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NOAA Science Advisory Board
Strategy Synthesis Subcommittee

Proposed Outline for Strategy Synthesis Session at the April SAB Meeting

The Strategy Synthesis Subcommittee was charged with developing a proposal for a strategy synthesis session to be held at the next SAB meeting in April. The purpose of the session is to help NOAA think through some of the bigger picture issues that it may encounter in the not-too-distant future (a 5-7 year "look ahead"). The committee was asked to think about what the world might look like in the future and how this might affect NOAA's ability to carry out its mission. In particular, the subcommittee was asked to design a session that would facilitate creative thinking about NOAA and its R&D, future technologies on the horizon, and major potential environmental changes as these relate to NOAA's mission. The end goal of the session is to better enable the SAB to provide strategic advice to NOAA about promising future directions for NOAA R&D and what questions NOAA should be thinking about in order to be best prepared to meet future challenges.

The subcommittee initially outlined five substantive areas:

1. Improving integrated observing systems: What are NOAA's observing capabilities now, how can they be better integrated, and what are promising new technologies on the horizon and that might increase NOAA's ability to carry out its mission?

2. Ecosystem science and management: What advantages are there for NOAA taking a more integrated and holistic ecosystems approach that goes beyond the traditional fisheries approach, and how might the agency develop such a systems approach?

3. Impact of ecosystem services on human well-being: Can NOAA develop scientific capability to translate ecosystem science and management into impacts on human well-being through the valuation of ecosystem services?

4. Improving integrated decision-making and system resilience: What kinds of information are most needed to better prepare for and adapt to change conditions and potential disturbances?

5. Communicating success: How can NOAA best utilize the information developed in its programs to demonstrate the value of NOAA science for society?

The subcommittee felt that "Communicating success" was a large topic that should probably be given more time in its own session. The subcommittee is recommending covering topics (1) – (4) in the April SAB meeting and topic (5) in the following SAB meeting. Further thoughts on each of the four topics are given below.

The subcommittee thought it would be beneficial to invite several eminent scholars who have a big picture view of science and policy to help the SAB to think through these issues. We are in the process of inviting these speakers. Simon Levin (Princeton) and Granger Morgan (Carnegie-Mellon) have tentatively agreed to participate. We have invitations out to several more scholars.

1. Improving integrated observing systems

The heart of NOAA's Environmental Intelligence is its observing system. NOAA's prediction and forecasting capabilities rely on an integrated observing system, but NOAA's current observing systems are fragmented. NOAA's strength is its capability to create an operational framework for forecasts, yet inadequate observing systems challenge this capability. Furthermore, NOAA's observing systems are challenged by a changing world and a changing environment.

Improving NOAA's integrated observing systems requires thoughtful consideration of the following:

1. What are NOAA's observing system capabilities now?

2. What does an integrated observing system look like in the future? What is the vision for system integration so that interactions and feedbacks are adequately addressed? How can NOAA gain efficiency, cost effectiveness, and improve its models and products? An integrated observing system should capture a full suite of ocean, atmosphere, and ecosystem observations, and include the fluxes between these components. The Agency must continue to study the linkages and complexities across systems (human and natural) to improve its forecasting capabilities.

3. How does NOAA take advantage of new technologies (both new observing technologies, and technologies that better integrate NOAA's observations) that would allow NOAA to better carry out its mission? How can NOAA capture and integrate external technology advances?

One suggestion for integrating new technologies into NOAA's capabilities is for NOAA to form a small standing group that annually reviews the state of the art observing systems to inform NOAA with an adaptive management format. The group may have representatives both internal and external to NOAA, and would be a service to the greater community as well as NOAA.

2. Ecosystem Science and Management in NOAA

Understanding the structure and function of ocean ecosystems is fundamental to understanding how and why ecological communities behave in the ways they do and the nature and limits to the services they provide. Ecosystem science is a major discipline comparable in complexity and scope to meteorology and climate science. Yet, whereas these latter disciplines function within NOAA as coherent entities with the necessary scientific critical mass and independent administration to tackle major questions, ecosystem science within NOAA is scattered as a side activity within the Marine Fisheries Service and NOS.

