Delta Stewardship Council

Delta Science Plan

Vision, Principles, and Approaches for Integrating and Coordinating Science in the Delta

— **JUNE 2019** —

“The only thing that is constant is change.”

HERACLITUS OF EPHESUS

Preamble

A coordinated, science-based approach is essential for managing the Sacramento-San Joaquin Delta (Delta) to achieve the vision of *One Delta, One Science* and further the coequal goals in a manner that enhances and protects the Delta as an evolving place. As members of the 18 federal and state agencies composing the Delta Plan Interagency Implementation Committee (DPIIC), we recognize that we must avoid a siloed, single-interest approach to management and science issues in the Delta. Such an approach hampers effective management and efficient resource use to address complex issues including increasing risks from climate change related effects such as sea-level rise, prolonged dry periods, and floods. Our focus must be twofold: a more integrated effort among federal and state agencies and stakeholders to advance Delta-relevant scientific knowledge and using that knowledge to inform decisions that address these complex natural resource management issues.

The Delta Science Plan is a call to action for a more collaborative Delta science community that contributes to improving decision-making in the Delta. This document provides direction for collectively prioritizing research questions, setting goals, developing shared protocols for how science is conducted, and verifying and communicating scientific results with an eye towards usability for decision-makers and the public. This direction is only possible if the Delta science community, including members of DPIIC, work together to implement and conduct work consistent with the actions identified in the document and to speak with one voice to marshal support for scientific efforts.

The members of DPIIC are committed to promoting and investing in coordinated and collaborative efforts that generate scientific knowledge to support both the Delta Plan and the objectives identified in the 2009 Delta Reform Act. This commitment has been expressed through DPIIC's endorsement and acceptance of the Interim Science Action Agenda (2014), the High-Impact Science Actions (2015), and the Science Action Agenda (2017); documents that identify and prioritize collaborative science efforts. In endorsing the Delta Science Plan, we accept the document as a shared guide to build the collaborative science community and support efforts to work together in carrying out integrated actions that achieve the vision of *One Delta, One Science*.

Acknowledgments

This document would not be possible without the energy and enthusiasm provided by the Delta science community, including a broad range of agency staff and stakeholders. Special thanks to the many participants of the April 6, 2018 public workshop for their time and thoughtful insights, to the individuals and agencies who provided input during the public comment period, to the Delta Science Program's Science Advisory Committee for their guidance, and to the Delta Science Program staff for input and support throughout the process. Review and comments from the Delta Independent Science Board further improved the contents of the document, and their dedication and time in providing valuable input is much appreciated.

Unless otherwise noted, all photographs are courtesy of the Department of Water Resources.

Suggested Citation

Delta Stewardship Council, Delta Science Program. 2019. Delta Science Plan: Vision, principles, and approaches for integrating and coordinating science in the Delta.

> "The Delta Science Plan is a call to action for a more collaborative Delta science community that contributes to improving decision-making in the Delta."

How to use this document

The Delta Science Plan provides a framework for science cooperation across authorities vested in multiple agencies and programs. Implementing the actions identified in this document will help to build this lasting community of cooperation. Below are examples of the users and uses of the Delta Science Plan (these are not exhaustive):

USERS	EXAMPLE OF HOW THE DELTA SCIENCE PLAN CAN BE USED
Science Programs in the Delta[1]	• Develop programs and work plans tiered from the broader actions identified in the Delta Science Plan and Science Action Agenda • Incorporate long-term planning into project and program activities to better account for climate change effects • Establish more holistic approaches to address ecosystem-scale challenges including integrated modeling
Delta Scientists	• Foster and enhance science networking to support collaborative actions identified in the Delta Science Plan • Participate in collaborative efforts that inform decision-makers about the state of scientific knowledge and provide implications for management issues
Delta Decision-Makers[2] **and Policymakers**[3]	• Encourage agencies in the Delta to apply concepts from the Delta Science Plan to guide coordinated work plan development • Instill forward-looking approaches to planning to address climate change effects • Enhance connections with Delta scientists to guide management relevant science and support use of high-quality science to inform decision-making • Utilize scientific conflict management mechanisms identified in the Delta Science Plan including policy-science forums and supporting transparency and information sharing • Support improvements to the science infrastructure identified in this document
Delta Stakeholders[4] **and Interested Public**	• Promote collaborative mechanisms identified in the Delta Science Plan and integrate stakeholder perspectives into science-based decision-making • Support co-production of science by continuing to engage with Delta scientists and science community activities and provide context to science efforts in the Delta
Delta Independent Science Board	• Inform Delta Science Plan and other strategy documents through reviews of programs that support adaptive management • Provide input on Delta Science Plan actions • Inform recommendations for strategic science planning and activities

1. These include collaborative groups such as the Interagency Ecological Program and Delta Regional Monitoring Program but also individual programs within agencies and organizations focused on conducting science.
2. These include both managers and agency directors. Managers include individuals responsible for overseeing day-to-day functions (e.g. operations), implementing programs, research, policies, strategic planning, coordination and communication of the organization. Examples include participants of the Collaborative Adaptive Management Team, Interagency Ecological Program Coordinators Team, and Delta Regional Monitoring Program Steering Committee. Directors are individuals who oversee agencies and large divisions (e.g. United States Geological Survey Bay-Delta region). Examples include members of the Collaborative Science and Adaptive Management Program, Delta Plan Interagency Implementation Committee and Interagency Ecological Program Directors Team participants.
3. Individuals who develop policies for their agencies and departments and also those who participate at the legislative level who develop state-wide and nation-wide regulations.
4. Anyone or any entity who can influence, or will be affected by the issue, set of findings, or action (Haddaway et al., 2017).

Contents

Executive Summary

Why a Delta Science Plan?

There are few places in the world with the ecological, economic, and political significance of the Sacramento-San Joaquin Delta. The region supports an array of complex ecosystems, is part of the largest estuary on the west coast of the United States, and provides water for more than 26 million people. The Delta also sustains a large agricultural economy that serves an international community and is a place of cultural and historic importance. However, over the last century and a half, the Delta has been transformed by large-scale changes in water routing, non-native species, land use change, climate change impacts, and other factors. These changes have made the Delta ecosystem vulnerable to numerous threats such as floods and long-term droughts. There is a shared sense of urgency to take action to protect and manage the Delta's resources.

The Delta Science Plan is a guidance document that provides principles and approaches to better coordinate Delta science and communicate the outcomes of these efforts with policymakers so they can effectively take on the region's natural resource management challenges. The first element in a three-part Delta Science Strategy (see pages 6–9), the Delta Science Plan fulfills the Delta Plan's recommendation[5] for an overarching document that guides coordination and organization of information among science activities in the Delta. The Delta Science Plan also supports requirements in the 2009 Delta Reform Act, which calls for the use of science in the development and implementation of all Delta policies and management. The initial Delta Science Plan, adopted in 2013, established the shared vision of *One Delta, One Science:* an open Delta science community[6] that works collaboratively to build a shared body of scientific knowledge with the capacity to adapt and inform water, environmental, and societal decisions. This document updates and expands on the initial 2013 Delta Science Plan by identifying opportunities to further the original effort, as well as new initiatives to promote science integration with regional management actions. The goals of the Delta Science Plan are to: 1) strengthen and unify the Delta science community; 2) assure the credibility, relevance, and legitimacy of Delta science; and 3) provide tools, organizational structures, and mechanisms for scientists, decision-makers, stakeholders, and the public that will increase collaboration to ensure Delta science supports effective management.

