California Bay-Delta – Photo Credit: Paul Hames, Courtesy of the California Department of Water Resources

The Science Enterprise Workshop: Supporting and Implementing Collaborative Science

Proceedings Report

Scientists, science-policy experts, and stakeholders gathered for a two-day workshop on November 1-2, 2016 at UC Davis to better understand how collaborative science is being managed, funded, and communicated in several high-profile ecosystems around the country. The program was designed to identify common themes and differences in the approaches being used in the California Bay-Delta, Chesapeake Bay and Watershed, Coastal Louisiana, Great Lakes, Greater Everglades Ecosystem, and Puget Sound.

This Proceedings Report combines information found in the Science Enterprise Workshop Advance Briefing Paper, including an overview of each system, with abridged transcripts of the presentations, panel discussions, and audience questions and answers. The report is organized according to the workshop agenda and integrates slides and graphics used during the program. The contents of this report, including individual sections, can also be viewed online at (www.mavensnotebook.com) and videos from the workshop can be viewed online at (www.deltacouncil.ca.gov/youtube-page).

Co-hosted by U.S. Geological Survey and the Delta Stewardship Council

USGS science for a changing world

Delta Stewardship Council

Introduction

The Science Enterprise Workshop, held on **November 1- 2, 2016,** at **Davis, California**, brought together scientists and science-policy experts from across the country to share information about how collaborative science is funded, managed, and communicated in several high-profile and complex ecosystems – the California Bay-Delta, Chesapeake Bay and Watershed, Coastal Louisiana, Great Lakes, Greater Everglades Ecosystem, and Puget Sound.

The workshop was conducted at a critical time for the California Bay-Delta. In the Delta, "every decision becomes unimaginably complex," because virtually any change intended to improve a public value is perceived to degrade some other value.[1] The Delta is not unique in this regard. At the Science Enterprise Workshop, participants had the opportunity to hear from a wide-range of experts highlighting how different regions have developed science management mechanisms to support managers who are working on improving long-term health and viability of the nation's high-profile ecosystems.

The Delta management and policy community is looking for a path forward marked by better coordination, collaboration, and innovation – guided by the vision of **"One Delta, One Science."**[2] This workshop provides a way for California's Bay-Delta to identify possible ways to improve science management and funding. Feedback and lessons learned from the workshop were given to the Delta Stewardship Council's (Council) Delta Plan Interagency Implementation Committee (DPIIC) within two weeks of the workshop. The discussion at the DPIIC meeting in late November 2017, focused on how best to improve funding, management, and communication for science enterprise in the Delta.

Purpose and Expected Outcomes

The Science Enterprise Workshop was designed to orient participants to how science is being conducted in several high-profile ecosystems and identify common themes and variations in the approaches across key points of comparison. This workshop offers an opportunity to draw lessons from other systems, including a few with more highly-integrated science programs than the California Bay-Delta's. As a first step, this workshop was designed as a comparative review that may reveal important lessons from other systems, helping managers and policymakers to:

- Avoid mistakes or "reinventing the wheel" in efforts to better coordinate and integrate science, including integrative approaches to deal with social, biological, chemical, and physical aspects of complexity;
- Better understand governance and management systems that have been set up in other high-profile systems to jointly manage resources and conduct science;
- Identify practical means by which science programs manage financial and intellectual resources and ensure the relevance of ongoing lines of research and monitoring;
- Hear expert's perspectives on what makes science "legitimate" to stakeholders and the public, and on the limitations of traditional approaches to applied science; and
- Enhance networking among programs and experts, and contribute to the body of knowledge on natural resource management of major regional systems.

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[1] Luoma SN, Dahm CN, Healey M, and Moore JN. 2015. Challenges Facing the Sacramento-San Joaquin Delta: Complex, Chaotic or Simply Cantankerous? San Francisco Estuary and Watershed Science, Volume 13, Issue 3. http://dx.doi.org/10.15447/sfews.2015v13iss3art7

[2] "One Delta, One Science" means - an open Delta science community that works collaboratively to build a shared body of scientific knowledge with the capacity to adapt and inform future water and environmental decisions. Delta Science Plan. 2013. Delta Stewardship Council. http://deltacouncil.ca.gov/science-program/delta-science-plan-0

Working Definitions

Science refers to information gathered in a rational, systematic, testable, and reproducible manner (Lackey 2009).[3] Although there is no definition specific to the California Bay-Delta, the 2013 Delta Science Plan encompasses all of the following activities:

- Research
- Data collection and monitoring
- Data management and accessibility
- Modeling
- Analysis and synthesis
- Independent scientific peer review and advice
- Science communication

Science Enterprise is not interchangeable with "science program." Instead, it refers to the collection of science programs and activities that exist to serve managers and stakeholders in a regional system. The elements of an enterprise range from in-house programs within individual agencies or other organizations to large-scale collaborative science programs funded by governments. Included in this definition is academic research, recognizing that academic researchers often operate independently of management and stakeholder entities. Science enterprises can vary greatly in the degree to which resources are concentrated in collaborative programs and produce publicly-available results. The differences among regional systems can reflect historical factors, depth and persistence of conflict regarding resource issues, governmental guidance and engagement, the range of agencies and interests involved, and other factors.

