

**57th Meeting of the NOAA Science Advisory Board
November 17-18, 2016**

Location: The Nature Conservancy
4945 North Fairfax Drive, Suite 100
Arlington, VA 22203

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, Director Institute for the Environment and Sustainability, UCLA; Dr. David Lodge, Professor, Cornell University; Dr. Jennifer Logan, Research Associate, 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;; 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; 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; Dr. Douglas Lipton, Senior Scientist for Economics and Dr. Richard Merrick, Chief Scientist, NOAA National Marine Fisheries Service; Dr. Jeff de la Beaujardiere, NOAA Data Management Architect, 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, Ms. Elizabeth Akede and Ms. Mary Anne Whitcomb

November 17, 2016

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 Scarlett welcomed everyone to the meeting. Self-introductions were made.

SAB Consent Calendar

Lynn Scarlett, The Nature Conservancy and Chair, NOAA SAB

- August 2016 SAB Meeting Minutes
- Working Group Status Reports

Lynn Scarlett asked for approval of consent calendar items and they were unanimously approved.

NOAA Update

Kathryn Sullivan, Under Secretary of Commerce for Oceans and Atmosphere

Summary

Dr. Sullivan acknowledged the members leaving the SAB before the next in-person meeting in Spring 2017: Peter Kareiva, Jeremy Jackson and Dawn Wright and expressed thanks from NOAA for work done under their tenure.

NOAA Personnel Updates

Jon Hare was appointed Director of the NMFS Northeast Fisheries Science Center. John Armor was named Director of the NOS Office of National Marine Sanctuaries.

Overview of Major Events

Since the last meeting, there were three major categories of events she highlighted.

High Impact Weather Events

August Flooding in Louisiana - A slow-moving storm released up to four feet of rain on parts of Louisiana and 13 people were killed. According to the Red Cross, it was the worst U.S. disaster since Hurricane Sandy. The National Weather Service issued an outlook for high flooding two days in advance, and local forecast offices provided 90-120 minutes lead time for local flash flooding with 94% forecast accuracy. After the flooding, the NOAA King Air aircraft flew four survey flights to assess the extent of damages. This was a rapid assessment scheme and 100,000 homes were quickly categorized into FEMA's database within a day of storm.

Hurricane Matthew was the first category 5 Atlantic storm since Felix in 2007. The storm produced a ten-foot storm surge in Ferdinand Beach, Florida; 107 mile per hour winds in Cape Canaveral and seventeen inches of rain in Savannah, Georgia among other impacts. Data from NOAA satellites, Hurricane Hunter aircraft, Global Hawk drones and from buoys and surface observing systems were used in the forecasts and warnings. National Weather Service staff briefed President Obama, FEMA, governors and community leaders prior to the storm. After the storm the NOAA R/V Hassler surveyed Charleston and Savannah to assess damage and get the ports back open; data provided to FEMA from the King Air aircraft confirmed resources to be prioritized to address inland riverine flooding.

The National Water Model, now operational, provided multiple hours of lead time showing streamflow spikes in previously “hydro-blind” areas. NOAA is optimistic that NWS meteorologists will increasingly incorporate the National Water Model data into their prediction of local flooding conditions.

Ocean Conservation

The President expanded the Papahānaumokuākea Marine National Monument to cover 582,578 square miles, protecting 71 additional species. A new Northeast Canyons and Seamounts Marine National Monument was announced; it is the first Marine Protected Area (MPA) in the Atlantic and covers 4913 square miles. NOAA has a co-manager role in both protected areas. On October 17, the Ross Sea Marine Protected Area was created; located in Antarctica, it is the largest MPA in the world at 590,458 square miles.

Global Ocean Acidification Network website makes real time ocean acidification data from buoys and moorings around the world freely available. ESRI’s Ecological Marine Unit Explorer makes ocean data understandable by the use of 3D characterization of oceans built on NOAA’s World Ocean Atlas.

Other exciting announcements include removal of nine of 14 humpback whale population segments from the endangered species list and NOAA’s role as lead of the US involvement with Australia’s International Partnership for Blue Carbon.

Arctic

NOAA played a significant role in the White House Arctic Science Ministerial meeting in August; an emerging priority from the meeting was a focus on better integration and coordination on observations and data sharing. The Pacific Marine Environmental Laboratory held an Arctic Heat Open Science Experiment; and is using data from the Twin Otter aircraft and from autonomous floats to help bridge the open ocean data gap. The US holds Arctic Council chairmanship through May 2017. The White House is looking at the national security

implications of climate change including a report from the National Intelligence Council suggesting the climate change will threaten global political security. The President signed a Memorandum directing federal agencies to account for climate change impacts when developing national security policy. NOAA is a member of the newly-formed Climate and National Security Working Group and co-chairs the data and modeling and greenhouse gases working groups.

Updates on NOAA's Four Priorities

Observational Infrastructure

On November 19, the Geostationary Operational Environmental Satellite-Series R (GOES-R) will be launched; GOES-R will have five times faster imaging with four times sharper spatial resolution than current GOES imaging. NESDIS has simulated imaging to help prepare for data ingest.

New research shows trends in global fossil fuel industry methane emissions may be up to 60 percent higher than estimated by previous studies. Since announcing that carbon dioxide surpassed 400 parts per million (ppm) at South Pole in June (likely 1st time in 800,000 years), NOAA scientists have concluded its unlikely current generations ever see CO₂ below 400 ppm again.

Resilience

The Climate Resilience Tool Kit now has a built environment portal to help users understand vulnerabilities and risk and incorporate resilience into civic planning

The Marine Debris program's online citizen science initiative engages partners and volunteers to help conduct marine debris surveys. Over 250 sites have been surveyed; 66 sites are currently being monitored.

There are several updates in the coral reef conservation program. NOAA awarded \$9.3 million in grants and cooperative agreements to support conservation projects and ecosystem management studies. The Atlantic Oceanographic and Meteorological Laboratory (AOML) developed an experimental aquarium to manipulate ecosystem stress for studying coral bleach resistance.

American's first offshore wind farm became operational in Rhode Island this month; Rhode Island Sea Grant used stakeholder input and ecosystem understanding to help select an appropriate location for turbine siting.

Under the National Ocean Policy, the Northeast and Mid-Atlantic ocean plans will pool ocean insights into consolidated data portals to help streamline processes of environmental decision-makers.

Evolve the National Weather Service

There now is a NOAA umbrella Memorandum of Understanding (MOU) with the National Science Foundation (NSF); the Office of Oceanic and Atmospheric Research (OAR) Office of Weather and Air Quality (OWAQ) will leverage \$4M of NOAA funding with NSF funding for projects to examine the effectiveness of risk communication over social media and to study the communication of forecast uncertainty to stakeholders, particularly emergency managers.

In space weather, a new geospace model of the upper ionosphere was added to the operational supercomputing suite; this new model will provide more sophisticated space weather forecasts, giving the electric power industry 30 minute lead time for regional geomagnetic storms.

Organizational Excellence

NOAA completed its Fleet Plan and sent it to Congress; the plan includes construction of two new AGOR (Auxiliary General Oceanographic Research)-type vessels to maintain Pacific Ocean capabilities.

NOAA held a Diversity and Inclusion summit with career leaders who will keep this effort moving; Line Office Assistant Administrators are also driving this program throughout the organization.

The National Earth System Prediction Capability, an effort to increase collaboration and data sharing across the federal family using tools such as the operational global ensemble, continues. Recent progress includes formal connection with Federal Committee for Meteorological Services and Supporting Research and engagement with the National Science and Technology Council and the Committee on Environment, Natural Resources and Sustainability.

Discussion

Lynn Scarlett thanked Kathy Sullivan for her leadership over the years with four priorities and all relevant to well-being of nation and world.

Walt Faulconer asked if there were lessons learned from Hurricane Matthew. Dr. Sullivan responded that a service assessment is completed after each event. Louis Uccellini added that while the assessments are still under way, one observation from Hurricane Hermine was that there was a shortage of forecasters to embed in emergency management centers. For Matthew they searched for forecasters for this purpose as a lesson learned. There were good connections

to state officials and fast response teams; and experimental storm surge models were very effective in their use. Kathy Sullivan said she noticed a shift in media coverage with a shift to focus on storm surge, new maps and more understandable information provided with one NOAA voice.

Richard Moss asked about the content of an umbrella agreement with the National Science Foundation. The National Academy of Sciences has a Board on Environmental Change and Society and there is an opportunity for discussion on human dimensions. Is social science involved with after-event assessments? Kathy Sullivan said human dimensions have been in post-assessments since the 1990s. Louis Uccellini said before the event, the storm surge product stream involved a \$2.5 million effort to design products with user input. The NWS is assessing that now. In post storm mode, changing risk assessment, occurs, with a fatigue or overhype factor that kicks in. NWS needs a better understanding of people's changing risk assessment when that happens.

Rick Spinrad said the NSF MOU came from a meeting with Kathy Sullivan and NSF Director France Cordova and the decision was made to include all the NSF directorates. John Cortinas started this effort with leveraging NOAA funding of \$4M in social science projects with NSF. The next target for joint effort is the computer science and engineering division in NSF.

Susan Avery asked if, after Hurricane Sandy, NOAA has expanded ocean observations for hurricanes using robotics. Craig McLean said ocean observations have been expanded through the Integrated Ocean Observing Systems program. In addition, they are still analyzing data from the glider fleet but would like to have a "picket line" of gliders to deploy as hurricanes arise. Louis Uccellini added in addition to planes, NOAA has dropsondes and is also using satellites for derived heat content ahead of storms; the agency is using a combination of observations to address this problem.

Everette Joseph asked about the John Cortinas work with NSF. Rick Spinrad said OWAQ is using NOAA funds to support efforts at NSF that meet NOAA needs; this is not a co-mingling of funds but adding social science to physical science in separate projects. Craig McLean said there is a need to look at entire range of products between the OWAQ program and Sea Grant. Sea Grant is first on shore after a storm. John Cortinas looked at subject matter area of awards the NSF had made and realized he could leverage a social science layer on a physical science layer.

