



SCIENCE AND TECHNOLOGY AS A GUIDE: MOVING FROM COMBAT TO COLLABORATION

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The decision-making environment in the United States differs extensively from many other parts of the world where a single agency, program or science team develops the understanding of the problem and projections of alternative futures as a single scientific basis for community feedback and decision-makers to act upon. In the California Delta, major contributions to the scientific knowledge to guide decisions and policies are derived from agency programs, special studies initiated by environmental groups, local agencies (including water contractors), as well as through university research projects, single agency or collaborative programs. The federal government, State of California, local governments, water agencies, and Non-Governmental Organizations (NGOs) all recognize that science-based decisions are likely to result in more enduring strategies, reduced uncertainty in water supply reliability and more sustainable and desired ecosystem outcomes. This commitment results in diverse data sets, modeling approaches, and analyses focusing on a specific problem or issue. This approach results in innovation and a dynamic scientific community, but also has inherent challenges when synthesis is required across issues to understand cumulative system-wide response to multiple management actions.

Science and Technology in the California Delta

High stakes and tall expectations for science and technology exist in the California Delta. Beyond legal obligations, a commitment exists to actively use science to guide how to make challenging decisions about the management of California's water resources, building even greater hopes for the role of science in the future. These expectations have evolved over time, are riddled with challenges, and will only be met if champions arise from all interested parties who can lead California into a new era of collaborative science-based water policy.



They shall beat their swords into ploughshares – from Combat Science to Collaborative Science.

Dueling Science

The history of science-based decision-making in the Delta includes mistrust, frustration, and legal disputes. This history includes the advent of "combat science", defined as the selective development and presentation of facts and analysis primarily for regulatory advantage (or disadvantage) of one stakeholder group or another (Hanak 2011). This advocacy science has clouded the use of science in Delta decision-making and has been the source of court-based interpretations and decisions on science (Cloern and Hanak 2013). It has been destructive to collaboration between scientists, resulting in dueling scientific presentations between scientists from different backgrounds and differing levels of financial support, and has exacerbated struggles for managers, policy makers, scientists, judges, and the public to find consensus on critical decisions based on science (NRC 2012).

Further complicating the science-scape in the Delta are the numerous science efforts conducted by multiple entities with multiple

agendas. All levels of governments with jurisdiction in the Delta engage in scientific research and monitoring to meet individual agency mandates. This institutional fragmentation adds a layer of complexity to an already complex physical and biological system and has been identified as a major obstacle to achieving ecosystem management goals (NRC 2012; Hanak et al. 2013).

In a system that is both complex and rich in scientific knowledge, there is a growing recognition that continuing to hold an open door to combat science and endless litigation is neither sustainable nor productive. There is general acknowledgement that forthcoming challenges will be greater than today's troubles and that a new way of using science to guide decision-making is needed (Luoma 2013). Here we discuss the paradigm shift underway that is moving California beyond the status quo and into a new era for science under the vision of 'One Delta, One Science' – which 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.

A Change of Course for Delta Science

In 2009, California passed legislation (Delta Reform Act) that set new requirements for how science would be used in decision-making about water policy and environmental management of the Delta. This same legislation established the Delta Stewardship Council, Delta Science Program, and Delta Independent Science Board; each with specific roles for supporting, coordinating, and overseeing best available science and adaptive management in the Delta. With regulatory requirements for the use of best available science and adaptive management set by the Delta Stewardship Council's Delta Plan, a Delta Science Program with a mission to provide the best possible science to inform water and environmental

decision-making, and a Delta Independent Science Board (Delta ISB) tasked with overseeing science and adaptive management programs in the Delta – a higher standard and accountability for the use of science was established. In 2012, California Governor Brown and U.S. Department of the Interior Secretary Salazar further elevated expectations for science-based decision-making in their joint statement about direction for the draft Bay Delta Conservation Plan and California's water future, *"with science as our guide, we are taking a comprehensive approach to tackling California's water problems..."*. With this momentum for moving beyond the status quo, a cultural change was set in motion to build science collaboration and bridge the cultural divides of science and policy.

Building a New Culture for Delta Science and Technology

As recommended by the Delta Plan (www.deltacouncil.ca.gov) and encouraged by the Delta ISB, the Delta Science Program completed a Delta Science Plan (2013) to address the challenges of combat science, institutional fragmentation of science, and the need for new mechanisms that bring scientists and decision-makers together.

The Delta Science Plan aims to achieve a vision of 'One Delta, One Science' – an open 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. The objectives of the Plan include enabling and promoting science synthesis across agency programs and mandates that result in actions that can be taken, managing scientific conflict, building effective policy-science interactions to ensure decision-makers are receiving information that is useful and defensible, provide support to the adaptive management of this complex socio-environmental system, and supports fundamental research that continually advances the understanding of this dynamic ecosystem. Hundreds of scientists contributed to the development of the plan with well over 1000 individual suggestions and comments incorporated into the final version. The actions in the plan reflect the principles of relevancy (science is developed to guide actions to address the problem being considered), legitimacy (scientists from different perspectives and organizations are engaged in the science activity, and credibility (hypotheses have been tested and the findings have been peer-reviewed) (Scarlett