Science-Policy Interface is the methods by which scientists and policymakers communicate with one another. A science-policy interface (SPI) may be entirely informal, somewhat formal, or highly formalized, depending on the circumstances. The Intergovernmental Panel on Climate Change (IPCC) is an example of a highly formalized SPI. Building and maintaining an effective SPI is an important aspect of science program management.

Cooperation, Coordination, Collaboration are often used interchangeably, but with recognizable differences, in order of increasing joint commitment:

- Cooperation –involves sharing information and sometimes resources while each party pursues its own goals;
- Coordination –involves sharing information and resources, with the parties pursuing a common interest or objective. The interest or objective, however, is defined independently by each party; and
- Collaboration –involves sharing information and resources with the parties pursuing a common interest or objective that they jointly define.

Co-production denotes the participation of managers or stakeholders in the design, execution, and interpretation of scientific studies. The term has come into use as the practice of integrating science consumers into the process of science production. Co-production may be implemented as a transparency measure or as a form of actual collaboration (see above).

[3] Lackey, R. 2009. Is Science Biased Toward Natural? Northwest Science 83(3):291-293. 2009 doi: http://dx.doi.org/10.3955/046.083.0312

Useful versus Useable Science distinguishes between the perceptions of scientists who conduct research to answer questions important to resource managers and the perceptions of the managers. While all useable science is useful, the converse is not true. Useable science "directly reflects expressed constituent needs, should be understandable to users, should be available at the times and places it is needed, and should be accessible through the media available to the user community" (Lemos and Morehouse 2005).[4] One purpose of an effective science-policy interface is to increase useable science as a fraction of all science produced within a science enterprise. Of course, management and policy processes sometimes have difficulty assimilating science to make it used.

Enabling Guidance is the combined set of laws, treaties, executive orders, agency policies, regulations, court rulings, and other authorities that provide a framework under which science programs are developed and implemented.

Relevance, credibility, and legitimacy are three features commonly thought to be essential for science to play a role in policy and management decisions (Sarkki et al 2013;[5] Heink et al 2015[6]). Legitimacy is the belief that the scientific process is being applied impartially and without partisan bias or prejudice and can be the most difficult, and important, of the three factors to foster in situations where science is being used to inform contentious resource management decisions. An effective science-policy interface generally acts in part to increase legitimacy (Posner et al 2016).[7]

Workshop Agenda and Proceedings Report Layout

The format for each panel included presentations from experts representing each region organized by common points of comparison or specific topics and concluded with an open question and answer session.

Day 1: Comparison of Science Enterprises – Regional Programs

The workshop started with presentations by science leaders on the structure and organization of the science programs in several major systems: California Bay-Delta, Chesapeake Bay and Watershed, Coastal Louisiana, Great Lakes, Greater Everglades Ecosystem, and Puget Sound. Common points of comparison included:

- History of regional program development;
- Major resource management issues;
- Current science enterprise structure;
- Funding for science;
- Important tools for implementing science; and
- Communications and co-production.

[4] M.C. Lemos, B. Morehouse. The co-production of science and policy in integrated climate assessments Global Environ. Change, 15 (2005), pp. 57–68. http://www.sip.ucar.edu/thorpex/pdf/Lankao.pdf
[5] Sarkki,S., et al. (2013)Balancing credibility, relevance and legitimacy: A critical assessment of trade-offs in science–policy interfaces. Science and Public Policy first published online August 28, 2013 doi:10.1093/scipol/sct046. http://spp.oxfordjournals.org/content/early/2013/08/28/scipol.sct046.short
[6] Heink, U., et al. (2015). Conceptualizing credibility, relevance and legitimacy for evaluating the effectiveness of science–policy interfaces: Challenges and opportunities. Science and Public Policy 2015 42: 676-689. http://spp.oxfordjournals.org/content/42/5/676.abstract
[7] Posner, S. M., et al. (2016). "Policy impacts of ecosystem services knowledge." Proceedings of the National Academy of Sciences 113(7): 1760-1765. http://www.pnas.org/content/113/7/1760.abstract

Following presentations from experts representing each system, outcomes from the 2013 Puget Sound Science Enterprise Workshop was presented. Lastly, a panel discussion presented additional data and allowed questions from the audience. Panelists also discussed practical and field-tested examples of how to achieve greater science integration, and how networking among programs and experts can contribute to the body of knowledge on natural resource management of major regional systems.