Updates to the Delta Science Plan

The Delta Science Plan calls for an update every five years. Updates are intended to provide an opportunity to incorporate new concepts and actions relevant to the current science and management needs of the Delta. While the Delta Stewardship Council, Delta Science Program (Delta Science Program) has led and facilitated the effort of developing and updating the Delta Science Plan, the document is intended for use by the wider Delta science community to guide science efforts throughout the Delta. This is reflected in the broad public engagement to update the plan, as well as opportunities for multiple agencies to serve as the "primary responsibility" for actions throughout the document. Several concepts are introduced and emphasized in the updated Delta Science Plan based on recommendations from a diverse range of agency staff and stakeholders, with guidance from the Delta Independent Science Board. These include:

- Social sciences and their importance in supporting meaningful research and effective management
- The need to more fully address climate change and long-term considerations in current science efforts
- Actions to enhance the transparency and efficacy of science governance
- The need to develop topic-specific science implementation plans

Central to all of these concepts is modernizing and maintaining the science infrastructure, which includes staffing for monitoring and research, open access, and widely accessible data to modeling and science synthesis. This update also emphasizes the importance of addressing funding shortages and improving science management linkages. Although no specific actions were developed for science governance, the Delta Science Plan provides an overview of the current science enterprise[7] to establish a common understanding and continue the current discussion of governance issues within the Delta.

In the updated Delta Science Plan, a total of nine new actions were added, eight were removed, and another eight actions were substantially changed from the 2013 Delta Science Plan to reflect the current state of science. Based on public input,[8] key actions were identified in the updated Plan to highlight important concepts and areas for emphasis. These are identified below and include both new actions and ongoing efforts.

- Develop, coordinate, and implement topic specific Delta science implementation plans
- Develop guidelines and best practices for policy-science forums
- Establish shared mechanisms and processes to enhance science funding
- Routinely evaluate monitoring programs in the Delta to identify gaps, redundancies, and management relevance
- Provide support and opportunities that foster synthetic thinking throughout the Delta science and management communities
- Develop, compile, and share methods for science communication to leverage existing efforts
- Implement adaptive management and structured decision-making approaches more fully and consistently in the Delta
- Develop and implement a strategy to grow the collaborative modeling community

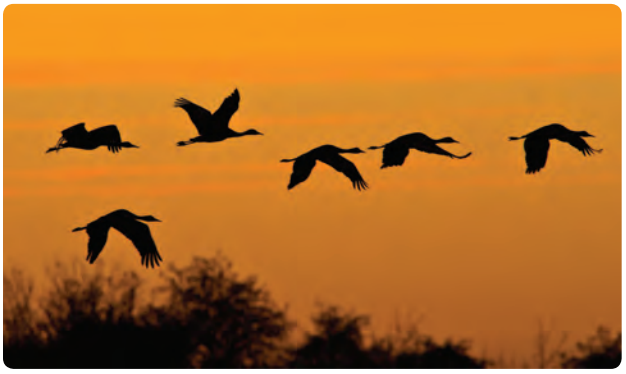
Six appendices were also added. These provide more details on the update process and status of 2013 Delta Science Plan actions, expand on the science governance discussions, and provide additional information on scientific review and advice. Some actions from the 2013 Delta Science Plan have been completed, while many are ongoing and emphasize the need to maintain efforts to continue building the collaborative science community. Appendix A provides an overview of the status of the actions from the 2013 Delta Science Plan.

The Objectives and Actions of the Delta Science Plan

The updated Delta Science Plan identifies six objectives for achieving the shared vision of *One Delta, One Science:*

1. Strengthen science-management interactions
2. Coordinate and integrate Delta science in a transparent manner
3. Enable and promote science synthesis
4. Manage and reduce scientific conflict
5. Support effective adaptive management
6. Maintain, communicate, and advance understanding of the Delta

Collectively meeting these objectives will result in a more vibrant community of scientists and integrated efforts to produce science that will help reduce risks and increase resilience of the State's water supply, the Delta ecosystem, and the Delta as a place. To reach these objectives, the updated Plan includes a total of 26 actions (Table E-1). These actions address multiple objectives and are grouped under four thematic chapters: informing policy and management (Chapter 2), science infrastructure (Chapter 3), adaptive management and decision support (Chapter 4), and implementation and funding (Chapter 5). Together, these actions guide the development, coordination, and communication of science to provide relevant, credible, and legitimate decision-support for policy and management actions. The actions identified in this updated Delta Science Plan are intended to promote more forward looking and nimble science and management efforts. They address how to use open and transparent processes to prioritize science activities, determine how these can be carried out effectively and efficiently, and identify how the resulting information is best communicated to those who need it.



5. See Delta Plan GR 1: *Development of a Delta Science Plan.*
6. Those who are actively participating in science and management actions in the Delta. These include federal, state, and local government agency scientists, non-governmental organizations, and interested public.
7. The collection of science programs and activities that exist to serve managers and stakeholders in a regional system.
8. These include the public workshop held on April 6, 2018.

Achievements since the 2013 Delta Science Plan

The Delta science community has made significant improvements across all six of the original Delta Science Plan's objectives including the following highlights:

- **Bridging science and policy:** Recognizing the complexity of the science landscape of the Delta (see Appendix C), there has been widespread acknowledgement of the need for tighter coordination and communication among scientists and managers. In the last five years, several venues have emerged where decision-makers, scientists, and stakeholders came together to discuss science and management needs including the Collaborative Science and Adaptive Management Program and associated Collaborative Adaptive Management Team (from the 2013 federal court order to extend the revision of salmonid and Delta Smelt Biological Opinions), science panels at the Delta Plan Interagency Implementation Committee, and regional science conferences.
- **Increasing transparency:** A major accomplishment for transparency has been the ongoing development of open data initiatives that grew out of the 2014 data summit (action 4.3.1 of the 2013 Delta Science Plan), which played a key role in informing Assembly Bill 1755, or the Open and Transparent Water Data Act.
- **Expanding science synthesis efforts:** While still in need of major attention, synthesis efforts have grown. Several products that provide an overview of important ecological processes in the Delta have been produced by various groups including the Interagency Ecological Program and Delta Nutrient Research Plan Science Work Group. The 2016 State of Bay-Delta Science and 2017–2021 Science Action Agenda were also completed (actions 2.2 and 2.6 of the 2013 Delta Science Plan), offering additional avenues to distill scientific knowledge and identify critical management relevant science topics.
- **Promoting research to inform management:** Support to fill critical knowledge gaps has grown. The most recent accomplishment has been the joint proposal solicitation effort between the California Department of Fish and Wildlife and the Delta Science Program with additional funding from the U.S. Bureau of Reclamation.

The Delta Science Plan is supported by the broad Delta Science Community and was developed through a transparent, open, and inclusive process. Similarly, the actions in this updated Delta Science Plan need to be collectively implemented to produce and communicate the credible, relevant, and legitimate science needed to support effective and robust management actions directed at balancing the coequal goals of achieving a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem.

Table E-1 | Summary of actions and the corresponding objectives they address.

