAA wants to make sure that the role of the Chief Scientist and other NOAA staff is clarified as well as roles for the SAB.

The recent practice to bring in high-level strategy speakers has been successful and NOAA wants to continue to do this in the future. The ideas from the speakers led to issue papers that will help NOAA focus on how it wants to use the information provided; NOAA is also trying to involve the Line Offices in these processes.

Kathy Sullivan added that another benefit of having the SAB and the Working Group Concepts of Operations in place by November is because this administration has broken some new ground and this is the time to capture it and agree that the tasks done by the SAB are most useful.

Lynn Scarlett summarized some key points. There are two Concepts of Operations - one for SAB and one for WGs. There was more legal review to be done for the WG Concept of Operations so it was not ready for this meeting. She also noted there was prior review by the SAB of the Working Group Concept of Operations last year and the revised document will reflect that discussion.

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## Discussion

Peter Kareiva liked the SAB ConOps document; he suggested adding how the SAB members interact with NOAA scientists.

Denise Reed said the document was well done but she did not see mention of feedback from NOAA on the SAB advice; perhaps the Chief Scientist could periodically respond to the SAB on advice given to make it clear for the future. Rick Spinrad said he was happy to add something without being prescriptive on how it is done.

## **Discussion of Working Group Membership Process and Evaluation of Working Group Portfolios**

Lynn Scarlett, The Nature Conservancy and Chair, NOAA SAB

SAB members

## Summary

Both the EISWG and the EMSWG submitted requests for new members for consideration; today, as the Working Groups will be convened by the SAB under a new WG ConOps, she noted the SAB needs to consider the process for approving new members, including the criteria and input needed. Past membership approval processes have not fully engaged the SAB and NOAA in the nomination process. In the new process, the SAB will take the suggestions on proposed members from the two working groups as well as nominations from NOAA, circulate them and make a final determination on members. In addition to the membership issues, there should also be discussion about nimbleness and dynamism of working group structure.

Bob Winokur said the membership relates to the work plan for the working group; there has not been top down input from the SAB so that leaves the working group to provide ideas and get input from Line Offices. Bob Winokur also noted that he chaired a short-term task force that was nimble and the SAB should consider that format.

Susan Avery said it is difficult to look at names for proposed members without looking at work to be done and asked if there is going to be a change in the working model of the working groups. The SAB has been doing things differently so perhaps the Working Groups need to be more nimble as well.

Michael Donahue said Working Groups do the heavy lifting on the Board but there is a lack of substantive interactions with the Working Group Chairs so perhaps the SAB should allot more time on agendas for discussions. In terms of nimbleness, every charge to Working Groups does not require a 12 month report; reports could be shorter and delivered more quickly.

David Lodge commented on nimbleness; on one hand a standing working group gives you nimbleness as you can ask them to do something without establishing a new group but standing groups have not been nimble in practice. He sees value in the task force approach for nimbleness. There are supposed to be liaisons for Working Groups but some members were not prepared for it. If the SAB members take liaison responsibility more seriously it may drive what members you choose and you may not want to do that.

DRAFT

Lynn Scarlett said this discussion is about how the SAB and its affiliated groups can be the most strategically impactful and helpful to NOAA. There are many dimensions of this-engagement in membership, work plans and liaisons and also recognition that there are multiple approaches - task force, working group and many kinds of working group work products.

Cynthia Decker pointed out that task forces aren't necessarily more nimble because it still takes time to assemble them and charge them versus giving a charge to an existing WG to provide a product on a short time frame.

Kathy Sullivan said this discussion is very useful. NOAA and the SAB must decide what is the best way for any particular question and what is the essence of the work for the SAB. There should be shared cognizance between the SAB and Working Groups. The current model for the SAB is that of investigation by working groups and bringing back findings. Another model might be using the expertise of the SAB members themselves and provide the input directly without the investigation. Dr. Sullivan stated that she found the issue papers provided today more valuable to her than other reports by the SAB.

The EISWG and ESMWG membership vacancies coming up should be addressed now. The SAB ConOps can be used in the future to make the process work better. Perhaps there can be a small number of standing working groups with richer engagement with the SAB and perhaps the SAB can meet with Working Groups directly; the meeting time of the SAB and Working Groups could be reallocated.