Day 2: Collaborative Science Management, Governance, and Funding

The second day featured comparative discussions on common challenges and opportunities that often arise in the management of science enterprises. Regional experts were joined by social scientists, legal experts, and economists on panel presentations to discuss decision-making and key topics related to:

- Science strategies in large programs;
- Governance and adaptive management;
- Funding and resource allocation; and
- Legitimacy, co-production, and communication.

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asking them to make trade-offs. Their decision was not based so much upon statistics, but it was based upon their willingness and ability to manage the uncertainty in front of them within their budgets and get to the next step. They were willing to make a step forward without a forever commitment, but to try something a little further together. It was really decisions based upon a common professional agreement more than anything legal or very binding… It's having the numbers but not relying on them so much because they don't translate one to another. The rectification from one unit of measure to another seems to be something that's borderline emotional."

Dr. Bill Labiosa (Puget Sound) said they are often asked questions framed from the engineering perspective, but there are certain aspects of the system where it is definitively not an engineering problem. "Complex adaptive systems are inherently unpredictable. It's not, do I have uncertainty in my prediction; it's that complex adaptive systems just cannot be predicted over the time frames of adaptation. My point being that we have to figure out how to talk about uncertainty in a useful way in these contexts. We still have a State of the Sound report that tells the legislature how ecosystem recovery is progressing in the context of the paradigm that they hold - the engineering paradigm… I would argue we have to figure out how to answer back within the complex adaptive systems paradigm in a useful and clear way. Uncertainty has multiple interpretations in the complex systems paradigm."

Question: What science tools would be really useful for your system, and how would those be useful across other systems?

Dr. Nick Aumen (Everglades) said they have an effort called Joint Ecosystem Modeling[127] that's an attempt to take some of these complex ecological models, bring them down to the level of a desktop viewer than anybody in any agency or entity can use to solve complex problems. The cape sable seaside sparrow viewer they developed took the needs of the Fish and Wildlife Service and put that into a desktop application. "It draws on very complex background information but makes it so it's very usable. I think there's some approaches like that that can be used as examples across some of these programs."

Scott Phillips (Chesapeake Bay) noted that a lot of the models that are developed don't do a good job of transferring this information across different ecosystems. "If we had a more collective approach saying we need ecological models to look at species groups A and B, and develop that as a consortium that we can apply that model in any of these coastal systems, we'd be so much further along. That's what I see as a big limitation. Whether it's a model or a web service or a web viewer, there's too much individual effort in a particular system and not enough collective approach on this."

Scott Redman (Puget Sound) said that some of the models from the Chesapeake sound very similar to some of theirs and he thinks he could learn from them. "I was inspired by hearing about their goal teams and how those are interdisciplinary, where the scientists and the people making management decisions are working together. We implement that sort of thing. We tend to do it on a more ad hoc than standing committee basis… The other is synthesis. We've tried things like that; we have taken a 700-page document and brought it all the way up to a two-page management implications document but we haven't, even in our own system, replicated that through time and through all the topics."

Dr. Denise Reed (Louisiana) said that she uses the EverView[128] system which was developed in the Everglades and is an example of something that could be more widely used. She also said that

[127] Joint Ecosystem Modeling. https://www.jem.gov/
[128] EverVIEW Data Viewer. Joint Ecosystem Modeling. https://www.jem.gov/modeling

Figure 100, Slide 12

The Restore Council issued their first comprehensive plan was in 2013; the plan has just been updated. During the public comment phase, they received over 65,000 public comments. The Council is expected to finalize the plan in December of 2016. The Council's plan is not as detailed as the Louisiana Coastal Master Plan; they don't select projects and programs. The plan provides the framework for how things are prioritized and how commitments are made; they make some science commitments in the comprehensive plan. One of the commitments they make is a commitment to implement or improve science-based adaptive management.

There are a number of overarching challenges, none of these are particularly new, noted Dr. Dausman. There are issues with coordinating across numerous programs with different missions, and no matter how much money there is, it's never enough and it is a balancing act between science wants and needs. It is helpful to stress the difference between *useful* science and *usable* science – it is important to have science that is usable for managers. In addition, decision-makers must be educated on why science investments are important for the future and where there are win-win scenarios.

