Draft Memorandum: Summary of Discussion on Delta Science During Rapid Environmental Change

For the Delta Independent Science Board's discussion at its April 7, 2020 meeting.

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Date: April 2, 2020

To: Delta Stewardship Council Members and Delta Plan Interagency Implementation Committee Members

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From: Delta Independent Science Board

Subject: Preparing for accelerating and uncertain future environmental change

Science guides the conservation and management of species, ecosystems, and natural resources in the Delta. An accumulation of past drivers, compounded by the intensity with which climate change is arriving, is changing the Delta more rapidly than ever before. *Our findings indicate that Delta science and management needs to employ existing methodologies and develop new ones for looking ahead to anticipate changes and thresholds.*

The Delta Independent Science Board (Delta ISB) has been exploring how Delta science and management might better anticipate the environmental consequences and management implications of rapid and accelerating environmental change and growing uncertainty about the future. The Delta ISB's discussions have focused on the best available science to anticipate and manage how individual species might respond to more rapid change and how these responses might affect the character of ecosystems. Our findings apply to environmental science and management in general. The Delta ISB discussions have been taking place in parallel with the preparations for the Science Needs Assessment Workshop that is planned for later this year.

Summary of the Discussion Paper

The Delta ISB prepared a discussion paper during the latter months of 2019, titled: *Toward a Preemptive Ecology for Rapid, Global, and Increasingly Irreversible Environmental Change* (http://deltacouncil.ca.gov/pdf/isb/meeting-materials/2019-11-25-rapid-change.pdf). The paper was written to promote discussion of this important issue in the process of seeking consensus within the Delta ISB.

The thesis of the paper is that although the Delta has experienced rapid human-driven environmental change ever since the Gold Rush of 1849, the changes are now more rapid, more pervasive, and are accelerating. Historically, scientists have studied and managers have responded to the changes after the fact—for example, by adjusting the timing of water flows and restoring habitats in order to reverse recent declines in salmon migration. However, scientific research and management responses have lagged behind the pace of environmental changes. Early response options became less effective as populations of native species declined and non-native species better suited to the changed environment thrived.[1] With changes in underlying conditions projected to be more rapid and more uncertain in the future, such lags will make science and management increasingly less effective.

The Delta ISB's discussion paper focused on how rapid environmental change challenges ecology. A search for more forward-looking approaches identified several ways in which not only ecological science and management but Delta science overall could be more deliberately forward-looking. These included:

- *Enhancing the resilience of systems* so that they adapt to change while retaining key system properties.
- *Undertaking scenario analyses* to organize thinking about possible future directions ecosystems might take.
- *Undertaking horizon scanning* by interdisciplinary teams to better foresee possible future directions.
- *Eliciting the judgement of experts from multiple disciplines* in a Delphi or similar process to foresee and respond to possible futures.
- *Focusing science more directly* on foreseeable management needs.
- *Accelerating the synthesis, interpretation, and communication* of science for management.

[1] The pelagic organism decline (POD) in 2002 provides an example of not foreseeing potential changes and not being in a position to respond sooner. The diverse causes of the POD were still deemed scientifically uncertain five years after the rapid decline happened. Had Delta science been more forward looking and possible changes due to different drivers projected, the drivers might have been spotted earlier and managed sooner and better. Scenario analysis was well developed by the late 20th century and used extensively in climate science. There were notable examples of invasive mollusks transforming stressed food webs elsewhere. Delta science might have had a team dedicated to portraying possible futures through scenario analysis to aid in the early detection of such changes when they do occur.

Several of these approaches are already being used to some extent. Yet, the paper argues, they could be undertaken more formally and become a stronger, integral part of Delta science.

Summary of the Commentaries by Invited Panelists

The Delta ISB invited seven scientists to prepare written commentaries on the discussion paper and to participate in a panel discussion with the Delta ISB. The panelists provided very insightful commentary and were generous in their responses (http://deltacouncil.ca.gov/pdf/isb/meeting-materials/2020-01-27-isb-panel-response-rapid-change.pdf). The written commentaries were made public prior to the Delta ISB's meeting on January 30, 2020, and the invited panelists had read each other's contributions in advance of the panel discussion.

The panelists agreed that environmental change will likely accelerate and become more uncertain, and that this presents new challenges to environmental science and to ecology in particular. Several panelists also noted that climate change is not the only driver of rapid change. The difficulties of managing Delta ecosystems are also due to historic human activities such as levee construction and the use of mercury in gold mining, as well as more recent drivers including enrichments and toxics from agriculture and urbanization. Climate change is a new and additional driver affecting already vulnerable ecosystems.

One panelist, however, felt the discussion paper was "a bit alarmist, grounded more in general ideas and global trends than in what is known about the Delta region …". Another also felt the discussion paper needed to be more specific with respect to the Delta. The intent of the discussion paper was to raise a broad issue; some members of the Delta ISB are now drafting a paper with more Delta specificity for submission to *San Francisco Estuary and Watershed Science*.

Several panelists argued that adjusting to more rapid change will require changes in science and management that are inhibited, if not completely prohibited, by current institutions and regulations. Some institutional change will be needed in both governmental agencies and academe to address the challenges of the future more effectively. One panelist proposed forming a "futures program" to address more rapid and uncertain change. Several argued that the disciplinary structure of universities continues to discourage academics from collaborating across disciplines and training graduate students in interdisciplinary collaboration, as well as engaging effectively in policy making and management.

While the discussion paper focused on the challenges of doing science under rapid change, several panelists noted that identifying public goals during more rapid change will also be a challenge. Ecologists are shifting their emphasis from maintaining ecosystem composition and structure to maintaining functions and processes. Particular stakeholders and the broader public will be faced with novel options and wholly new

choices for which informed preferences will be needed. The interests of stakeholders are changing. Maintaining trust from science through management to policy and politics will be a greater challenge than it already is. Greater public participation in the process of interpreting and synthesizing science would help the public realize how management options are changing.

Several panelists suggested building a conceptual coupled human-natural systems model and adjusting it as conditions and knowledge of feedbacks change, to help in thinking about longer term policy issues.

Several of the panelists elaborated on how improved monitoring and modeling can be used more effectively to understand and respond to the complex dynamics of more rapidly changing ecosystems. They recommend the use of dynamic models of ecosystems that go beyond replicating past changes in, for example, shifts in the spatial distribution of species. Progress is being made on how to anticipate critical thresholds or tipping points, although definitive indicators may remain elusive. New types of monitoring may be needed to measure tipping-point indicators. Even if prediction remains elusive, dynamic models can help structure discussions of what seems to be understood well enough to be used in an anticipatory management process. Perhaps most importantly, anticipatory management using multiple possible scenarios can address a range of possible outcomes rather than a single specified future.

One panelist stressed that we need to become better at learning from management interventions, treating them as experiments. This will entail monitoring for outcomes, both expected and unexpected, and doing so quickly as outcomes unfold. Learning from “management experiments” in other places will also become more important. This too will require breaking down the divisions between science and management.