ACTION	TITLE	OBJECTIVES ADDRESSED
CHAPTER 2: Shared Mechanisms to Inform Policy and Management		
2.1	Develop guidelines and best practices for policy-science forums	● ● ● ● ● ●
2.2	Update and continue to implement the Science Action Agenda	● ● ●
2.3	Regularly update and publish the State of Bay-Delta Science	● ● ●
2.4	Develop, compile, and share methods for science communication to leverage existing efforts	● ● ● ●
2.5	Support and enhance communication efforts and tools	● ● ● ●
2.6	Support opportunities for training that enhance science communication skills of Delta scientists	● ● ● ●
2.7	Ensure consistent application of scientific peer review and independent science advisors	● ● ● ● ●
CHAPTER 3: Modernize, Integrate, and Build the Delta Science Infrastructure		
3.1	Host a summit to identify useful emerging data science and technology	● ●
3.2	Establish a social science task force and a strategy to engage and integrate social science research in the Delta	● ● ● ● ●
3.3	Routinely evaluate monitoring programs in the Delta to identify gaps, redundancies, and management relevance	● ● ● ● ●
3.4	Develop a working group to facilitate monitoring program coordination and integration	● ● ● ●
3.5	Establish sustainable funding for forward-looking science	● ● ● ● ●
3.6	Develop a shared framework that broadly addresses the data life cycle to support the goals of Assembly Bill 1755 and beyond	● ● ●
3.7	Promote accessibility to peer-reviewed scientific literature, data, and tools	● ● ● ●
3.8	Develop and implement a strategy to grow the collaborative modeling community	● ● ● ● ●
3.9	Support high-priority model development across agencies and programs	● ● ● ●
3.10	Establish a shared set of best practices and protocols for focused synthesis	● ● ● ● ● ●
3.11	Provide support and opportunities that foster synthetic thinking throughout the Delta science and management communities	● ● ● ● ● ●
CHAPTER 4: Support Effective Decision-Making Through Science-Based Adaptive Management and Decision Support Tools		
4.1	Implement adaptive management and structured decision-making approaches more fully and consistently in the Delta	● ● ● ● ● ●
4.2	Provide Adaptive Management Liaisons	● ● ● ● ●
4.3	Convene regular Adaptive Management Forums	● ● ● ● ●
CHAPTER 5: Collectively Support Implementation of the Delta Science Plan		
5.1	Establish shared mechanisms and processes to enhance science funding	● ● ●
5.2	Develop, coordinate, and implement topic-specific Delta science implementation plans	● ● ● ● ● ●
5.3	Develop a web-based tracking system for science activities in the Delta	● ● ● ● ● ●
5.4	Maintain and grow the scientific expertise workforce needed to support Delta Science Plan implementation	● ● ● ● ● ●
5.5	Develop and report performance measures for the Delta Science Plan	● ● ●

- Strengthen the Science-Management Interface
- Coordinate and Integrate Delta Science in a Transparent Manner
- Enable and Promote Science Synthesis
- Manage and Reduce Scientific Conflict
- Support Effective Adaptive Management
- Maintain, Communicate, and Advance Understanding of the Delta

One Delta, One Science and the Delta Science Strategy

The vision of *One Delta, One Science,* refers to an open Delta science community that works together to build a common body of scientific knowledge. Achieving this vision requires a sustained culture of cooperation and stewardship among decision-makers, scientists, managers, stakeholders, and the interested public.

Three guiding documents were developed to form the Delta Science Strategy to further the vision of *One Delta, One Science:* the Delta Science Plan, the State of Bay-Delta Science, and the Science Action Agenda (Figure E-1). Each of these three documents plays a different role to promote use and understanding of collaborative science in the Delta that can be used to effectively inform decision-makers.

The Delta Science Plan is the overarching document that identifies the tools, organizational structures, mechanisms, and actions needed for a more collaborative and integrated Delta Science community. Objectives and supporting actions lay the foundation for science in the Delta to be credible, relevant, legitimate, produced collaboratively, conducted efficiently, and shared openly.

The State of Bay-Delta Science is a summary of the current scientific knowledge for the Delta. The purpose of the State of Bay-Delta Science is to communicate the state of knowledge to address key management needs, highlight progress made on key research questions, and identify remaining knowledge gaps. The State of the Bay-Delta Science also provides context for the Delta Science Plan and guides updates to the Science Action Agenda.

The Science Action Agenda establishes focused science actions to achieve the objectives of the Delta Science Plan and to address key management issues. The science actions are specifically focused on filling gaps and promoting collaborative efforts. The Science Action Agenda serves as the common agenda from which agencies and programs can develop more detailed, shorter-term work plans (e.g. the Interagency Ecological Program Annual Work Plan) and provides the basis for topic-specific science implementation plans.

All three guiding documents in the Delta Science Strategy have been developed openly based on input from the Delta science community, including the Delta Independent Science Board, and information gathered from peer-reviewed literature, existing science plans, and synthesis reports. However, these documents alone cannot achieve the vision of *One Delta One Science*—the Delta science community must enthusiastically embrace and implement the concepts laid out to ensure science is used effectively to support natural resource management decisions.

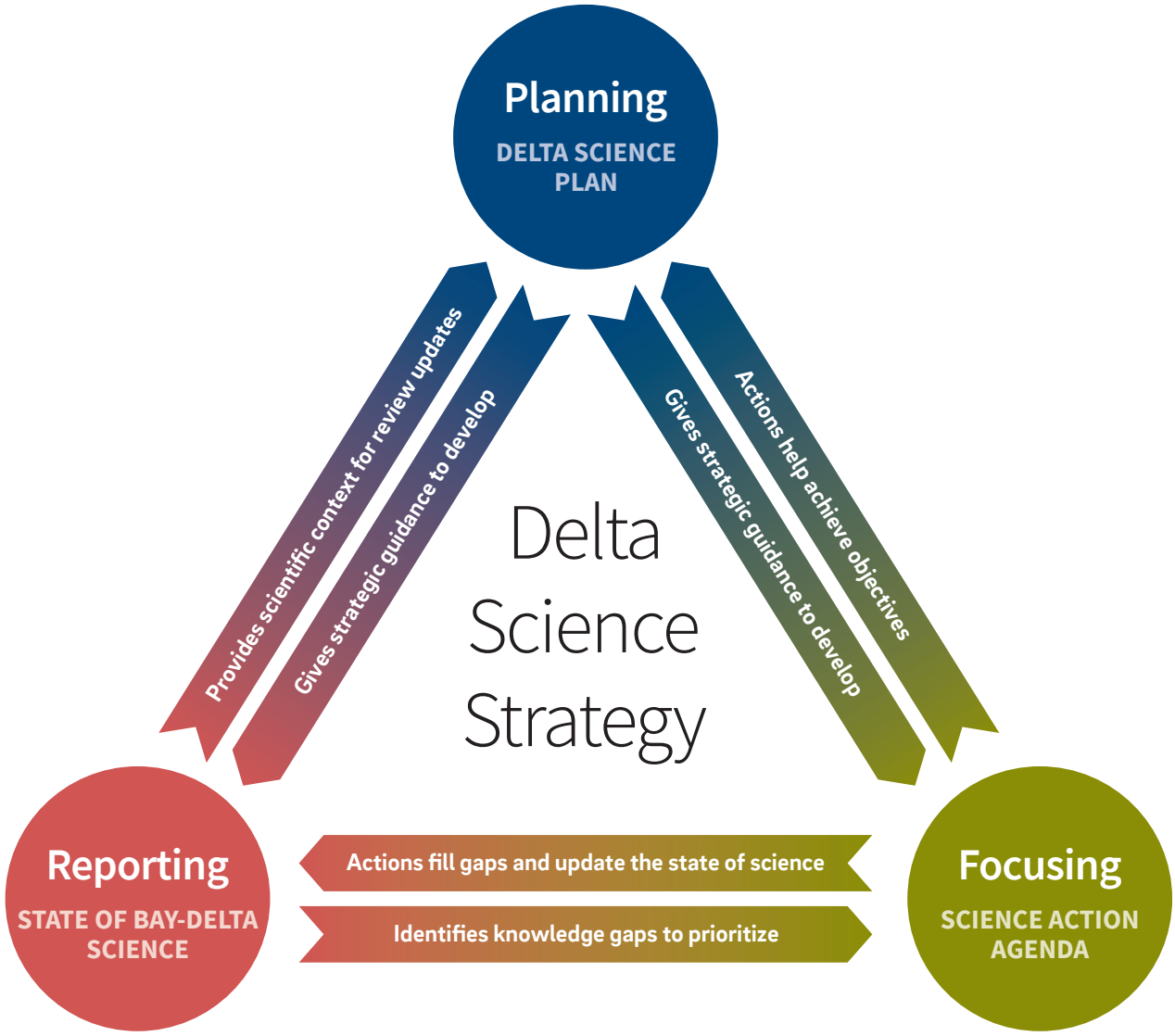


Figure E-1 | The Delta Science Strategy.
The three guiding documents that make up the Delta Science Strategy and the relationships among the three elements. These documents are formed openly and transparently based on input from the Delta science community, drawing from a variety of existing documents.