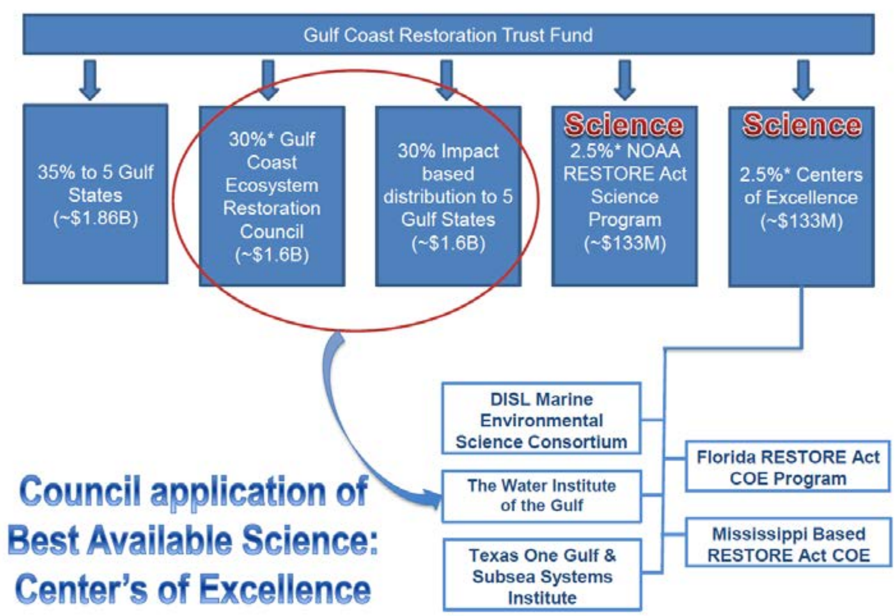

Figure 101, Slide 16

The general Council philosophy, being a federal agency, is that they are very small, lean and mean. They operate on less than 5 percent overhead, and try to avoid duplication of efforts or support processes that aren't working. A central question that they ask is how can they change business so that they are being more effective with the money that they have and build on existing capacities? The Restore Council invests in best available science. The Centers of Excellence which exist in each of the Gulf states represent a "capacity nexus" as each of the Centers provide an essential line to academics and other universities.

Figure 102, Slide 17

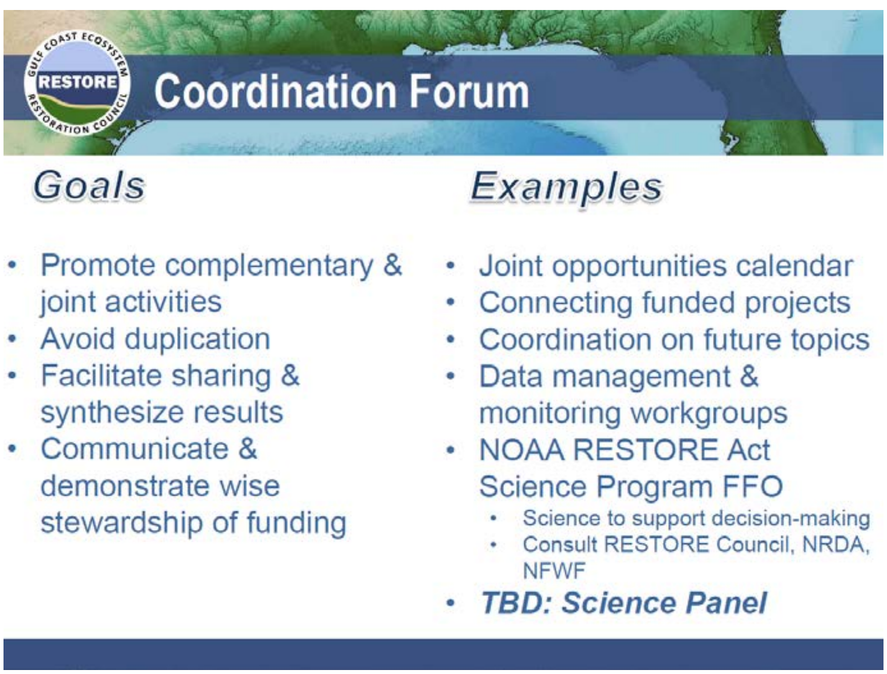

Figure 103, Slide 19

They have started implementing some coordination structures. On the state and federal side, there are similar efforts to leverage "management coordination structures" through workgroups comprised of relevant members from different agencies on subjects like monitoring. To reach the broader stakeholder interests, a Community of Practice on Monitoring was created to include NGO input.

There is also a Science and Restoration Coordination Forum that NOAA Science Program runs; the goals of the coordination forum are to promote complementary and joint activities, avoid duplication, facilitate sharing and synthesize results, and to communicate and demonstrate wise stewardship of funding. They have been working to get different groups to start to work together; for example, the Natural Resource Damage Assessment (NRDA)[171] program did a FFO to fund science tools for management to help managers make better

[171] Natural Resource Damage Assessment (NRDA). http://eli-ocean.org/gulf/nrda/

decisions. They are also interested in a Science Review Panel that could be used by other DWH settlement recipients.