Denise Reed said on integrating natural and social sciences, Gulf Coast organizations have been made aware of this need. They also need to adjust the way things are built such as levee resilience and capability. The community must include the built environment and have relationships with engineering practice to adjust the way it builds and lives in a physical space. Kathy Sullivan said that was congruent with the post-Sandy task force, to recognize the need to

build forward to new risk environment and to determine the new risk posture one would like to have. Lynn Scarlett said The Nature Conservancy has found in its interactions with the engineering community that the challenges are not simply information transfer but better understanding of how the engineering community makes the decisions it does. What are the decision and cultural barriers that impede information change? Richard Moss said there are a number of activities underway through National Institute of Building Sciences to improve climate information dialogue as they improve codes and standards. On engineering they want best estimate and risk case but that can only be done under deep uncertainty and the data that can be provided is quite different from what engineers need so scientists need to learn a way of discussing this differently.

NOAA Chief Scientist Update

Richard Spinrad, NOAA Chief Scientist

Summary

Rick Spinrad used this time to present an overview of the Chief Scientist Annual Report (CSAR) that was released [December 12, 2016]. It is a concise, external-facing document that details NOAA's portfolio logic: why, what, where, and how NOAA invests in research. NOAA supports research that is of high impact and high relevance (Pasteur's quadrant). In this manner, NOAA transforms basic research into data, tools, and information to support mission priorities.

Beyond outlining the guiding principles of NOAA research, the CSAR includes 53 vignettes organized into five theme chapter (based on the Strategic Research Guidance Memorandum (SRGM)); each highlighting the most exciting scientific results from the past year (2016). A few vignette examples and the chapters they fall under are summarized below:

Integrated Earth System Processes and Predictions

The high resolution rapid refresh model (HRRR) increased the timing of weather forecast capabilities. The Federal Aviation Administration (FAA) has already experienced the benefits from this enhanced capability.

Environmental Observations and Data

The coral reef outlook to predict future bleaching events released the newest version of the four-month bleaching outlook. The result is a four-fold increase in resolution.

Another example is the use of gravity data from an unmanned aircraft to improve floodplain management. NOAA conducted one of the first tests of a gravity measurement device on an

optionally piloted aircraft which resulted in improved accuracy of these measurements and improved floodplain management. *Decision Science, Risk Assessment, and Risk Communication*

In September, NOAA published the first-ever Ocean Noise Strategy Roadmap based off of this work that came out of Marine Sanctuaries on the potential acute behavioral and physiological problems anthropogenic noises causes in marine life. Additionally, the Pacific Marine Environmental Laboratory (PMEL) Acoustics Program has established an ocean noise reference station network.

Arctic

NOAA has utilized innovative technology for arctic exploration, including the use of Sail drone through partnerships with private industry.

The second part of the CSAR represents a bibliometrics analysis; one of the most rigorous performance assessments of NOAA's scholarly research conducted to date. The Office of the Chief Scientist used Web of Science and the web based platform InCites to perform analysis on data collected from papers published between 2011 and 2015. This analysis established NOAA's core research areas; NOAA's productivity based on the number of published articles; and the impact of NOAA research using the Hirsch Index, normalized citation impact, and other citation metrics. These findings are benchmarked with those of other federal agencies that conduct research in the same areas. NOAA has high productivity and impact in Meteorology and Atmospheric Sciences as well as Marine and Freshwater Biology and Oceanography.

The final section of the CSAR highlights the creative and vibrant scientific workforce at the core of NOAA's research and development and mission services enterprise. Internally, between 2015 and 2016 NOAA had 345 individual awardees and 11 team accolades. These include Department of Commerce Gold and Silver Medals, NOAA Bronze Medals, NOAA Administrator's Awards. Externally there were awards to 6 teams and 72 individuals. These awards come from an assortment of sponsors including American Meteorological Society, American Fisheries Society, and National Weather Association. Additionally, NOAA has 36 scientist holding elected positions in 22 scientific societies.

The report also links to the laboratory and program science reviews in NOAA's line offices. The CSAR is now available [online](#).

Discussion

Many members (Susan Avery, Peter Kareiva, Dawn Wright) commended the document finding it powerful, and useful in many different ways. Many members expressed interest in helping to

publicize the document. Dr. Avery asked if there was a digital way to navigate through the document, similar to walking through a virtual museum. Dr. Spinrad indicated once there is a better understanding of how people are using the report, a digital roadmap could be implemented in future years.

Based on member questions on citation metrics, Dr. Spinrad clarified this bibliometrics analysis used NOAA-employed authors only. In the future, bibliometrics may expand to include use of authors using NOAA datasets, Cooperative Institute authors, and other sponsored research. While the actual papers are not linked due to journal paywall issues, this would be interesting to do in the future.

Denise Reed asked how the 53 vignettes were selected. Dr. Spinrad explained the Office of the Chief Scientist received 70-80 initial entries selected from an even larger number by the Program Coordination Offices.

Review Report for the Cooperative Institute for Research in Environmental Sciences (CIRES)

Walter Faulconer, CIRES Review Panel Chair and SAB Member

Summary

Walt Faulconer led a panel of six members in a review of the Cooperative Institute for Research in Environmental Sciences (CIRES) on August 29 – September 1, 2016 in Boulder, Colorado. The CIRES vision is to ensure a sustainable future environment by advancing scientific and societal understanding of the Earth System. Its mission by conducting innovative research that advances our understanding of the global, regional, and local environments and the human relationship with those environments, for the benefit of society.

CIRES houses four centers including the Center for Limnology; Center for Science & Technology Policy Research; Earth Science and Observation Center; and National Snow and Ice Data Center. In addition to these centers, the CI (Cooperative Institute) houses four programs including the Energy and Environment Initiative, Geomagnetism, Western Water Assessment, and Education and Outreach. Research is organized around nine themes: 1) Air quality in a changing climate; 2) Climate forcing feedbacks and analysis; 3) Earth system dynamics, variability, and change; 4) Management and exploitation of geophysical data; 5) Regional science and applications; 6) Scientific outreach and education; 7) Space weather understanding and prediction, 8) Stratospheric processes and trends; and 9) Systems and prediction models and development.

Summary of External Review

The review panel unanimously agreed to an “Outstanding” performance rating for CIRES.

Overall Findings

- CIRES has a well-written vision statement and mission statement for the research they conduct and has excellent administrative structure overseeing a rich and diverse research portfolio.
- The research conducted at CIRES is world-class and award winning.
- The Institute has successfully reached beyond the initial NOAA funding by developing additional research activities that are beneficial to NOAA interests. There is a well-organized structure for the interaction between CIRES and the NOAA Boulder Laboratories. Some of that structure is illustrated in the five-year work plan from 2012 to 2017 provided to the committee during the review.

Strategic Plan Findings and Recommendations

- The physical separation of NOAA and CU (University of Colorado) naturally creates boundaries to scientific collaboration. The challenges with passing through security at NOAA and finding parking at CU serve as additional barriers
Recommendation: While acknowledging the financial challenges of this recommendation, the panel encourages consideration of a new building at NOAA that is located outside of the secure area, which would serve as a point of connection for the communities from NOAA, the CU campus, and other partners.
- It is clear that CIRES is very responsive to NOAA and gets very high marks to responding to NOAA needs.
Recommendation: CIRES should also be more proactive as a NOAA partner in helping to be thought leaders in the strategic direction of critical science, research, policy, etc. This should also be reflected in the strategic planning of CIRES.
- CIRES does an excellent job of partnering with many government, academic and industry organizations, as reflected by the variety of sponsors funding many of its projects.
Recommendation: There are still untapped/non-traditional organizations that CIRES should investigate partnering with that could be beneficial to NOAA in the future, including partnering with a HBCU (Historically black college and university, e.g., Howard, Morgan); Defense and Intelligence organizations and other parts of the university.
- CIRES has seen significant growth in both breadth and depth. While CIRES leadership is doing very well at managing the challenges that come with significant growth, it raises the potential concerns including not losing what makes CIRES unique and special to NOAA, avoiding “stove pipes” and maintaining a “one team” culture.

Recommendation: Capture lessons learned and incorporate continual improvement into overall practices.

- CIRES does an excellent job of tracking progress through metrics and “market indicators” (e.g., funding, awards, paper citations)

Recommendation: CIRES should add a few metrics that are useful in indicating organizational health including win rate of opportunities; win rate of dollars; percentage of re-compete opportunities versus new opportunities and diversity.

Science Findings and Recommendations

- CIRES is producing outstanding science. A testament to this is over 700 publications involving CIRES authors or coauthors in 2015 alone, along with numerous awards received by CIRES scientists in the last 4 years. CIRES researchers are leaders and emerging leaders in their scientific fields. The numerous awards and broad recognition of the work is a testament to the high quality of the work conducted.

Recommendation: We recommend CIRES continue with research in all 9 identified themes and maintain their excellent level of scientific achievement. Well done.

- CIRES researchers have a fantastic capacity to work along the research lines of ESRL (Earth Systems Research Laboratory) and NCEI (National Center for Environmental Information) while being nimble enough to accommodate opportunistic work have established themselves as the go-to institute for a number of research topics.
- The IGNITE talks presented by the graduate students during the review were brilliant and a great way to get an overview of a number of research activities.
- CIRES is ideally positioned to bring together the space weather enterprise. Space Weather is a large growth opportunity.

Recommendation: The Director of CIRES should consider reaching out to other Universities, interested stakeholders and other Government Agencies involved in space weather to create a Space Weather Consortium and a Center for Space Weather Research at CU to provide some leadership and focus on this developing area.

- Some CIRES presentations mentioned the integration with social sciences but no real evidence or products were shown.

Recommendation: Social science integration may not be a major focus area or core competence of CIRES, however, given the growing importance at NOAA; CIRES should at least address it more through proactive partnerships, etc. This is an opportunity to help NOAA.