CHAPTER 1:

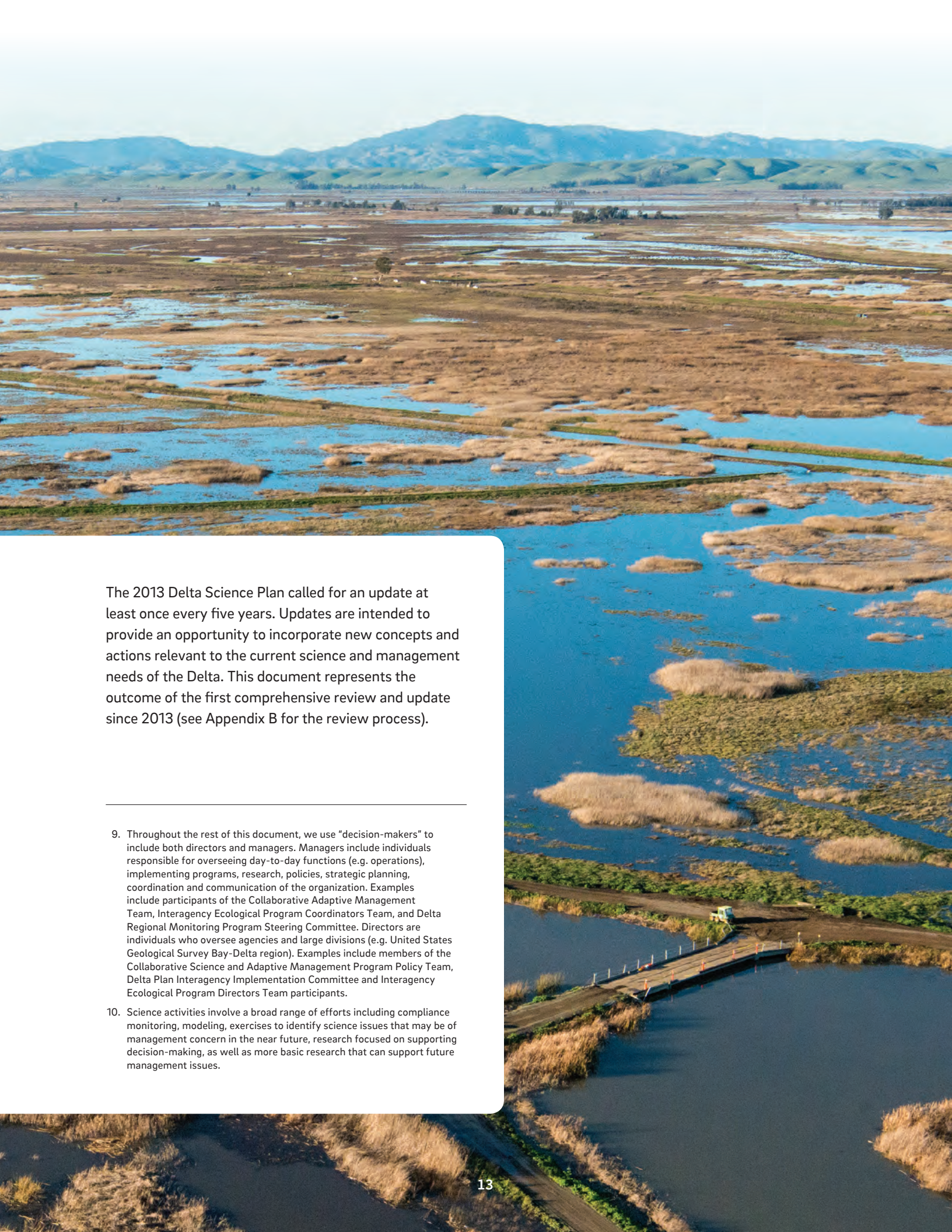
What Is the Delta Science Plan, Why Do We Need It, and What Will It Achieve?

Why do we need a Delta Science Plan?

The Sacramento-San Joaquin Delta (Delta) is a critical resource for California, supporting millions of people and a diverse ecosystem (Box 1-1). Large-scale human reliance on the Delta has transformed the region into a system riddled with conflicting demands of declining species and provision of limited water resources to California. The system has become more vulnerable to numerous threats including catastrophic damage from floods and long-term drought. Climate change, increasing water demands, invasive species, and land use change impose rapidly changing conditions and greater variability onto the system. These factors add multiple levels of complexity to the already challenging management issues, which have consequences for millions of people and the sustainability of the Delta ecosystem (Luoma et al., 2015). There is a shared sense of urgency to take action to protect and manage resources now and into the future.

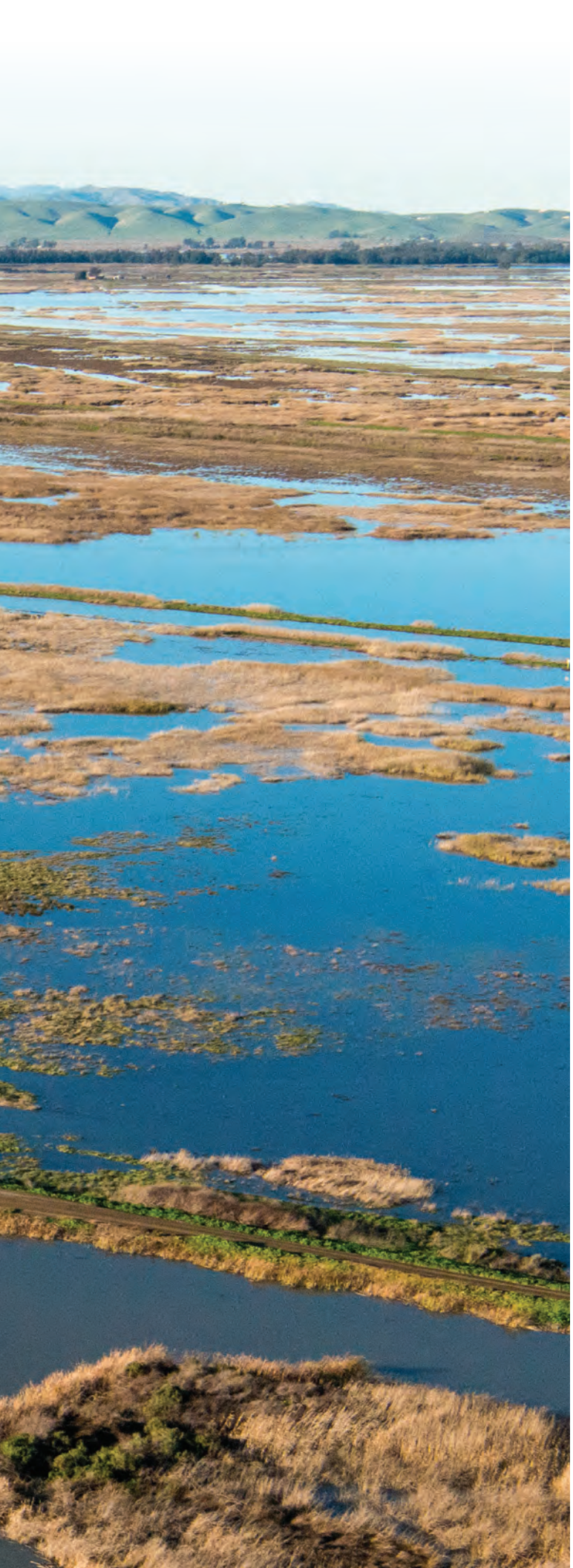
The importance of using science to inform management and policy decisions has been widely recognized in the Delta and legally mandated with the passage of the Delta Reform Act in 2009. However, science alone cannot address the Delta's challenges (NRC, 2011); effective and collaborative science governance (see pages 18–19) is required to provide decision-makers[9] with credible, relevant, and legitimate scientific information to guide effective management actions.