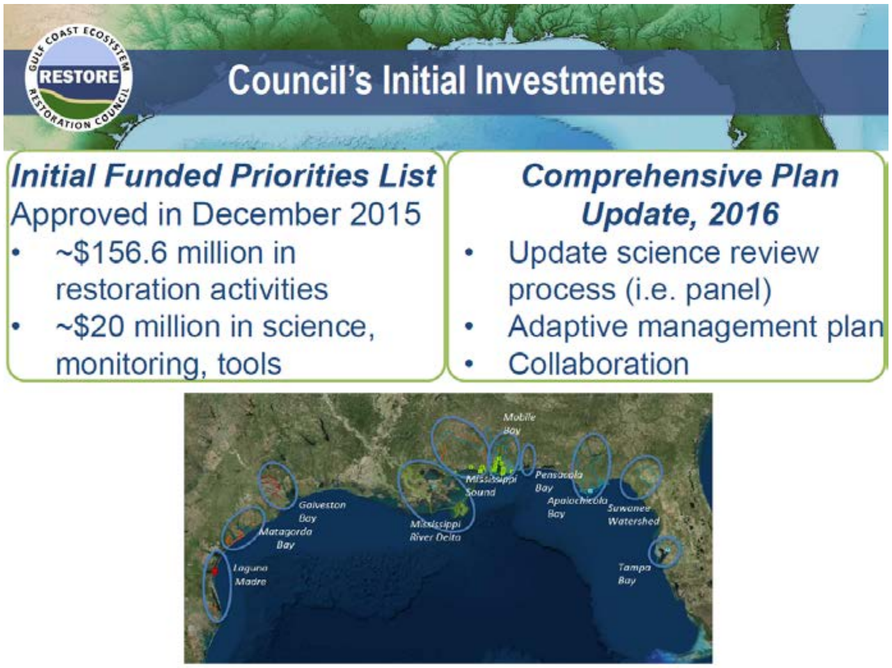

Figure 104, Slide 20

With the Council's initial investment in December of 2015, they approved over $150 million for restoration activities, and $20 million for science monitoring and tools.

In the comprehensive plan update that the Council will be voting on in December, the science review process was updated to incorporate the science review panels, and committing to an adaptive management plan.

In terms of collaboration and in the spirit of moving from cooperation to coordination to collaboration, the council is sponsoring some workshops next year.

Dr. Dausman then concluded with three main points; building on capacity, balancing wants and needs, and moving from coordination to collaboration.

Figure 105, Slide 22

Panel 3 Discussion

Panelists

Alyssa Dausman, Science Director, Restore the Gulf
Peter Goodwin, Former Delta Lead Scientist, Director of Center for Ecohydraulics Research, University of Idaho
Stephanie Johnson, Senior Staff Officer, National Academy of Sciences
Scott Phillips, USGS Chesapeake Coordinator
Denise Reed, Chief Scientist, Water Institute of the Gulf
Lisa Wainger, Professor, University of Maryland
Josh Collins, Lead Scientist, San Francisco Estuary Institute (SFEI)

Erin Foresman introduced the panelists, and began with several observations from Day 1 of the workshop: funding levels vary substantially for each of the six systems, funding for science is difficult to distinguish from program-wide investments, and when able to – it is generally a very small portion (~7 percent). There was agreement for need for long-term funding for science, and some debate on differences between "compliance" monitoring, long-term monitoring, assessment, and investigative science.

Question and Answer

Question: Proven strategies to fund science

Josh Collins began with the observation that as a non-governmental organization, he thinks about fundraising for basic and applied science. Applied science is in the service of place-based ecosystem management. Given the partners in research, which are generally state/federal agencies and academic partners, the research that is undertaken is in response to carefully constructed questions. After that, generally seeking to fundraise for capacity building (always entrepreneurial - public, private, philanthropic and usually 3-5 year contracts or grants) and development of tools and hiring staff. Generally dynamic. "Where I am, capacity building is always entrepreneurial," he said. "It's getting the money where ever you can. It's government, private sector, philosophic grants, and contracts. It's 2 years, 3 years, 5 years off. You hire people, you get seed money, you build things, you get going. Sometimes it takes, sometimes it doesn't. Base funding is the idea that we've got something that seems to be useful, it's usable, it's getting used, it's being used by multiple agencies. No one of them can fund it; they don't want to fund each other. How do we get a collective body of money that will service all the clients, agencies, our clientele, or partners through this program application of science? That is almost always in my experience hinged to permitting." As a result, the tools are built for permit compliance. Science funding is built into permit compliance.

Peter Goodwin provided some science funding lessons learned from other scientific disciplines. The National Science Board which oversees the National Science Foundation produces a periodic report, the National Science and Engineering Indicators[172], and it provides some insights on historical science investments. In 1980s, most of the funding went to the National Institute for Health (NIH). Part of the reason why is that they went to Congress and said they cured cancer. This was a compelling statement (or brand), and they received support. As another example, in the 1990s, a lot of funding went to support the Laser Interferometer Gravitational-Wave Observatory (LIGO) – which was set up to test the hypothesis about space-time fabric of the universe. It failed, and so the physics community went back collectively to congress and asked for more sensitive equipment – they were successful and gravitational waves were discovered. It captured national attention and pride.