- In terms of financial goals, the Institute has exceeded expectations. Their outstanding work has attracted additional funding that has increased in each of the last 4 years.
- One of the challenges in the science management area of the institute is adapting to the different rules and expectations of the individual divisions at ESRL and the centers. CIRES administrators have demonstrated a willingness to work with the Labs and Centers to enable CIRES researchers to pursue their research interests in a manner consistent with meeting the research needs of the Lab.

- In some ESRL divisions, CIRES scientists are not allowed to be the Principal Investigator (PI) on proposals that are submitted through NOAA, creating a situation in which CIRES scientists do not receive appropriate external recognition for their work.
Recommendation: Establish a new internal designation of 'Science PI' to recognize the leadership of CIRES scientists on awarded proposals they wrote but were not allowed to be externally listed as PI.
- CIRES has four levels of internal promotion for both Research Scientists and Associate Scientists, allowing for career advancement within the cooperative institute. CIRES also internally awards scientists when their collaborative efforts with NOAA colleagues leads to Department of Commerce awards being issued on the NOAA side, as well as with annual Outstanding Performance Awards within CIRES.
Recommendation: CIRES should continue with the current program of career track advancement and recognition that seems to be working well.
- Workforce diversity is somewhat lacking at CIRES with approximately 80% of employees being white and 62% being men.
Recommendation: The review committee agrees with the current CIRES direction to build pipelines to minority academic institutions and consider cluster hires.
- A majority of CIRES scientists who are employed by CU as research associates or research scientists and work closely with NOAA Boulder Laboratory scientists to meet critical research and operational needs. CI funding levels for individual CIRES Scientists vary widely from full-time support to a fraction of the annual salary, which may vary year-to-year.
Recommendation: Strategic collaborative planning is needed among CIRES, NOAA and CU to further develop processes and infrastructure specifically targeting the ability of partially funded CIRES employees to secure continued full-time financial support, to foster equitable access to career development opportunities, and to nurture a climate of intellectual entrepreneurship and leadership.
- Cuts in staffing at the NOAA Boulder Laboratories have resulted in an aging organization.
Recommendation: NOAA should prioritize stabilizing the NOAA Boulder Laboratories' work force.

Education/Outreach Findings and Recommendations

- CIRES has a wide-ranging connection to education within the University and have developed a world-class structure for external education and public engagement. CIRES also benefits from identifying education and outreach as a major program theme.
- The magazine Spheres; Science on a Sphere; the NSIDC (National Snow and Ice Data Center) Sea Ice Index and related products; as well as a vigorous and noteworthy presence in the national news and social media are excellent examples of work in the education and outreach arena.

Recommendation: The panel recommends that CIRES continue their outstanding public outreach and education efforts by pursuing an even more global perspective, primarily through the internet.

- The panel found excellent graduate student involvement with 100-130 graduate students and thirty postdocs working with CIRES Faculty Fellows and CIRES Research Scientists. Recommendation: CIRES should continue their active engagement of graduate students at CU and look for ways to expand the reach of the CIRES Graduate Association even further.

Recommendation: Other successful educational programs including the visiting fellows and Post-Doctoral program should be continued and strengthened. CIRES should also investigate other area organizations to partner with, such as the Colorado Space Business Roundtable, Colorado Space Alliance and The Space Foundation that could be beneficial for the CIRES education and outreach pipeline.

Dr. Faulconer concluded the relationship between NOAA, CIRES, and the University of Colorado is of great benefit to all three entities. CIRES is essential to the successful research operations of NOAA and is critical to those at the University of Colorado. CIRES is highly regarded within the University and is broadly engaged. The CIRES director, Waleed Abdalati, is highly regarded by NOAA, CIRES, CU and the broader science community. He received particularly high praise from the NOAA division directors during the CIRES Review.

Discussion

The members discussed a number of best practices that can be taken from the CIRES review. Lynn Scarlett asked for more information with regards to the administration structure the review panel found successful and how CIRES amplified funding from other sources. Mr. Faulconer explained a fraction of the budget is spent on administration and personnel but it effectively minimizes stove pipes across multiple organizations and research areas in the CI. CIRES is able to leverage other funding, doubling the awards it brings in. Susan Avery commended CIRES on its established career track and internal awards.

Rick Spinrad said CIRES could be considered a posterchild for many of the CI21 recommendations that came out of the Chief Scientist's office.

Craig McLean noted that some of the sensitive points in the review are not just what CIRES can improve upon but also what NOAA can do better.

The SAB unanimously approved the report.

Action 1: The Science Advisory Board (SAB) approved the Review Report for the Cooperative Institute for Research on Environmental Sciences (CIRES) and will transmit to NOAA.

The State of Sea Grant: 2016 Biennial Report to Congress

Rosanne Fortner, Professor Emeritus, The Ohio State University, and Member, National Sea Grant Advisory Board

Summary

Dr. Rosanne Fortner, Professor Emeritus, The Ohio State University, and Member, National Sea Grant Advisory Board, presented ~~on~~ The State of Sea Grant 2016 Biennial Report to Congress from the National Sea Grant Advisory Board (the Board). Since the 2014 Sea Grant report, she noted some changes in personnel. Dr. John A. Knauss, for whom the Sea Grant Fellowship in Marine Policy was named, passed in 2015 and Dr. Leon Cammen retired after serving as director for 25 years; Dr. Jonathan Pennock became the new director of the Sea Grant program in 2016.

The State of Sea Grant 2016 provides an update on the National Sea Grant College Program (Sea Grant) over the past two years. The 2014 report made four recommendations to Sea Grant: (1) Address national priorities at the local level and through strong partnerships, (2) Track and report impacts to evaluate progress, (3) Balance federal funding among programs, and (4) Strengthen focus on environmental literacy and workforce development. The 2016 report addresses each recommendation and states ways that the Sea Grant has been able to address each recommendation since the time of the report. Also included in the report are the four identified focus areas of the 2014-2017 Sea Grant Strategic Plan - Healthy Coastal Ecosystems, Sustainable Fisheries and Aquaculture, Resilient Communities and Economies, and Environmental Literacy and Workforce Development. Over 3000 impacts and accomplishments were reviewed and grouped into the four focus areas.

In addition to the ongoing efforts within each of Sea Grant's four focus areas, Dr. Fortner also highlighted some of the ways Sea Grant is currently "in action" to address issues related to resilience, aquaculture, and ocean acidification. To address resilience each year the Sea Grant programs dedicated approximately \$16 million to address this issue. In 2015, Sea Grant provided 730 resilience-focused trainings and worked with 570 communities to implement sustainable development practices. To address aquaculture, in the past two years, Sea Grant has received over \$13 million in Federal funding to support both national and state programs for aquaculture research, extension, and technology transfer projects, as well as workshop and training support. These funds are supplemented with a corresponding state match of over \$6.5 million. An example cited New Hampshire Sea Grant, which designed an aquaculture raft that allows for a four-season fish and shellfish source and improves water quality by removing nitrogen. To address ocean acidification, NOAA Ocean Acidification program and Northeast Sea Grant programs provided \$800,000 in federal funds to assist coastal communities in adapting to current and future ocean acidification conditions in the region. Also, MIT Sea Grant worked with several

partners in Massachusetts to quantify the carbon storage of eelgrass beds, which could serve as refuges for marine bivalves. Washington Sea Grant was instrumental in obtaining a \$1.5 million grant from the Paul Allen Family Foundation to pilot a novel ocean acidification mitigation strategy in Puget Sound using algae. The report also highlights recent achievements and efforts related to Knauss Marine Policy Fellowship, Sea Grant Law and Policy Expertise, Performance Review Panels and Site Review Teams, Economic Impacts, and the Sea Grant Reauthorization.

Finally, Dr. Fortner also highlighted the five recommendations sent to the Sea Grant in the 2016 report:

1. Sea Grant should seek partnerships with more programs in NOAA to build on the existing investments and reputation of the Sea Grant Program.
2. The NSGO should support the expansion of the Sea Grant Liaison Program in NOAA offices, laboratories, and programs, based on the recommendations of the Board in their 2016 Liaison Subcommittee Report.
3. Sea Grant should continue to enhance diversity and inclusion throughout the network so that its workforce, programming and materials are more representative of the nation as well as the audiences the program serves.
4. Sea Grant needs to demonstrate how its K-12 and informal education programs collectively respond to national priorities and result in evidence-based accomplishments and impacts. To accomplish this, Sea Grant should enable collaboration through consistent programmatic and travel support at state and national levels so the Education Network can work together.
5. Sea Grant should enhance efforts toward gathering and sharing the wisdom and experience of experts in subject matter relevant to Sea Grant's mission. Previous theme/focus teams began this productive process and offer a mechanism moving forward.

The report ended by mentioning emerging opportunities within the four strategic focus areas, additional possibilities in data sharing, and results from a recent Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis.

Healthy Coastal Ecosystems: Sea Grant might benefit by building up its social science portfolio which can support development of ecosystem-based management strategies.

Sustainable Fisheries and Aquaculture: the regulatory environment for aquaculture is complex, and Sea Grant expertise is already proving valuable to the industry.

Resilient Communities and Economies: Sea grant can build on the progress achieved through the COP21 Climate agreement and portfolio opportunities related to climate change could include integrated approaches to water issues and climate adaptation.

Environmental Literacy and Workforce Development: Sea Grant can use new technologies to reach a diversity of new audiences.

Data Stewardship: The Sea Grant network has formed a “Sea Grant Data Stewardship Subcommittee” to develop a consistent set of principles that guide how Sea Grant uses and shares data.