The 2013 Delta Science Plan was developed in response to a recommendation in the Delta Plan and long-standing calls by the Delta Independent Science Board (Delta ISB, 2012) to address regional science challenges. At that time, science activities[10] in the Delta were generally conducted without an overarching plan for coordinating and organizing information among them (Delta ISB, 2012). This fragmented approach led to incomplete scientific information, high uncertainty, and disagreements influenced by conflicting interests. Inefficient resource management actions leading to unsatisfactory outcomes were often taken to the courtroom, with proponents employing "combat science" (Hanak et al., 2011), or scientific knowledge generated for the purposes of advocating a political viewpoint, rather than to improve overall scientific understanding.



The 2013 Delta Science Plan called for an update at least once every five years. Updates are intended to provide an opportunity to incorporate new concepts and actions relevant to the current science and management needs of the Delta. This document represents the outcome of the first comprehensive review and update since 2013 (see Appendix B for the review process).

9. Throughout the rest of this document, we use "decision-makers" to include both directors and managers. Managers include individuals responsible for overseeing day-to-day functions (e.g. operations), implementing programs, research, policies, strategic planning, coordination and communication of the organization. Examples include participants of the Collaborative Adaptive Management Team, Interagency Ecological Program Coordinators Team, and Delta Regional Monitoring Program Steering Committee. Directors are individuals who oversee agencies and large divisions (e.g. United States Geological Survey Bay-Delta region). Examples include members of the Collaborative Science and Adaptive Management Program Policy Team, Delta Plan Interagency Implementation Committee and Interagency Ecological Program Directors Team participants.
10. Science activities involve a broad range of efforts including compliance monitoring, modeling, exercises to identify science issues that may be of management concern in the near future, research focused on supporting decision-making, as well as more basic research that can support future management issues.



BOX 1-1

THE SACRAMENTO-SAN JOAQUIN DELTA

BACKGROUND

The Sacramento-San Joaquin Delta supports a wide range of needs for California, including water supply for two-thirds of the State's population and critical habitat and migratory pathways for a diverse set of species—many of which are threatened or endangered. A highly engineered landscape of levees and islands, the Delta is home to more than 570,000 residents and sustains a $3 billion agricultural and recreational economy (Delta Conservancy, 2018; Luoma et al., 2015; Lund et al., 2007). The Delta and its ecosystem are also at constant risk of catastrophic damage from climate change, sea-level rise, droughts, floods, earthquakes, invasive species, and other stressors. In this rapidly changing and intricately connected system, resource management in the Delta has been termed a "devilishly wicked problem" (Luoma et al., 2015).

GEOGRAPHIC SIGNIFICANCE

The Delta is situated at the confluence of the Sacramento and San-Joaquin rivers. The region is in the middle of the continuum of ecosystems and management issues connecting freshwater flows from the upper watershed to the larger estuarine system of the San Francisco Bay. However, given the complexity of the issues and the scope of the Delta Reform Act, the Delta Science Plan focuses primarily on the legal Delta and Suisun Marsh.

TODAY'S DELTA

New policies and initiatives have had wide reaching effects on both science and management efforts in the Delta. These policies and initiatives include the California WaterFix (2015), EcoRestore (2015), updates to the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta (initiated in 2009), the Water Infrastructure Improvements for the Nation Act (passed in 2016), and California Assembly Bill 1755 (The Open and Transparent Water Data Act, passed in 2016). These regulations and actions have impacted water supply for local residents and those outside the Delta, the surrounding economy, agriculture, and the native, migratory, and introduced species that utilize the Delta. Management needs that will arise from these initiatives will rely on many of the actions identified the Delta Science Plan, including coordinated monitoring, updated modeling, synthesis of data and information, exploration of alternative futures, peer review, enhanced interagency efforts, and adaptive management.

> The vision of *One Delta, One Science* is 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."

What is the Delta Science Plan and what will it achieve?

The Delta Science Plan is one element of a three-part Delta Science Strategy (see pages 6–9 and Table 1-1) developed to achieve the vision of *One Delta, One Science*—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. This document is intended as a shared framework for the Delta science community.[11] The document identifies strategies for improving the development and communication of scientific information to support the coequal goals[12] and to achieve the objectives of a coordinated, integrated, and open science community. This document emerged from a collaborative process involving the broad Delta science community (see Appendix B) and is intended to coordinate science activities for anyone actively participating in science and management efforts in the Delta.

This update reinforces the vision of *One Delta One Science,* established by the 2013 Delta Science Plan, by emphasizing the need to increase collaboration among diverse entities and to improve *science governance* within the *Delta science enterprise.* Pages 6–7 and Appendix C define and discuss both of these concepts further and provide network diagrams that illustrate the extent of the Delta science-scape, or the landscape of entities participating in Delta science efforts. These diagrams show connections across Delta science organizations and illustrate the dispersed nature of science decision-making in the current science-scape. Further exploration and analysis of these diagrams will help to establish a common understanding of the current science-scape and to identify opportunities to improve coordination and science governance.

The Delta Science Plan is a shared framework for collaboration; it does not identify specific research questions or monitoring programs for addressing knowledge gaps. Broad guidance on current science needs is provided in the Science Action Agenda, and more focused studies and programs should be further developed within individual science programs and work plans of various agencies and collaborative groups in coordination with the Delta Science Plan (Box 1-2).

Box 1-2

Existing work plans and topic specific implementation plans to coordinate through the Delta Science Plan

- Interagency Ecological Program science strategy[13]
- Interagency Ecological Program's annual work plan[14]
- Delta Regional Monitoring Program annual work plan[15]
- Delta Nutrient Research Plan[16]
- Delta Smelt Resiliency Strategy[17]
- Sacramento Valley Salmon Resiliency Strategy[18]

11. Those who are actively participating in science and management actions in the Delta. These include federal, state, and local government agency scientists, non-governmental organizations, and interested public.
12. The two goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place (California Water Code section 85054).
13. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Environmental-Services/Interagency-Ecological-Program/Files/IEP-Science-Strategy.pdf?la=en&hash=7580F3E9FBB153F794501785FBF04CED080E8E78
14. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Environmental-Services/Interagency-Ecological-Program/Files/2019-IEP-Work-Plan_2018-12-11.pdf?la=en&hash=C305D1B1DA7931D95E8676247669F098F26A28FA
15. https://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_regional_monitoring/wq_monitoring/
16. https://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_nutrient_research_plan/
17. http://resources.ca.gov/delta-smelt-resiliency-strategy/
18. http://resources.ca.gov/sacramento-valley-salmon-resiliency-strategy/

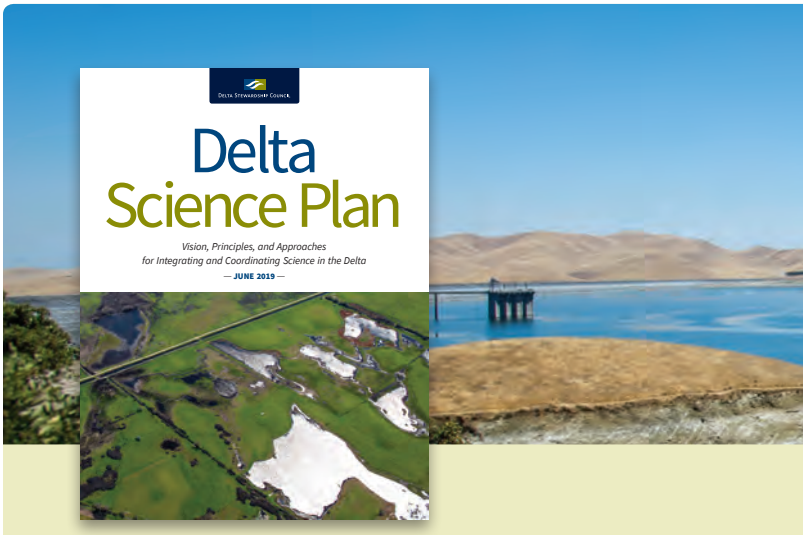
Objective for achieving the vision of *One Delta, One Science*

