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San Francisco
Estuary & Watershed Science:
Science & Policy for the Delta

It's Time for Bold New Approaches to Link Delta Science and Policymaking

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California's Sacramento–San Joaquin Delta is widely recognized as a highly damaged ecosystem. The Delta is also emblematic of a growing sense worldwide that society needs to do a better job of using scientific knowledge to guide conservation and resource management policies. Fortunately, we now have an unprecedented opportunity to get it right in building structures that support effective science–policy linkages in the Delta. By adopting bold steps to implement a "one Delta, one science" approach for a new Delta Science Plan, California can become a leading example of how to tackle the global problem of rapid ecological change and biodiversity loss.

In this essay, we first describe the current paradox—continued environmental declines despite considerable investments in science and policy actions—and the high stakes of gambling with failure. Next, we explore why it is so hard to use scientific knowledge to design and implement policies that meet society's sustainability goals. We then outline promising ways to overcome these obstacles, drawing on recent experiences. We conclude with thoughts on how to leverage this experience to develop a bold new approach to Delta science.

Science–Policy Disconnects, Not Neglect

The symptoms of ecosystem disturbance to the Delta are well-chronicled: low primary production; replacement of native zooplankton by non-native species that have lower food value to fish; recurrence of toxic algal blooms that threaten human and ecosystem health; waterways choked by introduced plants; and—most highlighted in the policy debates—population declines of native fish, many of which are now listed as threatened or endangered under the state and federal Endangered Species Acts.

This downward spiral has occurred even though the Delta lies within one of the world's best-studied estuaries, and the overall quality of science is high (NRC 2012). Yet despite calls to use science to inform decision-making in all the major Delta policy

processes (Gray et al. 2013), the system has fallen short on using scientific knowledge to guide policy effectively. Numerous policies have been established to regulate flows, salinity, and pollutants; to limit species introductions; and to restore habitats. But fragmentation in the landscape of scientific knowledge has led to piecemeal regulatory approaches to a systemic problem. The resulting failure to stem the tide of ecosystem decline, combined with the financial costs of mitigation (typically borne by specific stakeholder groups), has heightened scientific controversy and fostered the conduct of "combat science"—where science takes center stage in courtroom battles, far outside the traditional arenas of scientific inquiry and debate.

Bridging the science–policy disconnect is an imperative in the Delta and beyond. Today's breathtaking pace of global environmental change threatens sustainability of the Earth-system processes that have allowed humanity to thrive over the past 10,000 years. Sustainability thresholds for three of these processes, including climate change and rate of biodiversity loss, have already been crossed; and others, including global freshwater use and land-use change, are approaching critical thresholds (Rockstrom et al. 2009). In the Delta, the impending loss of native biodiversity is costly in its own right, and it also threatens continued human uses of the region's land and water resources.

Why Is This So Hard?

The first barrier to more effective science–policy linkages is scientific complexity. Understanding the causes of the Delta's environmental degradation—and, even more important, the likely effects of potential mitigation actions—is a tough scientific problem. Recent surveys show that scientists and a wide range of Delta stakeholders and policymakers recognize that ecosystem disturbance is the result of many stressors (Hanak et al. 2013). But we don't fully understand how today's Delta has been shaped by the cumulative effects of historic transformations (e.g., landscape) and more recent perturbations (e.g., water management, pollution, species introductions), and we know surprisingly little about the interactive effects between perturbations such as water exports and species introductions. An additional layer of complexity arises from the need to infer the causes of species population declines, because the underlying processes of population variability (migration, reproduction, mortality) are rarely all measured. Complexity grows as we consider future conditions driven by human population growth and a changing climate (Cloern et al. 2011). As a result, there is considerable uncertainty about the likely effectiveness of many mitigation actions. This makes it especially hard to communicate scientific findings to a policy audience looking for solutions to an urgent management problem.

The second barrier is a cultural divide. Despite a broad consensus that effective policies need to be grounded in scientific knowledge, scientists and policymakers have different understandings of what this means in practice. Many policymakers expect the scientific community to deliver a prioritized list of actions to meet policy goals.

In contrast, scientists are trained to measure and understand environmental change and to project outcomes of various actions; they understand that their credibility can decline when they advocate specific policy directions. Scientists can also naïvely expect policy decisions to be based solely on the knowledge they generate, not recognizing that policymakers must also consider political constraints and the social and economic outcomes of their decisions. (The 2009 Delta Reform Act acknowledges this reality by establishing "co-equal goals" of ecosystem sustainability *and* water supply reliability for the Delta.)

The third barrier is institutional fragmentation. Scientific research on the Delta ecosystem is conducted in numerous venues: federal, state, and local agencies; universities; environmental non-profits; and private consulting firms. The past 15 years have witnessed some progress toward coordination (notably through the Interagency Ecological Program, a scientific consortium of nine federal and state agencies) and in strategic funding (notably through the Delta Science Program—formerly CALFED science—which distributes state and federal funding for research). But there is no institutional structure with the resources, responsibility, and authority to assist with applying science to guide decision-making. Despite improvements in interagency coordination, many members of the regulatory community perceive agency science as biased because they don't participate in setting the agenda. The result has been growing incentives for separate stakeholder-funded science and courtroom battles over the scientific facts. Recent surveys highlight the resulting divergence in views: for example, 62% of scientists considered reducing water diversions to be a top environmental management priority, but only 5% of those who export water from the Delta—those most likely to lose from reductions in water diversions—agreed with this priority (Hanak et al. 2013).