National Program Opportunities: In addition to opportunities already identified, the following themes present new opportunities:

- Future funding opportunities to support the Sea Grant mission
- Additional and stronger strategic partnerships
- Regionalizing the Sea Grant model

Discussion

Lynn Scarlett asked whether the failure to reauthorize the Sea Grant program is due to Congressional inertia or have there been concerns raised? She also asked about the rationale behind the cap on administrative funds for the program. Dr. Fortner stated that the Sea Grant authorization, since 2008, has been appended to other bills which contributed to the delay in reauthorization. As to the cap, the Sea Grant directors in the field suggest that Sea Grant federal funding should be applied to field activities instead of in-house management. Jon Pennock stated that the 5% cap has been legislated for quite some time. There is a proposal to raise the cap to 5.5% but legislation has not been passed to authorize this. Despite the reauthorization failure the Sea Grant office will continue to do good work and continue to receive bipartisan support. Craig Mclean commented on reauthorization saying that Congressional committees aren't taking up legislation in a bipartisan manner and Sea Grant is caught in at least one of those committees. Also being added to the reauthorization in regards to Work Force Management, Knauss fellows work in both the executive and legislative branch. There is an effort being made that would allow the federal sector to directly hire Fellows as federal employees up to two years after completion of their fellowship.

Dawn Wright mentioned the National Geographic push towards ocean literacy and ocean literacy standards and wanted to know if Sea Grant was involved with this effort. Dr. Fortner stated that the push for ocean literacy is worldwide. Sea Grant is also moving beyond the United States to create a Pacific Marine Educators Network and European counterparts. Some Ocean educators have been Fulbright scholars and the ocean literacy principles are being matched with the Next Generation Science Standards to make sure ocean educators are meeting these. There are also standards set for the Great Lakes; states surrounding the Great Lakes will build Great Lakes literacy into their curricula.

Russell Callender praised the presentation and stated that the 2016 recommendations are very much in line with what NOAA is currently doing in regards to enhancing diversity. He suggested that the National Ocean Service and Sea Grant Office can work together to share best practices.

Jean May-Brett asked for more information on what Sea Grant means by regionalizing the Sea Grant model. Dr. Fortner stated that this idea came from the SWOT analysis that was conducted. Jon Pennock added that a lot of the line offices within NOAA have been organized around regions for a long time and this has not been the Sea Grant model. Within the last decade Sea Grant offices have evolved to be regional because the issues that offices are dealing with are by definition regional in nature.

Preliminary Reaction: An Assessment of the Use and Potential Use of Ecosystem Services Valuation in the NOAA ESMWG Report

Monica Grasso, NOAA Chief Economist

Douglas Lipton, NOAA Fisheries Senior Scientist for Economics

Summary

Monica Grasso said NOAA appreciated having an assessment of its Ecosystem Services Valuation (ESV) efforts by the SAB. The purpose of the report was to start a dialogue with the SAB as NOAA works to improve and build its capacity in ESV. The report focused on non-market valuation and on survey-based stated preference approaches.

NOAA developed a Social Science Vision and Strategy in 2015 that included a statement that NOAA will estimate and apply ESV to demonstrate connections between ecological well-being and community well-being to demonstrate

Monica Grasso said last year the Council for Environmental Quality (CEQ) published a memorandum providing direction to agencies on incorporating ESV into decision-making processes and requiring a plan for implementation. NOAA had four tasks in its response to the CEQ: 1) continue to integrate ecosystem service to support the implementation of statutes, 2) continue to integrate ecosystem service into NOAA's programs; and, once the CEQ implementation guide was released, 3) undertake a comprehensive review of policies and programs, and 4) provide senior-level direction to integrate ecosystem services into NOAA policies and programs.

NOAA Capacity to Use ESV in Management

This part of the presentation was made by Douglas Lipton. After the release of the NOAA Strategy, NOAA found the demand for the ESV is inconsistent in NOAA. The institutions that would deal with trade-offs across large ocean sectors (e.g., energy and fisheries) are just developing under the Regional Planning Bodies. The decision context depends on program and use - ESV is not used for Endangered Species Act analyses; it is included in analyses for critical

habitat designation, ecosystem decision context, and ecosystem-based fisheries management and by regional planning bodies.

There is also a reluctance to use ESV as it is considered controversial and may be misunderstood by leadership. Dr. Lipton finds it interesting that value of statistical life (VSL) is accepted in calculating costs and benefits in other environmental settings such as clean air and water, but the value of protected resources such as marine mammals or endangered sea turtles is not being used.

ESV is a specialty area in environmental and resource economics but not all economists are trained on it. NOAA can train the people it has and hire economists with experience and training in non-market valuation. NOAA can also create a community of practice within NOAA and with academic partners. They saw in the report the need to priority and focus NOAA efforts.

High Level Technical Issues.

Recommendations in the report suggested that NOAA follow guidance developed by the profession and to beware of off-the-shelf approaches and to exercise caution with benefits transfer. In terms of the latter, if the dollar value of benefits are done in one study, under what conditions may they be used for another purpose?

NOAA needs to identify high priority and focused studies to fill in information gaps.

Guidance Requested from the SAB

Rather than waiting a year to respond to the SAB report, this is a quick response. NOAA is asking for guidance from the SAB: is the agency interpreting the intent of the report correctly, how can the SAB help in identifying “low-hanging fruit” and how can the SAB continue to engage with NOAA as the agency attempts to build capacity and address concerns.

Discussion

Lynn Scarlett appreciated the more rapid turnaround on the reaction to the SAB report and said there are already some communities of practice now. She had a question about how well NOAA is plugging into what exists rather than creating something new. This is an arena where a lot is going on rapidly so building interconnections is very important.

Monica Grasso said there is a new push from the CEQ and other agencies to make ESV happen, including guidance for the National Environmental Policy Act (NEPA). On communities of practice, there are some unique things in the federal government because this is a small

community of people. NOAA is thinking about a network of networks that include people on the academic side as well as the federal side.

Peter Kareiva said there are two separate communities--the economic vs practitioner communities of practice; Douglas Lipton agreed. Lynn Scarlett said with ESV and intersections with practice there is a tendency to homogenize the decision setting—to think of it as uniform across circumstances. Just how refined the valuation must be varies with situations; the need to know what one is trying to determine is critical to determine how far to go in the process. The point is to have cross cutting engagement of economists as well as end users. Douglas Lipton said the implementation guidance from CEQ deals with both ESV and decision context; the challenge will be what does this guidance mean for NOAA.

Richard Moss wondered where they saw more traction with issues of valuation and where are these methods more problematic. Douglas Lipton said it is NOAA's job now to prioritize.

Louis Uccellini said the Department of Commerce Bureau of Economic Analysis (BEA) is looking at the issue of the intrinsic value of a forecast and what vulnerabilities can be mitigated by a good forecast. One case study is in snow; the issue is particularly challenging with winners and losers but NOAA is working with BEA on this.

Kathy Sullivan asked about the issue that the VSL being accepted while ESV is not, is this a function of maturity of line of questioning and methods to respond? Has anyone done an anthropological analysis of statistical life valuation versus nature? Douglas Lipton said ESV is as mature as statistical life valuation; he does not know why statistical life is more accepted except perhaps as it is used in legislation or more widely in federal decisions.

Monica Grasso said that the VSL is well established and widely used by government for regulatory impact analysis. The Department of Transportation published a guidance on the use and how to update the VSL. Kathy Sullivan said if there has been research done in the history of science on the widespread practice of using statistical life; NOAA may want to look for exemplars to use in advancing ESV.

Doug Lipton responded that would be an interesting research question but was not aware of anything being done. The issue may be there is a wider acceptance on value of human life versus the value of ecosystem services. Ecosystem services are thought of as public goods; statistical life is a private good.

Peter Kareiva drew a distinction between economic community of practice and the practitioner community of practice. Practitioners are slow to publish but they have a rich experience and it would be good for NOAA to make that connection.

David Fluharty said the Ecosystem Sciences and Management Working Group is willing to engage on behalf of SAB on ESV issues with NOAA. Two places in particular are on prioritization and the CEQ report. He said they agreed with practitioners approach; ESV does not make decisions for NOAA but the use of it helps with decision-making. Demand- pull is missing from the decision process. A lot of these things have distributional and fairness aspects that have not been brought out; the thinking on these issues is not complete. How would one bring these in? One example is whether Cooperative Institutes (CIs) should support more social science or should there be a social science CI to advance this. In social science data is really needed on human behavior and what is valued. Finding key areas where this makes sense to do in NOAA is very important.

Ecological Marine Units: A Three-Dimensional Mapping of the Ocean Based on NOAA's World Ocean Atlas

Dawn Wright, Chief Scientist, ESRI, and SAB Member

Summary

Dawn Wright started by acknowledging NOAA leadership in attendance. The Group on Earth Observations (GEO), a consortium of over 100 nations with an intergovernmental protocol related to Earth observation, commissioned the US Geological Survey (USGS) to develop a standardized, robust, and practical global ecosystems classification and map for the planet's terrestrial, freshwater, and marine ecosystems. Without any funding available for such a Herculean task, USGS turned to ESRI for help, and ESRI agreed to participate fully and at no-cost as part of a public-private partnership. The project started in February 2015 with an initial workshop led by ESRI and involving lead partners such as the National Oceanic and Atmospheric Administration (NOAA), the Marine Conservation Institute, Duke University, the University of Auckland, GRID-Arendal, Woods Hole Oceanographic Institution, and many more.

EMUs are comprised of an aggregation and computation of an unprecedented 3D point mesh framework spanning 52 million points and global measurements of six key variables over a 50-year period of the ocean's water column. To build the EMUs, physical water property data were extracted from the NOAA World Ocean Atlas at 1/4° by 1/4° in the horizontal; variable z depth (z thickness ranges from 5m to 500m) before being spatially analyzed and clustered using a multivariate statistical method and then verified by leading oceanographers. The result is a standardized, rigorous, and ecologically meaningful set of ocean ecosystem units which may be used as a base map alongside an organization's own geographic information system (GIS) overlays for climate change impacts studies, biodiversity priority-setting, economic and social valuation studies, research, and marine spatial planning.

Free and open EMU data products are accessible through the EMU web site (<http://www.esri.com/ecological-marine-units>). In addition there is a free EMU Explorer Web app which facilitates visualization of NOAA's World Ocean Atlas data regardless of whether or not one is working with the EMUs. In the next stages, Ocean Biogeographic Information System (OBIS) species abundance and distribution data will be added on the surface and within the water column and the temporal resolution of all data will be increased from a 50+-year average to seasonal. In addition, more ocean color data will be added for the surface, current velocity, and carbonate data will be added to the water column, and work will commence on a higher-resolution Ecological Coastal Units.