Lack of an independent home for ecosystem science is problematic on many levels.

1) Ecosystem science at NOAA needs independent guidance to evaluate the big picture of ecosystem change and to prioritize resources accordingly. The qualitative trends of emerging threats are increasingly certain, while the uncertainty lies mainly in rates of changes and nonlinear responses. NOAA should establish a small core team of ecosystem scientists to define and evaluate the scope of these challenges. To do this, there needs to be a separate Ecosystems Service led by a senior ecosystem scientist answering directly to the Chief Scientist, as is the case for the Weather Service. This core ecosystems team should lead much of NOAA's efforts for resilient ecosystems.

2) There is an inherent, unresolvable conflict of interest in having ecosystem assessments in the same part of NOAA that regulates fishing. Much of the ingrained resistance to setting catch limits with regard to ecosystem health as prescribed by the revised Magnusson-Stevens Act stems from that conflict. To name just one example, the section on ecosystem management in the assessment for Alaskan Pollock briefly discusses the near threatened Steller Sea Lion *as a threat to the fishery* rather than addressing the potential impact of the fishery on the well being of this declining species. As of 2011 (when I last read the stock assessment), there was no discussion of the impact of the fishery on ecosystem health and the fishery is still managed as a single species.

3) The Deepwater Horizon spill exposed a lack of a coordinated focus within NOAA regarding shoreline protection in relation to mounting threats of wetland destruction, nutrient and toxic pollution, and sea level rise. This is a very large and rapidly accelerating problem that would benefit greatly from a more coordinated focus within an ecosystem context.

4) There are other basic issues such as food safety from coastal fisheries and aquaculture and health risks to recreational boaters, fishers, swimmers, surfers, and divers.

A practical, low-cost route to enacting these changes would be to appoint a small core team of 3 to 5 leading ecosystem scientists to brainstorm how an Ecosystem Service could best function within NOAA and to have that team present their conclusions to NOAA leadership and the SAB within one year. There are excellent qualified people in house to do this but it would be important to bring in 2-3 people from outside NOAA to guide the process because of deeply entrenched views and the need for fresh perspectives.

3. Ecosystem Services and human well-being

Definition: Ecosystem services are the benefits that people obtain from nature, including ecosystem goods (e.g., food), regulating services (e.g., carbon sequestration), supporting services (e.g., wind power), and cultural services (e.g, recreation, spiritual sustenance). Natural capital is a synonym for the components of the natural world that supply goods and services flow; it emphasizes that goods and services can flow continuously from well managed ecosystems. Here we use ecosystem services as a shorthand term that encompasses natural capital, ecosystem goods and ecosystem services.

Topics/challenges within NOAA mandate that would require intellectual and/or institutional advances to accomplish:

1. Identification of ecosystem services from coastal and marine ecosystems and their interactions. What do people care about and what tools are available to measure them? To what extent are the ecosystem services that society want competing (i.e., entail trade-offs, e.g., between recreational and commercial fisheries) and to what extent are they positively synergistic (e.g, improved water quality for recreation *and* shellfish harvest)?

2. Prediction across intellectual domains. Logic chain is often: physical → ecosystem function → ecosystem services. Each step of logic requires environmental intelligence. Ultimate goal (ecosystem services) requires integration across observing platforms (or more integration of observing platforms) and integration across intellectual domains and/or new approaches to more direct intelligence on ecosystem services. Science, economic valuation, and the role that human expectations—as often expressed in institutions—all need to part of improved estimates of ecosystem services and how they are jointly determined by nature and humans.

3. Prediction across NOAA programs. Predicting and communicating how a holistic set of ecosystem services will respond to a holistic set of environmental changes requires greater integration across NOAA programs (e.g., climate, riverine hydrology, fisheries), perhaps in regionally focused case studies (e.g., Arctic, Gulf of Mexico). While NOAA has world-class prediction capabilities in some realms (e.g., weather, climate), it will need to build internal capacity to predict ecosystem services over long time and large spatial scales, because such capacity does not exist externally or internally.