Richard Moss said he was on the Climate Working Group and there was never much guidance to them on their relationship with the SAB. The members thought they were there to provide advice to NOAA on climate; the depth of knowledge in the Working Group was good so they probably just need a better relationship with the SAB.

Denise Reed said on the Working Groups you want relevant scientific expertise that can spend time understanding the agency so they can provide effective advice. She thinks the expectations of products from Working Groups have produced very detailed, thoughtful documents that may or may not have been helpful and may not have been a good use of members' time. They should give ideas on what investigations are needed and how to have them done. The Working Group products may need to be timelier, shorter; perhaps the Working Group ConOps can set reasonable expectation of timeliness and kind of advice needed.

Bob Winokur said the Working Groups can be nimble; the downside of National Academy of Science studies is that they can take two years. The Working Groups can provide tactical advice between nine months and a year. The SAB should ask the Working Group Chairs for their input. Kathy Sullivan said NOAA has asked the Chairs for their input and won't proceed without their input.

Rick Spinrad added that there have been discussions about the relationship of Working Groups with SAB and internal dialogue with NOAA. There is a difference of expectations among Working Groups including resources and staffing and there are some best practices to capture. There is also the work flow, dialogue and deliberation within NOAA through the SAB. NOAA leadership wants short and pithy



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advisory documents. On the cycle time, the issue papers were delivered in weeks without including specific recommendations.

Richard Merrick asked whether Working Groups with reviews in progress should carry on. The answer was the groups should continue with current reviews.

Lynn Scarlett said for the pending Working Group membership actions, will get out information with a timeline. The Working Group ConOps draft will be completed and provided to the SAB before the November meeting. The working groups should proceed with existing work but plan to develop work plans in the near future.

### **Discussion of SAB Issue Papers**

Lynn Scarlett, The Nature Conservancy and Chair, SAB; SAB members

Lynn Scarlett thanked the members for their work in preparing the five issue papers and asked each author to give a short summary of his/her paper.

#### *Compressive Sensing*

##### Summary

Everette Joseph said NOAA processes a lot of data and traditional processing requires scientists to collect more information than is often needed or used. The use of the compressive sensing technique allows the organization to process only the data needed; reduces the complexity of sensors required, and uses less energy because the focus is on the decompression algorithm rather than processing all of the data collected. Given the benefits of data compression, NOAA should consider using it more widely and have a strategy to investigate technologies with immediate short-term and longer-term benefits. Compressive sensing is a mature technique and being quickly applied. The focus of research now is sensor development and decompression algorithm methods that are accurate.

##### Discussion

Rick Spinrad asked if compressive sensing can be used in hydrographic surveys. Everette Joseph said there is opportunity in this area. Rick Spinrad asked NOS if the LO was using disruptive approaches for mapping and charting. Mary Erickson responded that NOS is working with mapping centers of excellence on improvements in mapping, charging and acoustic data; she will check about application of compressive sensing.

Kathy Sullivan asked if there is a way to use atmospheric profiling that is sparse in sampling but rich in data; if that is possible she wondered if NOAA could use small satellites more and radically shrink the cost of using large satellites. Everette Joseph said that for operational goals, compressive sensing is exciting but wondered about the risk for data that drives basic science.

DRAFT

Craig McLean said there is a greater potential to try to sustain existing systems than to find a new one. Science budgets are being consumed with sustaining the current systems rather than looking at the science needs and changing the technology to meet those.

Manson Brown said the Observing System Council will work on this issue.

Kathy Sullivan asked if this topic was sufficiently tractable that NOAA should take it up now or is it insufficiently developed and requires going to the National Academies of Science (NAS) or the National Science Foundation (NSF) to get a more thorough examination before NOAA works to apply compressive sensing.

Susan Avery suggested NOAA should look in-house for expertise and augment with people knowledgeable on the application or test bed with Observing System Simulation Experiments; another option is to engage the National Aeronautics and Space Administration (NASA).

Kathy Sullivan asked if anyone in the military is using compressive sensing. Everett Joseph said he did not know but thought NOAA had expertise in signal processing but may need some external expert help in application of compressive sensing.