[172] National Science and Engineering Indicators. https://www.nsf.gov/statistics/2016/nsb20161/#/

In general, there are some common traits that successful science investment efforts share; first there is a "big vision" (moon, cancer, gravity); second, the scientific community comes together and speaks with one voice; third, there is a champion on the political side (Rockefeller has been a great advocate of science), as well as a champion from the different agencies (chairs or secretaries). Fourth, consistent pressure to fund scientific research (Texas Universities), and fifth, need a proof of concept. Finally, need effective communication (NASA and Mars Rover).

In terms of private funding - Lisa Wainger provided some thoughts on funding from three motivational angles: legal, economic, and social-institutional. "In terms of the legal structures to motivate people to want better science, there's a basic strategy here of you give them something painful to do, unless they can demonstrate they can achieve the same performance in some other way," she said. "You motivate them to build a science that will let them find a more innovative solution." As an example of legal and economic motivation, in the Chesapeake Bay – a dam operator, Exelon Power, was notified that it needed to renew its permit on the Susquehanna River. Given that the dam stopped holding sediment, the operator started to fund research on what could be the most cost-effective ways to get in compliance. Similar examples for science investment exist through requesting Natural Resources Damages Assessment (NRDA).[173] On the restoration side, it important to create the ability to "pay for performance" which brings science into the funding model. As an example, in the Bay there is an impervious surface tax, or a"Rain Tax"/stormwater management fee that is a flat fee per property owner or on surface square footage.[174] Entities can avoid the fee if they are able to demonstrate that they have reduced their stormwater runoff flow. On the social-institutional side, behavioral motivations take many forms from incentives to threats. As an example, the Delmarva Land and Litter Challenge[175] brings together the medium-sized CAFOs which are motivated to find cost-effective solutions.

Question: Funding for long-term monitoring versus academic/investigative science

"I do think that we've been challenged in identifying longer-term sources and money to fund investigative, innovative, idea-driven science," said Dr. Reed. "Perhaps the challenge there is how that produces something which is usable in the end." Readiness is critical, both in ability to respond to disasters (such as Katrina, Hurricane Sandy, DWH spill) and in linking research interests to response needs. These are areas that are sometimes outside of the traditional academic funding avenues. There is great interest in "coastal green infrastructure" and the question of whether coastal restoration can actually mitigate sea-level rise/storm-surges risks. The attractiveness is that in general it's much cheaper than grey infrastructure – but need to characterize efficacy/reliability. Research community should be ready and able to respond. Another pot of money includes the National Fish and Wildlife Foundation (NFWF) Gulf Environmental Benefit Fund (GEBF)[176] has $1.2 billion in funds that needs to be spent on river diversions or barrier island restoration – as they start to draw down those funds, they have agreed to set aside small portion, or percentage, for adaptive management. This is innovative in that they are trying to think about how can set aside specific money for research needs.

Josh Collins cautioned that "repackaging" projects in a way that is more marketable (ie green infrastructure) plays upon concerns and interests, which may be over-promising the benefits before

[173] NOAA. What is a Natural Resource Damage Assessment? http://oceanservice.noaa.gov/facts/nrda.html
[174] The Facts About Polluted Runoff and Maryland's Stormwater Utility Fees. Chesapeake Bay Foundation. http://www.cbf.org/about-cbf/offices-operations/annapolis-md/the-issues/annapolis-maryland/the-issues/stormwater-fee#rain-tax
[175] 'Land and Litter' group proposes plan for Delmarva poultry manure. Chesapeake Bay News. http://www.chesapeakebay.net/blog/post/land_and_litter_group_proposes_plan_for_delmarva_poultry_manure
[176] National Fish and Wildlife Foundation (NFWF). Gulf Environment Benefit Fund (GEBF). http://www.nfwf.org/gulf/Pages/home.aspx

there is a robust, science-based understanding what will happen. It is important to have a multi-disciplinary assessment of projects before they go forward, otherwise failure can result in the entire effort being thrown out.

In addition, Collins noted there is great need to invest in information technology, or data management, as a critical part of science. For example, there are agencies that need to conduct quality assurance on evidentiary data– but are unable to do this because of the costs associated with QA/QC. Another example includes data that multiple agencies need to use and share, but there is not fiduciary mechanism to pool resources to develop and maintain a data platform. The recently passed AB 1755 The Open and Transparent Water Data Act,[177] for example, is housed within one agency (DWR), and that could mean that not all agencies will exactly trust the information that comes out of it. Our goal is to use technology in a cross-program, cross-agency way – and need to overcome the challenge of individual funding. Somehow we have to keep apace of technological invention and progress and pool resources development and maintenance. “Around information technology, there is a huge opportunity to be innovative about marketing, about paying for tools, how to keep them useful, and what is the fiduciary mechanism for both accounting for the cost and who is paying for what, and making sure there's QA/QC of the data being used,” he said. “The innovative possibilities are there, but accountability is yet to be proven.”