4. Prediction of changes in the ranges of communities and component marine species (including pathogens and parasites), based on dispersal of species in response to climate change, and on human vectors of species dispersal. Some species are key providers of ecosystem services, while others are indirect determinants of the health and production of species that are harvested.

5. Scenarios should extend and build on improved predictive capacity; in turn, scenario development should help guide the selection of priorities for further investments in prediction capacity. One area ripe for scenario development is aquaculture development and its potential trade-offs or synergies of other ecosystem services (e.g., energy development, capture fisheries) under different choices policy choices regarding managing risks, market development, and institutions.

6. Prediction of ecosystem services across people groups, demographic groups, geography. Considerations of social justice, environmental justice, and political jurisdictions require greater social science integration into predictions of changes in ecosystem services.

4. Improving integrated decision-making and system resilience

The future is uncertain. We cannot know for sure whether a hurricane will strike in a given location in a given year or its intensity if it does. However, NOAA has developed considerable predictive capability that allows us to say what is more or less likely. We have information about the likelihood of a hurricane strike at a given place on the coast in a given year and its likely intensity. We may have information about how likelihood and intensity will change with climate change or other long-term environmental change.

Improving our predictive capability has value in planning ("value of information") as does improved planning for mitigating risks and adapting post-disturbance. Improved predictive capability can allow planning to better match actions with likely future conditions thereby avoiding potential future damages, or increasing potential future benefits. How can NOAA best determine the events or long-term trends that will affect ecosystems and human communities in ways that pose major threats to the continued provisions of ecosystems services and/or that potentially cause major changes in the value of these services to society?

There are (at least) two ways to go about improving our predictive ability.

- Improving the ability to identify the "big unknowns."
- Improving predictive capabilities for known events (e.g., hurricanes) and long-term trends. Which are things that cause major loss? Furthermore, it includes adaptation or the ability to respond and rebound from major shocks.

1. The big unknowns
   By definition, these are events that are a "surprise," and because they are big, if they occur they really matter. Knowing what these events might be to allow for some preparation could have significant value for society. There are techniques that can expand horizons and get us to look more broadly to expect the unexpected. One technique used by the military to plumb the big unknowns is developing scenarios such as in war gaming scenarios. Should NOAA make use of some types of similar exercises and what would be the best way to structure such exercises for NOAAs purposes?

2. Improving predictive capabilities for known events
   Decision science has developed many tools for thinking about how to proceed with decision-making under uncertainty and "the value of information." It could be quite helpful to have these tools and ways of thinking more thoroughly integrated throughout NOAA. A sample of some tools include maximizing discounted expected value given subjective or objective probability distributions, incorporation of risk aversion into decision-making, robust strategies, precaution, adaptive management, learning, among others.

Additional issues that also have value are:

- Improving literacy about risk/uncertainty and how to make intelligent decisions in the face of uncertainty
- Thinking carefully about how scientific information is useful for policy and improving the science/policy interface
- Targeting of science to provide the type of information that can improve decision-making AND the ability of managers/policy makers to utilize the information
- Thinking through adaptation and improved ability to rebound from disturbances

5. Defining, Measuring, and Communicating "Success"

(Very preliminary thoughts...)

- How will we know that NOAA's environmental intelligence has made a difference (been a success)? What will we point out to constituencies? How will we talk about the "false positive," meaning that if EI (environmental intelligence) is effective, then communities have become more resilient, observing infrastructure is working well, etc. and it may be hard to see success! That is, an absence of disaster/catastrophe/impacts of other extremes may mean we just got lucky ... or that NOAA's EI was working superlatively.
- In the case of actionable information, which is an outcome of NOAA's EI, we know that informed people may choose NOT to take a mitigating or protective action in the face of an extreme event. This does not mean that NOAA has failed…