Collective progress towards the vision of *One Delta, One Science* will be advanced through a focus on six objectives:

1. **Strengthen science-management interactions**—Improve science governance through more effective interactions between decision-makers, stakeholders,[19] and scientists that support science-based management decisions and increased awareness of how people value, use, and depend on natural resources.
2. **Coordinate and integrate Delta science in a transparent manner**—Implement shared approaches for organizing and integrating ongoing scientific activities to promote long-term planning and efficient use of emerging knowledge and technology.
3. **Enable and promote science synthesis**—Improve existing collaborative mechanisms and increase capacity to conduct strategic syntheses of existing data to provide the best available science[20] in support of management and policy decisions.
4. **Manage and reduce scientific conflict**—Employ mechanisms to clarify the nature of conflicts, manage and resolve them, and deliver credible, relevant, and legitimate scientific information in a transparent manner.
5. **Support effective adaptive management**—Plan and implement adaptive management consistent with the Delta Plan's adaptive management framework.
6. **Maintain, communicate, and advance understanding of the Delta**—Support priority research and monitoring needs to advance knowledge of the Delta system, provide forward-looking insights, and increase understanding of the Delta landscape on a watershed scale and as a component of the Bay-Delta estuary.

19. A stakeholder is anyone or any entity who can influence, or will be affected by the issue, set of findings, or action (Sullivan et al., 2006; Murphy and Weiland, 2016).
20. Information and data generated through the application of a transparent and repeatable scientific process for informing management and policy decisions at a given point in time (Sullivan et al., 2006; Murphy and Weiland, 2016). Best available science shall be consistent with the guidelines and criteria found in Appendix 1A of the Delta Plan.

Table 1-1 | Overview of the Delta Science Strategy Documents. Summary comparison of the three guiding documents comprising the Delta Science Strategy: the Delta Science Plan, the State of Bay-Delta Science, and the Science Action Agenda. For more information on the strategy, see pages 6–9.



The Delta Science Plan

PURPOSE

- The Delta science community's guide to "how we do science" to achieve the vision of *One Delta, One Science*
- Identifies the tools, mechanisms, systems, and processes needed to optimize knowledge exchange among the different players in the Delta to gain a holistic understanding of the system

WHAT'S INSIDE

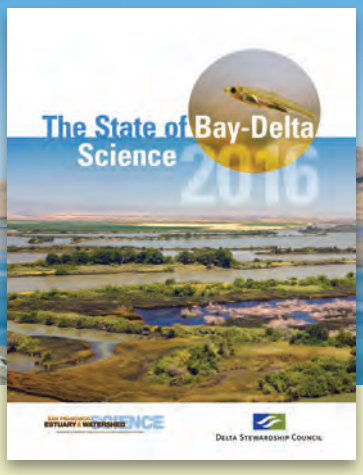
- A set of six shared objectives that collectively achieve the vision of *One Delta, One Science*
- Actions that serve as the tools, mechanisms, systems, and processes to achieve the objectives

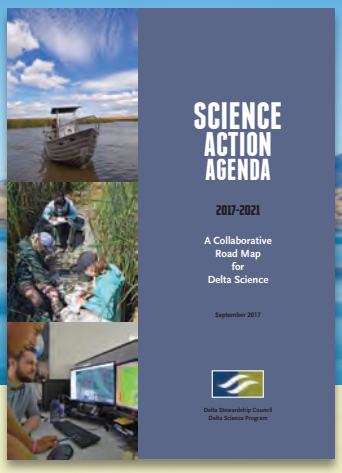
TIME FRAME

- First released in 2013
- Updated every five years to include new scientific concepts and mechanisms that achieve objectives
- Objectives intended to be met over the long term (10+ years)

USES

- Enhances connections between scientists, decision-makers, stakeholders, and the public to marshal support for science infrastructure improvements and usable science
- Provides actions, mechanisms, and tools to include in work plans to promote better coordination and transparency





The State of Bay-Delta Science

PURPOSE

- Synthesizes the current state of scientific knowledge on topics of high management concern in the Bay-Delta and where critical uncertainties remain
- Highlights emerging trends of potential management concern in the future

WHAT'S INSIDE

- Topic-specific and peer-reviewed reports that summarize the scientific understanding of the Bay-Delta and implications for policy and management

TIME FRAME

- First released in 2008, second edition released in 2016
- Updates are ongoing as major insights and information become available

USES

- Provides decision-makers with an overview of the current state of knowledge to support management actions
- Identifies knowledge gaps to guide updates to the Science Action Agenda

The Science Action Agenda

PURPOSE

- Identifies actions that achieve objectives in the Delta Science Plan and address priority management needs
- Science actions are specifically those that require collaborative efforts, identify gaps, and support knowledge advancement
- Identifies emerging science actions needed to inform management

WHAT'S INSIDE

- A list of major science actions and management needs
- Emerging ecological and sociological trends with management implications and associated science actions to support decision-making (for future updates)

TIME FRAME

- First released in 2017
- Updated every four years

USES

- Identifies science topics for proposal solicitation and collaborative science initiatives
- Guides funding decisions
- Guides contents of science work plans and topic specific implementation plans
- Identifies actions that provide knowledge for updates to the State of Bay-Delta Science

Visualizing the collaborative network structure of the Delta science enterprise to inform science governance

COLLABORATIVE SCIENCE GOVERNANCE AND THE SCIENCE ENTERPRISE

Collaborative science governance includes the processes and structures that determine how the science community prioritizes science questions, collectively funds high-priority science activities, carries out these efforts, and communicates the resulting information to decision-makers and other users (Lebel et al., 2005; Raik and Decker, 2007).[21] These structures and processes are intended to engage members of the science community across agency boundaries, universities, organizations, stakeholders, and the public.

Principles of good science governance include (European Commission, 2009; DSC, 2016):