Discussion

Susan Avery asked when the virtual reality component of the project will become available. Dr. Wright stated that work is underway on this in various formats, including a Google Cardboard prototype. Dr. Avery asked how difficult it is to add new variable to the system and also wanted to know what the time increment of resolution is. Dr. Wright explained that for increased spatial and temporal resolution, the project team will share their statistical clustering algorithm so that scientists can create their own EMUs (an example of open science best practice). The higher temporal resolution in the World Ocean Atlas needs to be teased out of the data (again seasonal, but also monthly). There is no desire to have to re-cluster every time new data are added, which is why the project focused on clustering based on salinity, temperature, dissolved oxygen, and nutrients, which are the likely drivers of many, if not most, ecosystem responses. Additional data can then easily be added as attributes.

Louis Uccellini asked for clarification about how hypoxia was presented in the animation shown and whether there were large gaps in the data. Dr. Wright and Dr. Sullivan explained that there are no spatial gaps in the data, as the point mesh constructed from the World Ocean Atlas is a continuous grid at the surface and on the seafloor, and with contiguous volumes in the water column. The visualization shown in the video depicted the center of each surface and seafloor grid cell with a *column* for easier side views of the clusters at depth, a unique twist in the cartography. Dr. Wright agreed that there is a need to engage with the modeling community to incorporate the results of climate models, especially for air-sea interaction studies. The project team looks forward to doing so.

Craig McLean asked about the longitudinal direction of the work being done. Dr. Wright informed the group that ESRI has made a commitment to support the project in perpetuity given its need and importance for ocean science.

Discussion on GOES-R Level 0 Data

Jeff de la Beaujardiere, NOAA Data Management Architect, National Environmental Satellite and Data Information System (NESDIS).

Summary

The next generation of the Geostationary Operational Environmental Satellite (GOES) series will begin with the GOES-R mission scheduled to be launched on November 20, 2016. In May 2013, NOAA decided only to archive Level 1b (and higher) data permanently, whereas Level 0 data would be retained temporarily in a two-year rolling window (for calibration and validation purposes). At the time, NOAA made this decision based on cost and the recognition that the primary purpose of GOES satellite data was for the very perishable mission of real-time weather forecasting.

The NOAA Science Advisory Board (SAB) and its Data Archive and Access Requirements Working Group (DAARWG) transmitted three recommendations to NOAA in August 2015 regarding the decision not to archive GOES-R Level 0 data. NOAA thanks the SAB and DAARWG for their interest in this important topic, agrees with the concerns, and welcomes the opportunity to respond. In September 2015, following an evaluation, the SAB suggested NESDIS should:

- Support a digital curation standard practice of archiving the lowest-level satellite data possible for potential future reprocessing, in addition to archiving derived products.
- Consider for future GOES-R satellites archiving both unprocessed data and derived products at the beginning and throughout the development process.
- Reach out to relevant communities, e.g. scientists and others, to examine in more detail the utility of maintaining a Level 0 copy of data for the long term.

In spring 2016, NESDIS reviewed the sustained ground system requirements for the GOES-R program and defined a path forward.

NESDIS recognized that, consistent with its environmental data archiving mandate, NOAA should maintain long-term storage of all satellite observational data at the lowest level necessary to retain full information content.

1. NOAA will establish long-term archival storage of the GOES-R Level 0 data prior to expiration of the two-year cache of data.
2. NOAA has developed a draft policy on NESDIS Environmental Data Management Planning that will be in effect prior to future satellite missions and will require long-term archiving of raw observations wherever feasible.
3. NOAA will utilize planner-user engagements, such as the NOAA Satellite Conference, to discuss use cases for GOES-R Level 0 data.

Discussion

Louis Uccellini asked if GOES-R data is included in the Big Data Initiative. Jeff de la Beaujardiere responded it is not yet but NESDIS would like to. This would not include GOES Level 0 data, however. Mark Paese, NESDIS DAA, said data storage costs are decreasing but NOAA is looking at options to consolidate storage in a cost-effective way.

Science Opportunities in the Gulf of Mexico

Mary Erickson, Director, National Centers for Coastal Ocean Science, National Ocean Service

Summary

Mary Erickson began with an overview of the NOAA RESTORE Act Science Program. The Program's long term outcomes are to understand the Gulf of Mexico ecosystem in an integrative, holistic manner and to have this ecosystem-wide understanding inform management and restoration activities. This objective requires partnerships and coordination between the research and resource management communities. Total funding for the NOAA RESTORE Act Science Program is \$133 million + 25% of trust fund interest.

In 2015, \$2.7 million was awarded to seven teams for assessment of ecosystem indicators, ecosystem modeling, observations and monitoring, Mississippi river impacts, and reef fish spawning aggregations. In 2017, the program will award \$17 million to projects focused on living coastal and marine resources which address one of six specific research priorities or the development of a decision support tool. Research priorities will focus on the movement of organisms, linkages between habitats, and food web dynamics. Decision support will fund improvements to existing tools where a tool developer and user relationship has already been established.

Future opportunities may include a long-term ecological research site, a modeling synthesis center, and the formation of test beds in the region.

Discussion

Michael Donahue asked what the trust fund interest is expected to be in dollars. Ms. Erickson predicted NOAA will receive \$2 million of trust fund interest over the fund's lifetime, but it difficult to know with any certainty.

Denise Reed asked how the NOAA RESTORE Act Science program is leveraging and coordinating with other sources of money. Dr. Reed noted it is easy to talk about coordination, but harder to put into practice. NOAA could be a leader in this area. Ms. Erickson explained the

program is working with a coordination forum. One challenge is the different rules and regulations about how the different entities are allowed by law to spend their money.

Rick Spinrad asked how the program plans to protect itself from mission creep. Ms. Erickson explained the program is focusing on being guided by the managers and their needs. Peter Kareiva suggested putting out a research call asking for mistakes managers may make due to a lack of science.

Lynn Scarlet asked how the program engages with resource managers and its relationship with the RESTORE Council. Ms. Erickson explained there have been sessions at conferences, open listening sessions, a number of interviews with various institutions. The RESTORE Council is part of the coordination forum.

Update on Gulf Coast Ecosystem Restoration Science Program Advisory Working Group (RSPAWG) Future Meetings

Michael Donahue, SAB Liaison to the RSPAWG

Jean May-Brett, SAB Liaison to the RSPAWG

Summary

Michael Donahue explained that together the SAB liaisons, NOAA, and the working group co-chairs have developed a prospectus with key focus questions. The group proposes to hold two 1.5 day workshops to tackle these questions. Jean May-Brett explained the RSPAWG would like the SAB input on this prospectus with respect to potential questions the RSPAWG should address.

Discussion

Rick Spinrad suggested the working group should be focused on scientific advice, not management implications.

Denise Reed asked how the activities of the working group are coordinated with the RESTORE Council, which will vote on a comprehensive plan in December. Mary Erickson explained NOAA staff attend both the working group and RESTORE Council review process. Chris Blackburn added that, as the NOAA representative to the RESTORE Council, she knows the agencies have not yet reached an agreement on the role of best available science.

Action 2: The SAB members will provide comments on the Draft Prospectus for meetings from the Gulf Ecosystem Restoration Science Program Advisory Working Group (RSPAWG) to the RSPAWG Co-Chairs, SAB liaisons, and SAB Office for review and incorporation.

Responsible Party: RSPAWG, SAB, SAB Office
Point of Contact: Bob Dickey, Michael Donahue, Jean May-Brett, Cynthia Decker
Due Date: 8 December 2016

Presentation and Discussion of SAB Subcommittee Concept of Operations

Kathryn Sullivan, Under Secretary of Commerce for Oceans and Atmosphere

Dr. Kathryn Sullivan presented the SAB Subcommittee Concept of Operations (ConOps). The document complements the SAB Charter and the SAB Concept of Operations by: (1) clarifying the operations of subcommittee noting the mechanics and differences between Standing Working groups and Task Forces, including guidance on meetings and work products/deliverables, (2) defining expectations for Subcommittee members and chairs, SAB members, and NOAA personnel including Line Office (LO), SAB Office, and Subcommittee liaisons, and (3) clarifying processes and strategic elements for subcommittee activities including guidance for establishment and disestablishment of Subcommittees; the process for appointing and replacing members are also discussed.

Dr. Richard (Rick) Spinrad also commented on the history of the SAB Subcommittee ConOps. There was a previous version of the document out in 2015 that many subcommittee members contributed towards. This Subcommittee ConOps is a living document that should be revisited when the SAB Charter is up for renewal.

Discussion

Dave Fluharty expressed gratitude for revising the document. He asked when the Subcommittee ConOps will be implemented and how the working groups should interact with the SAB to develop work plan. Dr. Sullivan outlined a process where working groups identify work that takes more than one year to accomplish on the quad chart that's given to the SAB at each meeting. The SAB should provide input, based on what is identified on the quad chart, to the working groups identifying high priority items that working groups plan to address. Chris Lenhardt, Chair of the NOAA Data Archive and Access Requirements Working Group (DAARWG), agreed with the outlined process. Working groups only meet twice a year so having guidance and better alignment with SAB goals will make meetings more productive. There may be a need for more calls outside of the two yearly meetings among working group members to get the work done. Other SAB standing work group chairs in attendance expressed their appreciation for the document and guidance given on quad chart use and development.

Walter Dabberdt, co-Chair of the NOAA Environmental Information Services Working Group (EISWG), mentioned that the EISWG has a meeting coming and has used the process outlined in the SAB Subcommittee ConOps to develop its agenda and to nominate new EISWG co-chairs.

Robert Dickey, co-Chair of the Gulf Ecosystem Restoration Science Program Advisory Working group (RSPA WG), mentioned that each working group needs to better communicate when there has been an update made to its terms of reference.