What Might We Do About It?

Overcoming these barriers will require more and stronger interactions between scientists and policymakers, to improve not only the process of science communication, but also the organization and conduct of science itself.

For instance, to address complexity more effectively, we need science–policy interactions that specifically target the problem of multiple stressors. Perhaps the best hope for advancing actionable knowledge is through coordinated efforts to use the rich data sets available to build holistic models of the Delta ecosystem. These models would provide new capabilities for isolating the effects of individual stressors and understanding their interactions through sensitivity analyses, and for projecting outcomes of future changes including a range of policy actions. A good starting place would be to clarify the bounds of what we know already.

More generally, narrowing the cultural divide and reducing fragmentation will require institutions that can facilitate more effective science–policy linkages. Facilitation should include processes to: (1) give scientists the incentives, communication skills,

and opportunities they need to become fully engaged with society (Smith et al. 2013); (2) reach broad agreement about the role of scientists; (3) develop syntheses of scientific knowledge tailored to meet the information needs of policymakers; (4) broker science–policy dialogues to, for example, reach common understanding of what is well-known and what is not, or how uncertainty is measured and can be used in policy development; (5) foster new partnerships in which scientists and policymakers (including regulators and representatives of the many stakeholders who use the Delta's resources) work collectively to shape, fund and implement policy-relevant research targeted to unravel the complexity of ecosystems disturbed by multiple stressors.

Fortunately, California possesses strong foundations—including knowledgeable human resources and budding institutional models—that can serve as building blocks for achieving this agenda. Useful experiences to build from include:

1. **Rapid Synthesis to Identify Research Priorities.** The Delta Science Program (DSP) is following a tradition established by the CALFED Science Program to organize workshops that aim to synthesize knowledge on controversial policy issues. A recent example is the June 2013 workshop on the effects of tidal marsh restoration on native fish populations, which brought together experts on the Delta and other ecosystems (DSP 2013). Such efforts could be intensified; they should inform near-term priorities for research as well as policy discussions (e.g., on restoration strategies of the Bay Delta).

2. **Consensus-based Synthesis for Policy.** The State Water Resources Control Board (SWRCB) has begun commissioning panels of researchers to synthesize scientific understanding for decision-making. For instance, Bennett et al. (2010) provide an overview of approaches to adopting Delta flow prescriptions to support native fish. The 11 authors—including researchers from two universities and five state and federal agencies—participated jointly in an expert panel discussion with the SWRCB. This is a welcome change from the traditional approach, where lawyers for competing interests at hearings take turns presenting their versions of the science to the SWRCB, which results in "dueling" interpretations and no effort toward synthesis or common ground. To be most effective, such efforts should not be one-shot deals, but rely upon ongoing interactions with policymakers.

3. **Policy-focused Collaborative Science.** Over the past few decades, useful models for science–policy partnerships have emerged in both Southern California (through the Southern California Coastal Water Research Program) and the Bay Area (through the San Francisco Estuary Institute [SFEI] and the Aquatic Science Center). These "common pool" approaches involve multiple parties setting the research agenda and supporting the work, where the resulting science provides a solid, less conflict-ridden basis for developing policy prescriptions (Gray et al. 2013). As an example, studies of sources and loads conducted by SFEI scientists were the foundation of the San Francisco Bay Water Board's plan to reduce mercury and PCB loads to San Francisco Bay. The commissioned studies were

specifically geared to policy-relevant issues, such as setting loading limits, and the result has been a set of environmentally protective policies that the regulated community supports.

4. **Collaborative Efforts to Move Beyond Combat Science.** Following several years of contentious litigation, water users and regulatory agencies have teamed up under the new Collaborative Science and Adaptive Management Process (CSAMP) to develop the science that will inform more protective water flow policies for Delta fish species listed under the Endangered Species Act (Maven 2013).

5. **Building Communication Skills and Opportunities.** Organizations such as COMPASS (Smith et al. 2013) are helping give natural scientists the communication skills and networking opportunities they need to become more effectively engaged with the media and policymakers. COMPASS's work with marine scientists has demonstrated the links between communication capacity and collaboration, enabling better synthesis of knowledge to guide ocean policies.

Conclusion: Going Bigger and Bolder

An unprecedented opportunity now exists for California to build on these experiences to forge effective science–policy linkages for sustainable ecosystem management. The DSP is now developing a Delta Science Plan (targeted for completion by late 2013) to support the attainment of society's broad co-equal goals for the Delta, as outlined in the newly adopted Delta Plan (DSC 2013). Early discussions of the science plan have recognized the need to reduce fragmentation and take a holistic approach, as summarized by the theme "one-Delta, one-science." To be successful, this effort needs to be bold. This means taking a common-pool approach to Delta science: (1) involve all parties in setting the agenda and funding the research; (2) foster synthesis and consensus about what is known and about scientific priorities to support management; and (3) provide new opportunities to improve the two-way communication between the scientific and policy communities to achieve their common goals for a sustainable Delta ecosystem that supports a healthy and prosperous economy and society. If we succeed here in California, the lessons may also benefit others seeking to tackle this global challenge.

ACKNOWLEDGEMENTS

We thank Erica Goldman, Naomi Feger, Cliff Dahm, and Sam Luoma for thoughtful comments on earlier versions of this essay.

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