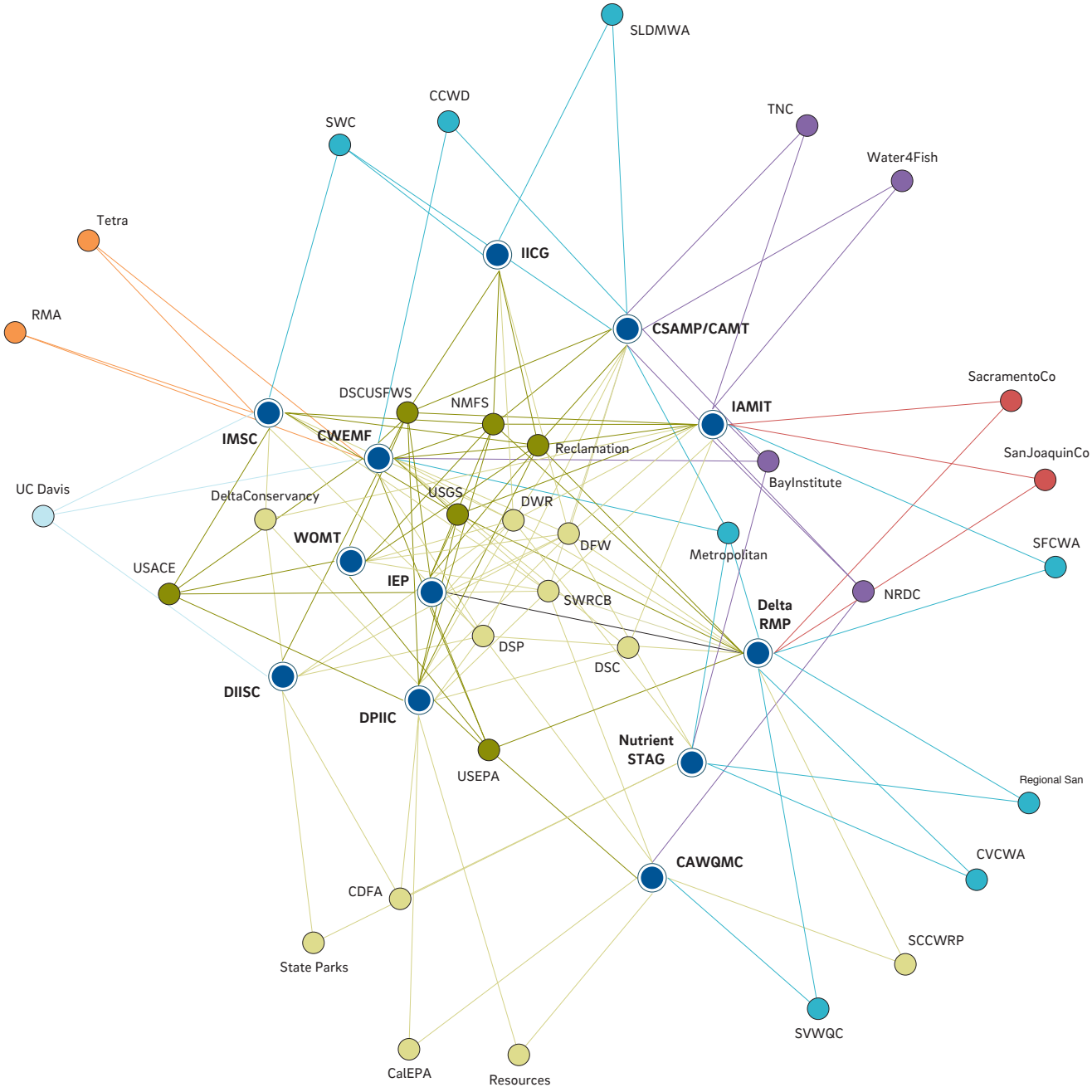
1. Openness and transparency
2. Public participation
3. Accountability clearly apportioned among institutions
4. Effectiveness in achieving goals and objectives
5. Coherence among institutions and policies
6. Clear and measurable goals

Collaborative science governance encompasses both the science enterprise[22] and the interactions among all of the different participants within the enterprise. The importance of the science enterprise and its governance was highlighted in the recommendations from the 2016 Science Enterprise Workshop,[23] which focused on improving science funding, management, and communication in the Delta.

VISUALIZING THE DELTA SCIENCE ENTERPRISE

Funding and identifying needed science efforts across a complex community like that in the Delta requires a broad understanding of the relationships within the science enterprise. A landscape-scale awareness allows for better coordination and funding of science activities that address resource management decisions at a regional scale. Social network analysis helps in understanding such a complex system. Figure 1-1 is a network map generated in response to a need to better understand collaborative interactions among organizations in the Delta. The network map showcases the Delta "science-scape," or the system of social organizations that participate in the Delta science enterprise and contribute to collaborative science governance in the Delta. This network diagram is a starting point and focuses on the structure of the relationships. The visualization emphasizes the complexity of the Delta network and highlights the critical need for coordinating communication among these groups. Future analysis will address the nature of these relationships and the processes contributing to decisions across collaborative organizations (e.g. the flow of funding and information). Appendix C has additional discussion on collaborative science governance and the network of organizations and collaborative science venues.

21. One common component of science governance is the "regulation" of science but this is not an aspect of the science governance in the Delta. Instead, the focus is on the coordination, facilitation and communication aspects of science governance.
22. The collection of science programs and activities that exist to serve managers and stakeholders in a regional system.
23. The Science Enterprise Workshop was an effort led jointly by the Delta Stewardship Council and U.S. Geological Survey to better understand how collaborative science is being managed, funded, and communicated in several high-profile ecosystems in the United States. For more information please visit https://mavensnotebook.com/science-enterprise-workshop/



ORGANIZATION TYPE OR VENUE

- **Collaborative Venue**
- Consultant
- Government (Federal)
- Government (General Local)
- Government (State)
- Non-Governmental Organization
- Research
- Water Special District

Figure 1-1 | Network map of collaborative groups in the Delta. This network diagram visualizes the connections between the 12 main collaborative Delta science venues (ringed circles) and all of the organizations (colored circles) that participate in more than one such venue (the "core" network). Colored lines connect each organization to venues they participate in (for a list of acronyms, see Appendix C). The more ties an organization or venue has, the more centrally located they are in the diagram. Appendix C discusses this network and the collaborative Delta science "full" network and further examines venues and participating organizations and how they contribute to collaborative science governance.

What has been achieved so far?

Since the release of the 2013 Delta Science Plan, there has been substantial progress towards the six objectives supporting the vision of *One Delta, One Science.* There have been advances in the scientific understanding of the Delta system, increased coordination throughout the science enterprise, and improved communication to support decision-making. Highlights of these efforts are provided below. Appendix A summarizes the status of each action from the 2013 Delta Science Plan.

Objective 1 | Strengthening Interactions

Several venues have emerged that foster more effective communication among decision-makers, scientists, and stakeholders. These include the Collaborative Science and Adaptive Management Program and associated Collaborative Adaptive Management Team,[24] Nutrient Stakeholder and Technical Advisory Group,[25] and Delta Regional Monitoring Program.[26] Science panels at the Delta Plan Interagency Implementation Committee,[27] biennial Bay-Delta Science and State of the Estuary conferences, the IEP Annual Workshop, and 2016 Science Enterprise Workshop have provided opportunities for interactive discussions between regional directors, agency leaders, and scientists about science and management needs. The 2016 State of Bay-Delta Science[28] and 2017–2021 Science Action Agenda[29] offered additional avenues to distill the scientific knowledge base and to identify critical, management-relevant science actions. Topics from the Science Action Agenda have subsequently been used in multiple research solicitations, while the State of Bay Delta Science has been used by scientists and managers to identify knowledge gaps.

Objective 2 | Coordinating and Integrating Delta Science in a Transparent Manner

The 2013 Delta Science Plan action 4.3.1 called for a summit to explore data sharing and infrastructure needs in the Delta. A data summit was held in 2014 and the ensuing white paper, *Enhancing the Vision for Managing California's Environmental Information* (DSOC, 2015), played an integral part in informing Assembly Bill 1755, the Open and Transparent Water Data Act. Improvements to web-based information tools and data platforms (e.g. California Water Quality Monitoring Council's My Water Quality portals,[30] Bay-Delta Live,[31] EcoAtlas,[32] SacPAS[33]) have improved access to data, while groups such as the Interagency Ecological Program and Bay and Delta Regional Monitoring Programs are working to increase coordination among monitoring groups. The Interagency Ecological Program Data Utilization Working Group has also worked to publish several long-term monitoring datasets on the Environmental Data Initiative website.[34]

Objective 3 | Enabling and Promoting Science Synthesis

Multiple recent synthesis reports and peer-reviewed articles have addressed key Delta scientific and management uncertainties. For example, the 2016 State of Bay-Delta Science provided overviews of multiple management relevant science topics. The Interagency Ecological Program synthesis teams evaluated the fall low-salinity zone (Brown et al., 2014) and produced updated conceptual models for Delta Smelt (IEP MAST, 2015) and Winter-run Chinook Salmon, which played a key role in the development of the Delta Smelt and Sacramento Valley Salmon Resiliency Strategies (CNRA, 2016; 2017). The Delta Stewardship Council recently supported three synthesis papers[35] to inform the amendment to Chapter 4 (Ecosystem Restoration) of the Delta Plan that focused on climate change, ecosystem stressors, and restoration issues for Delta ecosystems. Other collaborative groups including the Delta Nutrient Research Plan Science Work Groups[36] and the Delta Regional Monitoring Program[37] have produced multiple white papers[38] on nutrient effects and nutrient related data synthesis and modeling efforts.[39] Several synthesis workshops have taken place with ensuing synthesis documents spanning topics including invasive aquatic species, contaminants of emerging concern, and effects of stressors on fish species (CMSI, 2016; SWAMP, 2017; Ta et al., 2017).