Rick Spinrad suggested that maybe in six months the SAB should revisit the process and work being done. He also mentioned that issues related to the role and responsibilities of SAB DFO need to be revisited.

Action 4: The SAB Office will work with the NOAA and the SAB to develop appropriate SAB standing working group processes for member and chair replacement and work plan development.

Responsible Party: SAB Office/NOAA/ SAB Chair

Point of Contact: Cynthia Decker/ TBD/ Lynn Scarlett

Due Date: SAB Winter 2017 Teleconference MT (draft)

November 18, 2016

Lynn Scarlett welcomed everyone and called the meeting to order.

Draft Report on Emerging Technologies for NOAA Ocean Research, Operations and Management in the Ecosystem Context from the Ecosystem Sciences and Management Working Group (ESMWG)

James Yoder, Woods Hole Oceanographic Institution and Member, ESMWG

Summary

The purpose of the report is to highlight some emerging technologies that are proven in research laboratories, are commercially available, do not require significant additional development costs, and are relevant to NOAA's mission related to marine ecosystems. All technologies could be implemented in next five years and used for operations. They can provide better time and space coverage, better use of existing infrastructure, and result in long term cost savings for the NOAA mission. There is appropriate expertise in NOAA to help broaden use of these technologies.

'Omics, particularly genomics, offer very exciting applications including Environmental DNA (Edna) to identify the presence or absence of organisms. Applications in NOAA include monitoring for conservation and management of fish, coral and other organisms; there is a good relationship between Edna and traditional methods with reduced survey time. It is possible to put sensors, such as the Environmental Sample Processor, on moorings gliders and floats; sensors can also be moored and left unattended.

Unmanned Underwater Vehicles (UUVs) or Unmanned Marine Vehicles (UMVs) are revolutionizing the way we sample and study the ocean with gliders, motorized and sailed surface and underwater vehicles and ship-launched drones. Sophisticated sensors to study marine ecosystems are being developed and miniaturized and the use of artificial intelligence (AI) software so platforms can make decisions is a new capability. There are smaller UUVs bringing cost down; it is not yet clear if there are miniaturized sensors yet for the number of applications that are possible for the larger vehicles. One new development is to use fleets of UUVs, for a marine robot mission. For example, subsurface gliders can acoustically transmit data to autonomous vehicles on the surface which can then transmit data to ships or back to shore. Integrating sensors across platforms is also a new development.

Digital imaging covers a wide variety of spatial and temporal scales. FlowCytobot is an example of a technology can be left unattended and provide continuous phytoplankton counts. Habcam is towed by ships and can image bottom habitat and measure the size of scallops. For these automated systems data flow is high, that new analysis approaches from the field of informatics are needed to process and analyze the data

New European satellites can provide higher spatial and spectral resolution to improve the imaging in coastal waters. There are also space-borne Light Detection and Ranging (LIDAR) instruments that can be used to estimate phytoplankton abundance at high latitudes where ocean color radiometry is not possible owing to low sun angles. . Cubesats offer potential for inexpensive space platforms; there are some proof of concept issues.

Recommendations

NOAA is developing the capacity to utilize the multiple applications of 'omics relative to its multiple missions. NOAA should continue to invest in these technologies and their applications. Adopt now.

Many believe the future of ocean measurements will rely heavily on robotic vehicles and new sensor technologies, including measurements related to living marine resources. Adopt now.

Sophisticated data analysis techniques and personnel trained to use them are required to effectively utilize the high data volume of new sensing systems. Adopt now.

Sophisticated imaging systems for shipboard laboratories, moorings, UUVs, or towed behind oceanographic ships offer the potential to fill time and space measurement gaps of important species. Important, watch for future applications.

Passive acoustic sensors on moorings and mobile platforms, as well as new sensors for new orbital and suborbital platforms including ship-launched drones, aircraft and satellites are coming

on line and are adding to our ocean observing capabilities. Important, watch for future applications.

Discussion

Rick Spinrad appreciated the comprehensive nature and quick approach in providing this report; the report included a nice array of sampling capabilities. —He wanted to know if there was communication among remote platforms used in Navy demonstrations. Jim Yoder responded "yes" that it was mentioned in the report. Software is becoming available to allow vehicles to make decisions. The Navy currently is in the lead in this technology but it has great potential for the future in NOAA.

Eugenia Kalnay asked if the instruments can monitor species extinction and larger scale ocean acidification. Jim Yoder responded that the detection of coral reef bleaching can be improved with the use of drones with sophisticated cameras. The use of eDNA to document presence or absence of species over time could be an indication of species abundance. Changing environmental conditions from data collected by sensors on marine mammals can tell you if they are moving out of the area, but time series data are needed to see trends on the time scales relevant to species extinctions.

Louis Uccellini said there was an emphasis on mobile observing systems in the recommendations; he asked about the relative importance of moored observations in the future. To what extent will mobile systems monitor what has been done with moored observations? Jim Yoder said that it is not an "either or" issue; mobile platforms are becoming more popular. However for some sensors or processing techniques it does not matter if the platforms are mobile or moored; he thought moorings will continue to be used.

Kathy Sullivan asked if Jim Yoder was aware of the Defense Advanced Research Projects Agency (DARPA) activity in the field of swarm management and also aware of the riptide mini underwater vehicle maneuvering velocity. On the "adopt now" recommendations the community is not quite there on the maturity of some of these for operations.

Jim Yoder said 'omics are ready to adopt and are being used in biological sciences. On robotics and sensors, he understands the Integrated Ocean Observing System (IOOS) program and Rutgers University are using a lot of gliders. He is not sure of the sensor load but many more sensors can go on vehicles and some, such as sensors for temperature and salinity, are more mature. What is immature is more sophisticated use of vehicles such as swarming. DARPA may be on top of that; these applications may not be ready in five years for NOAA.

On the Riptide small autonomous vehicles, he has not seen one but they seem to be as capable as the Navy Remote Environmental Monitoring Units (REMUS) Vehicles. While not sure of the sensor loads, Riptide vehicles can operate for 30 hours and are cheaper than REMUS vehicles; this is a technology to watch.

Susan Avery asked for an update on how these work in long term distributed array of mobile assets and the Ocean Observatories Initiative (OOI) Pioneer array. It would give a sense of system of readiness.

She noted he didn't mention advances in robotics and sensors on Argo floats and capacities for building that out and going deeper with additional sensors.

Jim said the report did mention the Pioneer array and taking advantage of mobile arrays and moorings. Moorings have more power and can have more sophisticated sensors on them they can employ crawlers that move instruments up and down the wire. Mobile assets can look at waters around moored instruments. REMUS vehicles need to be recharged. There are ways to capture and recharge them; when fully deployed, they can do a mission for 24 hours, recharge and update them, but this capability is not available yet. The developments for Deep Argo are physical sensors to measure temperature and salinity, Of most interest to the ESMWG group is Bio-Argo, to equip them with the same sensors used on gliders now. Bio-Argo platforms are being deployed in the Southern Ocean funded by the National Science Foundation.

Rick said that, with respect to data streams from IOOS, the decision was made to use the National Data Buoy Center (NDBC) as the collector and IOOS is largest contributor to NDBC data stream. There is also an interagency committee that is working on this issue. Louis Uccellini added that the Argo and IOOS data streams account for over 70 percent of data in the NDBC operations centers and these data are included in the National Weather Service and National Ocean Service models.

Richard Merrick said there will be a National Oceanographic Partnership Program (NOPP) Federal Funding Opportunity to look at additional sensors on Argo. On the cost of buoys, this is a different tool—ships, buoys, mobile platforms can all work together depending on focus. NMFS used moored arrays for right whale detection, but now use gliders that are mobile as well as ships. Use of the appropriate sensors for the specific platform is the issue; eDNA is operational but can't be put on gliders yet. In the central Arctic ocean, eDNA can be used to identify what is there.

Bob Winokur said DARPA has invested in autonomous vehicles and built a 120 ft. autonomous vessel for warfare that could be used for other purposes. Also there is use of underwater technology using gliders for operations; Navy bought 150 gliders to use operationally to augment ship operations and has a glider operations center at Stennis Space Center, MS.

Susan Avery commented that most of the data collected from operational networks are physical data. but in higher order 'omics the data are in the form of imagery and pose analytical as well as archiving and storage challenges.

Lynn Scarlett thanked Jim Yoder for the report. A motion made to accept report by Susan Avery, seconded by Eugenia Kalnay and passed unanimously.

Action 3: The SAB accepted the report Emerging Technologies for NOAA Ocean Research, Operations and Management in an Ecosystem Context from the Ecosystem Sciences and Management Working Group (ESMWG) and will transmit to NOAA.

Responsible Party: SAB

Point of Contact: Lynn Scarlett

Due Date: 31 December 2016

Honoring Past SAB and ESMWG, CWG Member, James Curtis (Jake) Rice

Richard Merrick, Chief Scientist, National Marine Fisheries Service

David Fluharty, University of Washington and Co-Chair, ESMWG

Richard Merrick opened this event by stating the SAB is recognizing Jake Rice because he is one of the scientists with the longest service to the SAB. Jake Rice said he was an original member of the first SAB and has been associated with service on SAB working groups since that time. Dave Fluharty added that after his service on the SAB, Jake Rice was appointed to the Ecosystem Sciences and Management Working Group and made significant contributions to its reports. Richard Merrick said Dr. Rice also kept NOAA in touch with his work with Europe and with native communities.

Jake Rice said he was honored to receive this recognition. One job of the SAB has been to provide an external perspective to NOAA and to look over the hill and see what is coming next; making sure NOAA is doing science today to answer questions Administrators will be asking in 5-10 years. He has seen many ways the SAB has influenced NOAA to make things better. Dr. Rice added that using the diversity and depth of knowledge makes this board valuable.

Kathy Sullivan thanked Jake Rice for his service to NOAA and presented him with a certificate of appreciation.