*'Omics*

### Summary

David Lodge began with a caveat that while aware that NOAA is working in 'omics he is not aware of the level of expertise in NOAA on this topic. Technology can drive management and policy and this is an example where there is rapidly developing biological genetic information or genetically-determined capability of organisms. 'Omics is a description of the genetic makeup of organisms (e.g. genomics, proteomics, and transcriptomics). The environment determines which genes are called into action; at the simplest level environmental DNA can be used to see if the organism occurs there or can detect the organism's response to the environment. The second revolutionary technology that is more of an urgent issue for NOAA is gene editing and technology. This is because it can make an edited genome into a gene drive that can change the entire population of a species. This technology is being applied in many fields. The NAS completed two studies on human and non-human use of gene editing, which are great primers on this topic. Gene editing will be used for how the organism will interact with the environment and may change the environment in the feedback loop. Aquaculture is an example where it can be used in response to ocean acidification. David Lodge said he was confident that NOAA will have to respond to gene editing issue; and NOAA will be faced with how to manage those organisms.

Susan Avery added that the higher level 'omics are still in novel use. It really gets down to how an ecosystem functions and whether the ecosystem is healthy. We need higher level information on health of ecosystem to know how gene editing will interact with the environment. NOAA must be involved with this science and look at the consequences of gene editing and how to preserve ecosystems at risk. David Lodge added that gene editing can achieve environmental goals like eradicating invasive species but there are risks as populations are connected.

## Discussion

Rick Spinrad said there are moral implications of gene editing. On diagnostic side, one use is early indicators in climate change. Is there a potential for using bioinformatics instead or in conjunction with traditional indicators for prognosis on climate change? For illegal, unreported and unregulated (IUU) fishing, what is potential for gene editing as the forensics for enforcing regulations?

David Lodge said there is nothing new in forensic use but there has been constant lowering of cost of use of this technology, making it more available. On early indicators, that is what some of the 'omics are being used for. The key is determining what signal would be used for early indication of climate change.

Mary Erickson said NOS, NMFS and OAR have been applying forensic tools in corals. The challenge is determining what capabilities NOAA has and what capabilities do other partners have. David said partnerships with universities are key because NOAA will never move fast enough using its own capabilities.

Craig McLean said in 2011 there was an external workshop on identifying microbial ocean research topics but NOAA was not able to get the move forward on this with enough additional funding. He said there is great value in bringing these conversations to the internal NOAA strategic Councils.

David Lodge said one of the things genomics can provide is a baseline description of biological environmental with geographic scope and affordability as no other technology can. It does not replace biological sampling but is a powerful complement. In looking at coral reefs without baselines, for example, environmental intelligence is useless. Susan Avery added that this is a data-intensive science; NOAA needs a data center that could store these data and make them accessible.

## *Risk Communication*

### Summary

Peter Kareiva said NOAA's business is risk communication. There was a NOAA report in April on risk and social science; there is an urgency to move this issue forward as it could be tailored to NOAA's work. NOAA needs the information on this topic and can do experiments to advance the field. On visualization, he identified the Vulcan method used by the Paul G. Allen Family Foundation as private sector partners. On site-based risk, partners are the reinsurance industry and The Nature Conservancy. For research on messages tailored to an audience, political consultants can be partners. For small probability events, a partner is the health industry. For applied psychology, partners can include design firms and applied psychology.

He suggested mechanisms to advance work on this topic including either one- or two --day workshops with academics to help you or using the Vulcan process with a one-day meeting with simulating evolution.

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## Discussion

Eugenia Kalnay wondered how important is conveying uncertainty in risk. Peter Kareiva said it was very important, particularly showing uncertainty in data visualization.

Kathy Sullivan asked if it was clear whether NOAA should convey risk or confidence to various audiences. It seems like the process recommended could work for other areas—is that correct? Peter agreed that the rapid process would work in other areas as the NOAA staff have already thought about it and he gives it good chance for success.

Everette Joseph asked, if in conveying risk uncertainty, we are doing this predictability in a way that maximizes risk communication. Peter Kareiva said different types of uncertainty require different approaches and NOAA should think about this.

Lynn Scarlett said if NOAA moved ahead with workshop concept, this may bring together practitioners such as emergency managers. Peter Kareiva cautioned to beware of conventional wisdom from practitioners. Lynn Scarlett clarified that there are practitioners that have departed from conventional wisdom and embracing new topics.

Richard Merrick said there is a huge amount of work underway beyond the NOAA risk communication report. There is a climate resilience tool kit; many of the tools are intended to convey risk including climate hazards and consequences. NOAA may want to examine what is in tool kit because many may be untested. In climate assessment, the United Kingdom (UK) produced a report on climate change with risk and urgency categories to help decision makers set priorities among multiple risks in different regions.