Erin Foresman agreed and noted the challenge in the California Delta in transitioning a monitoring system that is using technologies and equipment that are over 20 years old – and there is a big need to evolve the program.

Question: How do we evolve our science programs to support resource system goals? What are methods for making science programs efficient and strategic?

Stephanie Johnson noted that National Academy of Sciences, Engineering, and Medicine (NAS)[178] was chartered by the government to be an independent, non-governmental organization to provide scientific advice to the nation. As an example, NAS can provide valuable outside, independent review of programs which is useful to show funders a credible evaluation of the program over time. As an example, NAS provided a review of a 2002 Park Service Everglades science program, and Congress was interested in cutting funding for it. The review proved to be critical – it noted that the science program needed to incorporate peer review and stakeholder engagement. Overall, however, the evaluation found that the Park Service science program had value and was worth investing in, even if some improvements to the program were needed, because the Park Service ultimately held the responsibility of being the steward of that land and needed this science to support their stewardship responsibilities. In the Everglades, NAS has provided a bi-annual review of the program since 2004, and it has provided a critical long-term perspective through an external committee. These “outsider insights” can help overcome conflicts, for example scientific uncertainty was proving to be a barrier in restoration activities. The external committee recognized these stakeholder conflicts, and were able to recommend a series of incremental steps using science to address those uncertainties and resolve the problem.

Stephanie also noted that building capacity in science communication is important – and collectively, all of the science enterprises should think about how to elevate and advance scientific communication. For example, in the Everglades when funding for a monitoring program was substantially reduced, the scientists were upset while the managers were pleased with the outcome. “There was this conflict

[177] AB-1755 The Open and Transparent Water Data Act. California Legislative Information. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160AB1755
[178] National Academy of Sciences, Engineering, and Medicine (NAS). http://www.nationalacademies.org/

because there was a lack of communication," she said. "The independent panel tried to get in the midst of it, and they couldn't even understand what the cost versus the benefits of that cut were because the scientists felt like monitoring is inherently valuable. They were not able to articulate the value of what was being cut, and what was being lost." NAS understands that the value of building science communication skills be built at all levels of an enterprise – and has developed an award program for science communicators.

Scott Phillips noted that strategically, it's important to be ready for changes that expect to occur. For example, preparing information for political administration transitions that clearly articulates issues, the context and planning efforts, and the subsequent resource needs is critical. In the Chesapeake Bay, there was a need for additional monitoring stations in the upper watershed in order to detect performance changes after mitigation activities were initiated there. The program sought an independent review which evaluated tradeoffs and eventually provided information for an improved plan which included monitoring equipment in the upper watershed. When managers were able to understand the value of estuary monitoring and the roll the upper watershed played in the basin from the report, the rational was provided for funding and resources.

Lisa Wainger noted that an economic perspective provides the connection between information needed to inform managers on what actions are most effective in meeting a water quality objective. Valuation of ecosystem services (green versus gray infrastructure) is a common question, and it is critical to identify the types of research that are needed to provide the scientific basis of relative efficacy. "People come to me a lot and say, 'We want to value all of the ecosystem services of the green infrastructure,'" she said. "I say, 'Who's decisions are you trying to influence?' They usually say, 'Private property owners.' I say, 'I think you might be more successful if you showed that it worked as well as the gray infrastructure and that you're not asking people to take a bigger risk with green.' That's really what prevents them. Of course they can see it's prettier, and they'd rather have the birds than the concrete. It's the risk that's driving that decision. Alternatively, if you're trying to influence the people who might be providing grant money, then they do want to know social benefit. They want to know what society is getting back for this investment of public dollars."

In the Chesapeake Bay Program, the governance structure includes an independent review board called Scientific and Technical Advisor Committee (STAC),[179] which is comprised of 36 independent multi-disciplinary scientists from a variety of agencies, and they are tasked with evaluating long-term programmatic risks like climate change.