Recap of Strategy Session

Lynn Scarlett, The Nature Conservancy and Chair, NOAA SAB

Lynn Scarlett briefly explained these strategy sessions are meant to stimulate innovative thinking of new ideas and new partners for NOAA. The SAB's role is to highlight emerging issues, technologies, and partnerships. Past topics have included the integrated observation system, ecosystem science and management, ecosystem services and human well-being, integrated decision making and resilience, and communications. These presentations present a springboard into other avenues moving forward.

Strategy Discussion with Invited Speaker

Norman Augustine, Retired Chairman and CEO, Lockheed Martin Corporation

Summary

Norman Augustine began his talk detailing the ways in which he has worked on the periphery of NOAA for many years. After retiring from Lockheed Martin 19 years ago, he worked on the Hart-Rudman National Security Commission and wrote *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* for the National Academies of Sciences. In both reports, Mr. Augustine highlighted mismanagement of both science and K-12 education pose a danger to the U.S.

Mr. Augustine touted NOAA's achievements in weather forecasting. Space weather is of particular interest if the U.S. plans to send astronauts to Mars. He expressed that even the most devout climate change skeptics must shift from debating what is causing climate change to what to do about it. To address these issues, scientists need to move more aggressively in world politics; knowledgeable individuals cannot sit in the fray anymore. Many of the world's issues have science and technology as a major part of their solutions.

Mr. Augustine focused the next part of his talk on major problems that need to be addressed. These included decreased funding of basic research, polarization of science, and STEM education.

Basic research in the U.S. has fallen from 1st to 7th in the world. Furthermore, private industry has largely stopped funding basic research. While industries understand the value of basic research, shareholders (who on average only hold shares for four months as compared to eight years historically), do not want to see their money "wasted" on research. On the federal side, members of Congress are under pressure of re-election and basic research does not always return quick results. The US ranks in 29th place in the world in research funded by the government. Mr.

Augustine recommends that NOAA needs to take a longer perspective. Research has a huge leverage potential.

Science has become more politicized in the U.S. There is a debate as to what kind of science taxpayers should fund and who should decide. Basic research has many unseen benefits. For example, studies on Weddell seals in Antarctic ice led to the discovery of a way to save lives for children undergoing lung surgery.

STEM (Science, Technology, Engineering, and Math) education in the US ranks 27th in math and 25th in science. Interest in science and technology among young people is low. Women are underrepresented in the sciences as are Hispanics and African-Americans.

Scientists need to sell the public on the importance of science. Mr. Augustine provided an anecdote from testifying before the Senate Budget Committee requesting more science funding. A committee member interrupted his asking why he always asks for more money for science when the US has a budget problem. Mr. Augustine responded that as an aeronautics engineer when he working with rockets too heavy to fly, we never once took off an engine. Education and science are the engines that drive the country and the economy forward.

Discussion

Eugenia Kalnay explained that the world population is growing, doubling our extraction of natural resources every 20 years. However, talking about population control is a taboo subject. Dr. Kalnay asked Mr. Augustine what we can do to break the taboo. Dr. Augustine admitted it was a difficult question and not in his core capabilities. Since population growth tends to be higher in non-prosperous countries, raising the standard of living globally may help. Lynn Scarlett added that many taboo subjects like population growth become taboo when the public only sees one solution. Instead, broadening the problem to address poverty, family size and inequality makes the topic more approachable. The same issue befalls climate change: inaction comes from people assuming discussion about climate change will results in only one set of policy actions.

Many of the members discussed the necessity of science communication. Peter Kareiva mentioned 48 of the top 50 graduate programs in the country have a science communication course and asked if this would result in more scientists engaging in policy. Dawn Wright added that there are bridge organizations such as COMPASS (Communication Partnership for Science and the Sea) that teach scientists how to testify on Capitol Hill, talk to journalists, and communicate to the public. However, it is hard for some of these programs to keep their funding streams. Mr. Augustine added it is also important to have individuals from other communities talk about the importance of scientific research. Lynn Scarlett expressed the importance of co-

creation of knowledge and mutual learning in science communication. Jake Rice added that when speaking as a scientist in the policy realm, one needs to understand the big picture and understand the full scope of the policy question including the parts outside of one's expertise as a scientist.

Richard Moss noted the need for more science communication especially in the worldwide political climate. In the current climate, science is now perceived as part of the resented higher authority which will make it harder for agencies to play a role in the future of education. Mr. Augustine explained that many companies hold billions of dollars overseas that could be used for advancing research if it came back into the country.

Susan Avery explained the importance of having scientists who can translate from basic to applied research. Mr. Augustine explained that the idea in academia that scientists that work with industry are selling out needs to be changed. The best way to transfer knowledge is to transfer people between academia, industry, and government.

Dr. Sullivan also asked why companies like Lockheed Martin are not investing in science communication and a positive mindset on science. Mr. Augustine explained when he first became CEO of Lockheed Martin he directed funds to K-12 education. Rick Spinrad built upon Dr. Sullivan's question asking how best to deal with growing private philanthropy in environmental sciences. Mr. Augustine believes private philanthropy is a positive addition to science funding often with greater continuity than government funding. The one disadvantage is this money tends to be bounded by the interests of the philanthropist.

Craig McLean asked what the role of industry versus government should be in some lines of research. Mr. Augustine explained he believes in a free enterprise system, that research that can be done outside of government should be done outside of government. However, there are some issues too big for even large corporations to tackle. Everette Joseph added that partnering with industry may lead to more political power. Mr. Augustine explained that there are cultural differences in the pace of academia and industry and the best way to tackle this issue is for people to move back and forth between the two entities.

Jean May-Brett found that burdened by No Child Left Behind program, many schools gave science less weight. Mr. Augustine offered one solution; he was part of a successful program that paid students and teachers to pass the AP course.

Kathy Sullivan added to the science education discussion with an anecdote from a class she taught on science and technology policy at Ohio State. The science students in the course had more rigorous thinking than the policy students. She asked how we can bring that clarity of thinking into non-science majors.

Strategy Session with Invited Speaker

John Kelly III, Senior Vice President, Cognitive Solutions & IBM Research, IBM Corporation

Summary

Dr. John Kelly III started by giving a history of the International Business Machines (IBM) Corporation. IBM is a 100 billion dollar company; it's existed for 105 years making it the oldest technology company in the world, with nearly 400,000 people working for it globally. IBM has had a core strategic belief that there are two ways to prosper and survive in the information technology (IT) field; (1) be lowest cost producer of technology or (2) be the best innovator of technology. IBM has chosen the innovation roadmap and spends approximately six billion dollars a year on research and development (R&D). One way that IBM has leveraged the "ecosystem" of innovation and science globally is by having its own core research effort. IBM has over 3,000 researchers in thirteen labs around the world doing long term research, which it defines as 5-10 years.

Eras of IBM

Over the past three decades IBM has gone through three different stages as a company – first as a hardware company, then in IT services, and now as a software company. From 1900-1940s IBM experienced the tabulating systems era where the first computers were mechanical devices that performed arithmetic; essentially they were calculators. The fundamental breakthrough in the 60s was memory capacity. In 1964 IBM introduced the IBM System/360, a mainframe computer system designed to cover the complete range of applications, from small to large, both commercial and scientific in a cost effective way. The development of this system created the first programming discipline. A driving force for innovation and productivity was Moore's Law; computing power and density doubles every 18 months as devices get smaller and smaller. In 2007, IBM assessed the changes in the computing realm and noticed that there are vast amounts of data yet computing systems being built could only accommodate structured, enterprise level data and nothing was being built to accommodate unstructured data. Data amounts are doubling every 12-18 months as device size shrinks. By 2025, data will be highly unstructured (e.g. natural language, multimedia, medical images, and sensors and devices). It's estimated that by 2020 a bit of data will be created for every object in the universe. Due to the large amounts of data the programmable systems era is making way for the cognitive computing, also known as artificial intelligence, era. This era moves away from productivity towards extraction of information from unstructured data through machine learning, neural networks, and artificial intelligence (AI). Fundamentally, this means that no longer programming a system but letting a machine learn on its own.

Watson

In 1956 the first attempt at AI was by an IBM researcher trying to teach a computer to play checkers. In 1997 a computer called Deep Blue learned to play chess. These early attempts of AI failed because the necessary computing power and the information needed for the computer to learn weren't digitized. By 2011 IBM, based on long term research, knew the computational power, sufficient digitized information, and machine learning technology would be available to create a system to mimic a specific task that a human does in natural language. In 2011 IBM unveiled its first cognitive computing machine, Watson, named after its founder, Thomas J. Watson.

In 2012, IBM decided to use Watson in healthcare, an eight trillion dollar industry. Watson was taken to the Sloan Kettering Cancer Center to learn about colon cancer. In 2012, Watson was considered by doctors to be the equivalent of an average medical student. Eighteen months later Watson's knowledge was equivalent to a student who had been through medical school and was studying to be an oncologist. [there was another timeframe in which doctors considered Watson was considered a "trusted colleague – add that here] Today, Watson has been side by side with doctors and 2,500 cancer patients in the United States, China, and India. It is trained on four cancers, soon to be six; eventually Watson will be trained to diagnose and suggest treatment for all cancers. The time it takes Watson to learn this for a new cancer has shortened dramatically over the years. The technology was taken to the Mayo Clinic to learn about stage three and four cancers and clinical trials. It takes Watson three minutes to match patients with appropriate clinical trials; Watson now pre-matches all patients at the Mayo Clinic to clinical trials.

Originally, to operate the system, it took 85 Kilowatts of power. From this observation, IBM knew it had to scale down the system. The first thing done was to move Watson's "brain" into IBM's cloud. Watson is now positioned in over 60 cloud data centers globally. Data can be pushed, extracted, manipulated, and delivered to any physician anywhere in the world. Cloud computing is the next platform for the cognitive era; cloud computing allows insights to be ubiquitous globally and is able to handle enormous computing power.