Lynn Scarlett added another thing to review is the Army Corps of Engineers work on multi-values criteria assessment to understand what risks people most care about and the communication challenge.

## *Data Science*

### Summary

Data science should be explored now as this topic is critical in NOAA. It is a hot topic and curriculums are being developed that are relevant to NOAA. Data science is about providing data sets and tools to bring change into practice. Key challenges were posed by NOAA staff. These challenges could be addressed through the Vulcan process or workshops; so much is going on in the National Centers for Environmental Information (NCEI) on how to catalyze the momentum, including how to maximize the social returns on data. NOAA has a Big Data partnership with five corporations and there are a lot of quick returns that result from these partnerships and from work in the “blue economy.” NOAA can emphasize work in public-private partnerships. Another challenge is data management policy and practices; SAB Working Groups such as the Data Archive and Access Requirements, Environmental Information Systems, and Climate may be able to apply their expertise to these issues. To move forward

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quickly the issue paper suggests workshops or strategy sessions and provided a list of best people to engage with this.

### *Exascale Computing*

#### Summary

Eugenia Kalnay said the fastest computers reached one petascale in 2012; exascale is 1000 times faster. Moore's law, that every two years super computer power doubles, has governed this expansion in the past. NOAA's National Weather Service is using two very powerful supercomputers of 2.9 petaflops each but will need more power to increase weather model resolution. Data assimilation by models is optimized but the forecasts will not be improved unless the entire chain is improved from observations to assimilation to models. Exascale computing is needed to make this happen for both weather and climate forecasts.

#### Discussion

Rick Spinrad asked if there would be changes in data assimilation methodology that may not be feasible with current computers but which may be possible with exascale computing. Eugenia Kalnay said ensembling and resolution will be the main users of the higher capability.

Dawn Wright said Moore's law is beginning to flatten out and as the modeling community is able to deal with high-resolution grids in data assimilation, will the error checking improve? The response was that recent developments show the modelers can improve their products with data assimilation.

Craig McLean said research supercomputing is competing with operational computers but research is falling behind. Richard Moss said there is appeal in using the extra computing power to look at issues with risk, such as extreme events and perturbed physics, and not just to improve resolution.

Jennifer Logan said chemistry models are complex and more than just physical models; there is a need to run multiple chemistry models as they get different answers depending on the chemistry. There is a need for more computational power in the chemistry climate models.

Mary Erickson said NOAA needs to look at computing needs from complexity perspective similar to chemistry and broaden this to look at integrated coupled earth system approach. She wondered about cloud computing and its implications on how it affects research computing but is not sure about the exascale computing impact.

Susan Avery suggested that NOAA watch the new resolution in quantum computing and keep that on the horizon as well.

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Kathy Sullivan said how exascale power is used is one question; Europeans and others are trying to get to exascale computing and asking how to get ready for this as well as cloud and quantum computing issues, etc. NOAA needs to think about getting ready for exascale computing and what that means.

Eugenia Kalnay said the modeling community is doing data assimilation of the whole earth system but there is a big need for power to consider the human system coupled with feedbacks.

### **Next Steps on Strategic Discussions**

Lynn Scarlett, The Nature Conservancy and Chair, NOAA SAB

Lynn Scarlett thanked the entire SAB for the discussion with special thanks to members who completed the issue papers. The next steps on the issue papers involve NOAA internal work on those topics.

The SAB will explore additional speakers for strategic discussions at future meetings. She thanked David Lodge and Jennifer Logan, whose terms are ending, for their service on the Board.

### **Review of Actions**

Cynthia Decker, SAB Executive Director

1. SAB accepted the Arctic Research Report from the ESMWG with the provision that the WG will, in three weeks, provide a prioritized list of the 15 recommendations.
2. NOAA will provide the FY15 Strategic Research Guidance Memorandum to the SAB for comments to be provided in two weeks.
3. The SAB Office will distribute the PowerPoint presentation from P. Sukhdev to the NOAA AAs.
4. The SAB Office will circulate the suggested candidates for ESMWG and EISWG to the SAB with a timeline for this membership process.
5. NOAA will finalize the SAB Concept of Operations.
6. NOAA will present the revised SAB Working Group Concept of Operations at the November 2015 SAB meeting for discussion.