Denise Reed noted that STAC has an innovative structure in that while it is independent, it at the same time also includes "insider" scientists from the same agencies that are working on the program. This structure could have benefits in adapting to change. Stefani Johnson agreed that having knowledgeable reviewers helps when detailed input is needed. In parallel, it is complimentary to have NAS panels which can provide high-level strategic review which can identify support systems need to obtain goals. Peter Goodwin noted that in the Delta, the National Research Council (NRC) will periodically provide an external, heavy-hitting review - and the Delta Independent Science Board (ISB) provides a closely-engaged review panel. Josh Collins noted that when consider adaptive management, it's important to revise goals as needed – and science helps establish goals and the methods to measure progress and revisit the goals as appropriate. This means a periodic review is critical to inform resource allocation. Erin Foresman noted that it is very challenging for the Interagency Ecological Program (IEP) re-allocate

[179] Scientific and Technical Advisor Committee (STAC). Chesapeake Bay Program. http://www.chesapeake.org/stac/

resources. Much of the program focuses on compliance monitoring and it is not necessarily available for re-allocation. Scott Phillips emphasized that when the value of both the estuarine and upper watershed monitoring was considered, they were able to find additional resources.

Question: What is the case for science funding?
Denise Reed began with the observation that science can provide the information to folks out of bind. In particular, there are approaches to identify the value of information – or narrowing the uncertainty. "When you get into the details of some of these decisions, and you're really struggling to think about the need for science, sometimes uncertainty seems to be a distraction from that. I actually think that you can turn that around. If you can describe the uncertainty around the decision, then you can actually make a case for the value of narrowing that uncertainty through science."

Peter Goodwin noted that if able to characterize the worst case scenario and consequences of what will happen if don't do anything, that makes a compelling case for doing the research. Secondly, it is possible to leverage funding. "One agency steps up, starts doing science around a certain issue and it affects a lot of other folks. Other people start contributing to that source of funding. Suddenly, you find you have a lot of different groups taking ownership and interested in those outcomes. Building the science community through leveraging different funding sources I think is also very possible."

Peter Goodwin cautions that it's dangerous to rely entirely on disaster related funding, it tends to distract from long-term system goals – a diversity of funding sources should be cultivated. Denise clarified that understanding extremes, particularly in these coastal systems, are linked to long-term goals. Peter agreed and that it is a balance that must take into account limited staff resources.

Lisa Wainger noted that the value of information can be sold as a way to save money. "Don't spend money on stuff that's not working. Find the stuff that is working. I also think you have to remind them of when you save the money. That's where communication comes back in." She noted that they have their own newspaper, the Bay Journal.

Stephanie Johnson noted that critical to be able to be accountable to the public for how well public funds are spent. "There are some systems that do that extremely well. Chesapeake Bay has a wonderful system where they have a website that the public can find out how all of the different indicators are doing. Other systems really struggle with communicating with how well they are doing. Other systems struggle to even find the money to monitor to even be able to find out how well they're doing."

Alyssa Dausman noted that NGOs and advocates have been helpful in providing a sense to the elected officials of what is important – they received 60,000 comments requesting a science review panel. It is also critical to engage and lobby DC, success is linked to targeted communications with clear messaging on how science is usable to elected officials. "I work on a lot of politicians that are on election cycles. 'If you invest in the science we're going to help your restoration project be more successful and you're going to look better. You might get reelected because you're going to look better.'"

Scott Phillips agreed and noted that science investments ultimately help decision makers do their job more effectively in two ways – 1) identifying where projects can have most benefit and 2) monitor to see whether obtained desired benefit.

Josh Collins noted that it's important to sell science to make progress on challenging technical problems, provide accountability and credibly show how using tax monies to delivering on mission and why decisions were made in the way they were. “There are two major endeavors of our species that account for change so well that we can reverse it. One is the law. Where every decision is accounted for in writing, it is archived, and kept, and you can refer to it; it's called a case study. The other is science, where through publication we keep track of what we think is right and wrong, or likely or unlikely. Because of that accountability of ourselves through those processes, we can reverse our decisions and explain why we're reversing our decisions. That's a piece of accountability; you need science to explain why you're going to change your mind and account for that, and then get the money to keep going in a different direction.”

Question from Anitra Pawley at Department of Water Resources on how have dealt with long-term funding challenges – for much of their work, they rely on bond funding which cannot be put into an endowment funds. So, while able to do the restoration – there is no funding to do long term monitoring or management over time. Josh Collins noted that in California, it is possible to create Joint Powers Authorities (JPAs) among agencies where money can be place there and grants them fiduciary authority. In addition, JPAs are allowed to charge the agencies a subscription/membership/user fee for program they belong to. Another option is to establish a Public Service Corporations within agencies, which enable them to move money in different ways than is possible through normal budget processes. The central question is establishing who will be the fiduciary agent and what the legal options are to move money across programs.

Panel 4: Legitimacy, Co-Production, and Communication

Panel 4 Presentation: Perceptions of science in the San Francisco Bay Area

Dr. Mark Lubell, Director of the Center for Environmental Policy and Behavior, UC Davis

The focus of Mark Lubell’s presentation was the perceptions of science and political knowledge in the Delta and other estuaries he has been studying.