Programming was the foundation of the programmable era; data science and analytics is the foundation of the Cognitive Computing era. In the past year IBM bought four healthcare companies. Each company has vast amounts of medical/healthcare data which will help Watson get smarter and more knowledgeable. IBM also bought The Weather Company for two reasons: (1) Data gathered and insights generated by the Weather Company affects everyone and everything on the planet; (2) The Weather Company has one of the best data ingestion systems and engines built for the cloud, which can feed and give context all of the other data Watson is ingesting. The purchases of the Weather Company and the healthcare companies also gives IBM insights to the workloads for future computing and the necessary algorithms needed to drive

down the trillion dollars of waste attained by the health care industry. There are four big cloud providers in the world and IBM hopes to open up the cloud and create an “ecosystem” for different countries, industries, developers, enterprises, and partners to access.

The Jefferson Project

The Jefferson Project is a partnership between Rensselaer Polytechnic Institute and the Fund for Lake George (NY). The goal of this partnership is to build a laboratory for environmental science to instrument Lake George and the environment around it. The project will include a computing platform that captures and analyzes data from sensors tracking water quality and movement. These sensor data are combined with other monitoring and experimental data to create a thorough understanding of the factors that drive the lake’s food web and overall water quality. Once the technology is fully developed IBM plans to take the project to other freshwater and marine environments.

Discussion

Kathy Sullivan noted that in the past only government agencies had computing capability to create computer generated images and now the cutting edge of innovation, both at scale and speed, is in the private sector. If the intrinsic capacity of cloud computing is held in small places, how does this impact both agency and the economy, what is the new way of doing business? Will it be a fee for service, perhaps an hourly rate to Watson versus the use of the NOAA Hydrometeorological Prediction Center (HPC)? Dr. Kelly replied by saying that there are still going to be a lot of proprietary systems in places like banks and government agencies for security reasons; these systems may have unique algorithms. However, a large portion of computing in the future will either be in the cloud or in an edge device, such as a phone. The cloud allows people to effectively access a super computer but there is still a role for high performance computing. The number of places that want or need powerful systems will be smaller than in the past.

Peter Kareiva mentioned the Amazon, Google, Microsoft, and IBM as the largest companies investing in AI and cloud computing. What are the differences of innovation being produced by these companies? He also asked what business is generating the most revenue for IBM. Dr. Kelly agreed that these are the four largest companies investing in cloud computing and AI. The field of AI is exploding. In the first half of 2016, it was estimated that the venture capital community invested 2.5 billion dollars in AI machine learning. Within IBM, in their research division, there are 1,000 people working on AI and Watson, not in cloud computing. IBM does not report differently its revenue from different industries; the 17 billion dollar data and analytics business within IBM and healthcare is one of the fastest growing.

Dawn Wright mentioned the parallel between the three eras of computing mentioned by Dr. Kelly and the fourth paradigm of science. Science has moved from empiricism, analysis, and simulation to the fourth paradigm where scientific insights are being gained through data mining and knowledge discovery. Due to the convergence between the computing to science, what are the types of technical disciplines covered by the 3,000 scientists in the 13 IBM R&D labs? Dr. Kelly agreed with Dr. Wright's observation of the parallel between the fourth paradigm of science and the cognitive computing era. The cognitive computing era is not human versus machine but human plus machine. The two have to work together because both have limiting abilities. Regarding the research organization, in the past IBM was made up of mechanical engineers, electrical engineers, physicists, and computer scientist; this era will include all of those scientists plus data scientist, machine learning, neural network scientists.

Louis Uccellini commented that IBM was the first company to do parallel processing and the National Weather Service (NWS) was the first to use this mode of computer operations. Based on the set of partners shown in one of the slide, how do government agencies fit in as partners? Dr. Kelly thanked the NWS for being the first to use parallel processing and then stated that IBM is very open to being partners with government agencies or any organization that is interested. What makes IBM different from many other companies is its corporate research organization. This is where the relationship can be between an industrial company and a government research lab or agency. IBM is very sensitive of where the data resides by putting a data pod in that country.

Richard Moss asked two questions: (1) when reflecting on the model driven by data, what is the role of modeling simulation? (2) Related to the Lake George project, how large will the effort be? There are a lot of data and there may be issues with data quality. In trying to establish a framework that is problem-driven, many challenges arise, so how will the project evolve to overcome these? Dr. Kelly responded by saying that although there is an emphasis on data, modeling simulation plays a critical role as well. In every domain it will be a combination of both. Even though the data are what has been emphasized with Watson; there are enormous efforts in modeling organ systems of the human body and neurological systems at fundamental levels. The biggest breakthroughs on the R&D side of healthcare have been with a combination of the data and modeling simulation. The most advanced work being done is to use data to inform models in real time and vice versa. To answer Dr. Moss' question about data quality and complexity Dr. Kelly stated that the data ingested by Watson are unfiltered. Watson decides what is good and reliable. The only thing IBM has done is to tell Watson to trust Sloan Kettering data more than other sources, but not completely to trust Sloan Kettering alone. The belief is that by biasing the system, bad things happen. The old idea of "scrubbing data" is gone.

Everette Joseph asked how to prepare domain scientists for this new era of cognitive computing. Dr. Kelly mentioned that all of the projects mentioned are multi-domain so students must be trained to work in multidisciplinary teams. People need to be very knowledgeable in their areas

but they also have to be able to work with other areas. If someone is educated to be a data scientist, knowledgeable in AI computing, IBM will hire him/her. If someone is educated to understand an industry, domain, application space he/she becomes ten times more productive.

Susan Avery asked how the methodology of dealing with complex system advances. Is the data driven approach about correlation rather than causality? How should the next generation of scientists be trained? Dr. Kelly stated that complex systems and data driven approaches are a combination of both correlation and causality. There is always a danger that the systems will reach conclusions that may not be right. As long as a human is parallel with the system during the decision-making process or the last decision-maker, there is an optimal decision obtained.

Richard Merrick stated that the progress that's been made is based on IBM's research portfolio. Why did IBM decide to maintain a research portfolio? Dr. Kelly replied that the core of IBM is the belief that the only way to be successful is to innovate.

Discussion of SAB Work Plan and Speakers for Future Meetings

Susan Avery, President Emeritus Woods Hole Oceanographic Institution and Member, NOAA SAB

Summary

Susan Avery, President Emeritus Woods Hole Oceanographic Institution and Member, NOAA SAB, sat in as the Acting SAB Chair at the beginning of this session per the request of the SAB Chair Lynn Scarlett. Kathy Sullivan presented seven potential focus areas to the SAB; (1) Economic implications of climate products and services; (2) Exascale computing in NOAA's future; (3) Next-generation Big Data Project; (4) Value and complexity of the New Blue Economy; (5) Enhancing, optimizing and harmonizing the delivery of environmental services across the NOAA enterprise; (6) Synthesis of lessons learned from large ecosystem integrated research for restoration (e.g. Everglades, Prince William Sound); and (7) Citizen science and ecological/ecosystem data collection. These focus areas were developed by looking at the work proposed by the SAB standing working groups as listed on quad charts. These are just initial ideas that the SAB should modify as they see fit. Dr. Avery encouraged members to use these focus areas as a starting point and then opened the floor for discussion.

Discussion

Dawn Wright praised Jim Yoder's presentation on emerging technologies. Chris Lenhardt, chair of the Data Archive and Access Requirements Working Group (DAARWG), also made a suggestion to Dr. Wright about doing a similar study on emerging data, data science, and technologies. Dr. Wright suggested charging DAARWG with investigating focus areas two and

three. Lastly she asked if NOAA has a tech readiness framework. Rick Spinrad stated that NOAA does have one.

Denise Reed said she'd like to tackle focus area six on the list regarding large ecosystem integrated research for restoration. She noted it might be helpful to identify the nature of products for the work plan. Dr. Sullivan gave some possible timelines. The work plan for focus areas one and two should be longer than six months, maybe twelve month work plan. Regarding focus area three, this topic is not looking for management advice, bill legislation advice, or personnel advice but more of a diagnostics- how can this be guidance to the science for the agency and not management? She suggested SAB members could visit relevant parts of the agency, learn about them, and then make science recommendations.

Rick Spinrad commented that this type of discussion should be part of the "SAB DNA," that is, its way of doing business. Many of the proposed ideas derived from speakers from disparate communities. The SAB should continue to have speakers discuss topics that are not mainstream, such as behavioral sciences and medical science (e.g. microminiaturization). Dr. Sullivan agreed. She stated that 75% of the SAB values are when it is being generative, encouraging a thinner workflow instead of mechanical workflow.

Craig McLean suggested, looking at ecosystem science portfolio, adding microbial components of the ocean to the list.

Everett Joseph noted that the first focus area should be nuanced; maybe look at a subset of the topic such as extremes and resilience. He asked a follow up question about the upcoming administration transition about how the SAB might socialize this work plan or interact with the upcoming leadership. Dr. Avery suggested the SAB create a transition group. Dr. Sullivan recommended the SAB create a transition document that explains more than the mechanics of the SAB.

Peter Kareiva brought up the Cambridge Centre for the Study of Existential Risk (CSER) and another group in Berlin as sources for possible speakers at future SAB meetings. Both organizations have individuals who are business leaders and engineers.

Jake Rice remarked that the international landscape in ocean science has changed. With less participation from the United States and Canada, it's important to identify partners and process to get things done in ocean science. This would be a great time for the SAB to look at the international and domestic landscape of environmental sciences research and partnerships. It may be time for NOAA to readjust its approach.

Lynn Scarlett returned to close out the meeting reiterating the importance of developing a work plan and transition document as the group looks ahead to the new administration. She will work with NOAA leadership and the SAB office to establish a process for developing the work plan and transition document and identifying who to involve with the initially drafts of these documents.

Action 5: The SAB Chair will work with the NOAA Administrator, Chief Scientist, and SAB Executive Director on a strategy for developing the SAB work plan based on topics identified at the meeting.

Responsible Party: Lynn Scarlett, Kathy Sullivan, Rick Spinrad

Point of Contact: Cynthia Decker

Due Date: Mid-December 2016