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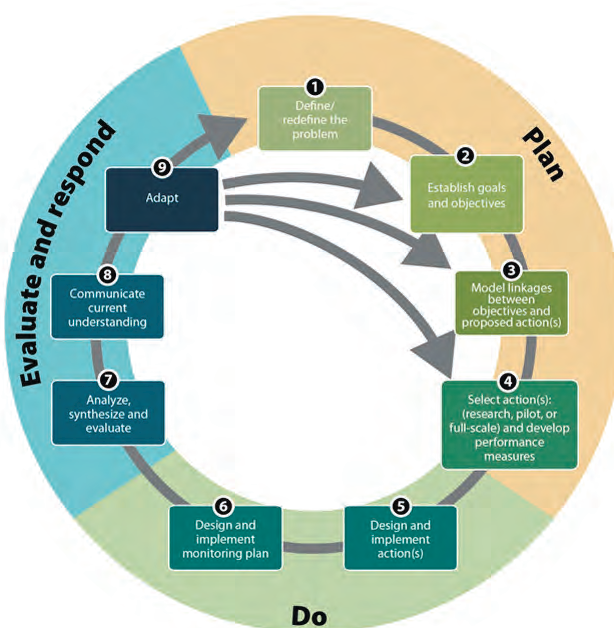
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The Adaptive Management Process being used for Delta restoration and water management



2013). The Plan is part of a three-part Delta Science Strategy that has two other key elements: the Science Action Agenda (SAA), a detailed workplan for a four-year period, and the State of Bay Delta Science which summarizes the new insights, discoveries and innovations generated from the SAA and other sources. This latter document summarizes the progress made in the preceding period and helps guide the next iteration of the SAA.

The Delta Science Program functions as a facilitator of collaborative science, a funding source for research, a convenor of independent scientific peer review and communication of science through workshops and conferences and an online peer-reviewed journal that is freely available (https://escholarship.org/uc/jmie_sfews). In support of the Delta Science Plan, the Science Program hosted a summit on sharing and accessing data in the era of Big Data in June 2014. In May 2015, the Delta Science Program in collaboration with IAHR, the California Water and Environmental Modeling Forum and the USGS will be convening a workshop on integrated modeling to simulate complex socio-environmental systems that will chart future directions for community modeling of the San Francisco Bay Delta. Details of these activities and resulting white papers are available at www.deltacouncil.ca.gov/science-program.

The Era of 'One Delta, One Science'

While establishing a Delta Science Plan initiated a new paradigm for Delta science, achieving its vision takes leadership, dedication, and commitment to change. Here we highlight two efforts that are evidence that change is underway and that we are entering a new era of Delta science.

Collaborative Science and Adaptive Management

The Collaborative Science and Adaptive Management Program (CSAMP) and the Collaborative Adaptive Management Team (CAMP) efforts are evidence of a recent positive step forward in achieving the vision of the Delta Science Plan (Connor 2013). The CSAMP and CAMP were formed to modify court-ordered schedules for remanding environmental permits to protect native Delta fish species. Important to achieving the vision of *One Delta, One Science*, the CSAMP represents an opportunity to test, in part, the types of collaborative, integrated science approaches described in the Science Plan.

The CSAMP has tested the Delta Science Plan's methodologies for adaptive management,



Scientists deploying sampling equipment in the Delta

conflict resolution, engagement of decision-makers in setting research and monitoring priorities, and new ways for organizing policy, science and management (Connor 2013). The CSAMP effort has successfully moved from talking about collaborative science to implementing collaborative science efforts (<http://www.sfcwa.org/2014/04/01/csamp-monthly-progress-reports/>). Even with a recent lifting of court-ordered requirements for the CSAMP, a commitment to proceed with collaborative science remains, evidence that "collaborative" has taken precedence over "combat" science.

Interagency Action

As an initial step to implement the Delta Science Plan's call for a Science Action Agenda that prioritizes science activities to address decision-makers policy and management challenges, an Interim Science Action Agenda (2014) was developed. This initial effort was enabled through the engagement of scientists and managers from all levels of government, non-governmental organizations, and the private sector, who participated in a public workshop and focused interviews to summarize proposed and ongoing science activities in the Delta. The development and completion of the Interim Science Action Agenda demonstrated the Delta science community's interest and ability to make progress on the vision of *One Delta, One Science*.

The Delta science community's efforts resulted in an Interim Science Action Agenda that includes 17 science action areas representing broad policy-relevant science needs. These 17 science action areas include science to reduce knowledge gaps critical to decisions about water management, habitat restoration, flood risks, water quality concerns, and the Delta economy. The science action areas also identify

topics in need of investment to build the Delta's science and technology infrastructure related to advancing collaborative modeling approaches, improved data management, and integrative system-wide monitoring and modeling. Encouraged by the Delta ISB's support for the Interim Science Action Agenda as a "credible, balanced, and technically sound as a near-term basis for guiding regional science activities in support of policy and management decisions in the Delta", an interagency committee of Federal and State agencies with responsibilities in the Delta (Delta Plan Interagency Implementation Committee), unanimously accepted the Interim Science Action Agenda as a step toward shared, collaborative science in the Delta. This action illustrates the forward momentum toward community and collaborative approaches to science that span institutional divides.

Conclusion

Changing the way we do science in the California Delta is challenging. Writing about this challenge Dr. Valerie Connor (2013) stated, "Conducting the monitoring, research, and modeling to inform policy isn't easy, but it isn't the most difficult part: The hard part is creating the new, supportive, and sufficiently strong organizational cultures necessary to succeed over the long run." The good news is that there is evidence that the organizational cultural changes needed are underway. Policymakers, managers, scientists, and engineers are actively engaging in a new culture of collaboration. We have a long way to go, but the vision of *One Delta, One Science* and collaborative science are in sight.

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