Objective 4 | Managing and Reducing Scientific Conflict

Independent scientific reviews have played a key role in building trust and credibility regarding the use of science in reports and programs. The Delta Independent Science Board and the Delta Science Program have facilitated multiple reviews of contentious topics. Past reviews facilitated by the Delta Science Program include the Long-term Operations Biological Opinions for the Central Valley Project and State Water Project, and the analytical tools for assessing Yolo Bypass salmon habitat restoration and fish passage project. The Delta Independent Science Board has recently reviewed the Final Environmental Impact Report/ Statement for California WaterFix (Delta ISB, 2017b) and various documents for the State Water Resources Control Board's Bay-Delta Water Quality Control Plan Update. Furthermore, the Collaborative Science and Adaptive Management Program/Collaborative Adaptive Management Team and Delta Regional Monitoring Program provide opportunities for members of both the regulated and regulating communities to come together and collaboratively identify and discuss research and monitoring needs to build a common understanding of the system and inform resource management.

Objective 5 | Supporting Effective Adaptive Management

The value of adaptive management has become increasingly mainstream in restoration and water management discussions in the Delta. The approach is required in the Delta Plan and in the 2008 Delta Reform Act. In response to an action in the 2013 Delta Science Plan, the Delta Science Program established Adaptive Management Liaisons to facilitate incorporation of adaptive management into restoration plans and water management projects in the Delta. Recommendations in the 2016 Delta Independent Science Board's review of adaptive management in the Delta (Delta ISB, 2016) called for increasing flexibility in funding and management decisions for more nimble responses to better support adaptive management. Building on these recommendations, the Interagency Adaptive Management Integration Team has led the development of the Delta Conservation Adaptive Management Action Strategy to provide guidance for implementing adaptive management to support future restoration efforts in the Delta and Suisun Marsh. Other efforts using adaptive management principles include the Nutrient Stakeholder Technical Advisory Group[40] and the Collaborative Science and Adaptive Management Program efforts associated with the Delta Smelt and Salmonid Resiliency Strategies (CNRA, 2016; 2017).

24. https://water.ca.gov/What-We-Do/Science
25. https://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_nutrient_research_plan/public_involvement_stag_meetings/index.html
26. https://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_regional_monitoring/
27. http://deltacouncil.ca.gov/
28. http://stateofbaydeltascience.deltacouncil.ca.gov/
29. http://scienceactionagenda.deltacouncil.ca.gov/
30. https://mywaterquality.ca.gov/index.html
31. https://www.baydeltalive.com/
32. https://www.ecoatlas.org/
33. http://www.cbr.washington.edu/sacramento/
34. https://environmentaldatainitiative.org/
35. https://deltacouncil.ca.gov/accessibility.html
36. https://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_nutrient_research_plan/science_work_groups/
37. https://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_regional_monitoring/
38. https://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_nutrient_research_plan/science_work_groups/index.html#whitepapers
39. https://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_regional_monitoring/reports/
40. https://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_nutrient_research_plan/public_involvement_stag_meetings/#nextstagmtg

Objective 6 | Maintaining and Advancing Understanding of the Delta

In the past five years, several science efforts have contributed information needed to fill critical knowledge gaps, including those identified in the 2017–2021 Science Action Agenda. These include monitoring, research, and synthesis activities supported by the Interagency Ecological Program and research funded by the Delta Science Fellowship program and California Department of Fish and Wildlife's Proposition 1 grant program.[41] In 2018, the Delta Science Program and the California Department of Fish and Wildlife issued a first ever joint proposal solicitation, with over $15 million for Delta research, including funding from the U.S. Bureau of Reclamation. Additionally, models such as the salmon life-cycle model (NMFS, 2017), which is called for in the 2015 High-Impact Science Actions (DSP, 2015), and the Department of Water Resources' mercury cycling model have been instrumental in shedding light on the interactions of multiple ecosystem components (e.g. fish movement, contaminant transport, food web mechanisms) and supporting management actions that can affect these relationships.

What are some remaining challenges?

The Delta science community has taken considerable steps in building trust and working together to address the Delta's many challenges. Below are some areas that, when addressed, will bring the Delta science enterprise closer to meeting the objectives of the Delta Science Plan and providing science support to achieve the coequal goals.

LONG-TERM PLANNING AND FORWARD-LOOKING ACTIONS IN RESPONSE TO CLIMATE CHANGE

Ecosystems are in constant flux, but the rate of change associated with climate change and other large-scale human impacts is extremely rapid and unpredictable. The need to incorporate climate change impacts in restoration plans and other decisions is widely recognized and often required (e.g. Delta Reform Act, Governor Brown's April 2015 Executive Order). However, despite recent efforts such as the Delta Stewardship Council's Climate Change Vulnerability assessment and Adaptation Strategy Project, there is limited incorporation of climate change risks and effects in modeling and restoration planning within the Delta (Delta ISB, 2013). In addition, management decisions tend to focus on urgent, immediate matters, leading to a lack of consideration for longer-term challenges on the horizon (Luoma et al., 2015; Healy et al., 2016; Delta ISB, 2019). To promote long-term planning, there is a need for more research and models on the appropriate time scales that integrate the physical, biological, and social sciences. Investigative science, incorporating experimentation and exploratory methods, is also critical to uncover new insights and anticipate and prepare for large-scale changes. Currently, there are few resources to support this type of forward-looking science.

MORE EFFECTIVE KNOWLEDGE TRANSFER AMONG SCIENTISTS, STAKEHOLDERS, AND DECISION-MAKERS

Communication between scientists and decision-makers continues to be inefficient resulting in reactive and uncoordinated management. Decision-makers need to understand that updated scientific knowledge is essential to properly answer management questions,[42] while those generating scientific information need to effectively communicate the management relevance of their findings. Deliberate and frequent interactions among scientists, stakeholders, and managers are essential to exchange information and to build trust across groups. These are concepts that have been discussed repeatedly at venues including the 2016 Science Enterprise Workshop and science conferences. Forums that offer blueprints for information interchange exist, such as the Collaborative Science and Adaptive Management Program and Interagency Ecological Program Project Work Teams, but there is still need for increased and targeted science

41. https://www.wildlife.ca.gov/conservation/watersheds/restoration-grants

42. In this document, management questions will refer predominantly to more high-level questions posed by natural resource managers (e.g. "how does this variable effect the ecosystem?" as opposed to "when is the best time to treat for specific vectors?").

communication efforts and a widespread, shared understanding of Delta management issues with clear linkages to science activities.

TRANSPARENCY AND COORDINATION

Similar to communication issues, there is still distrust associated with the use and interpretation of scientific data. This underscores the need for greater transparency and coordination within the Delta science enterprise. Coordinated efforts to increase data sharing and organization, peer review, and synthesis will enhance scientific understanding to support collaborative resource management. Of equal importance is identification of the science needed to fill gaps to resolve disagreements and reduce ambiguity in policymaking discussions.

IMPORTANCE OF THE SOCIAL SCIENCES

The human values of the Delta as a place and the social and economic processes that underlie these values need to be better understood (Delta ISB, 2017a). These values can play an important role in constraining potential management actions even when there is strong scientific consensus. Modeling efforts should integrate socio-economic parameters, and research is needed to understand interactions among social and economic drivers (e.g. land and water use, cultural values) and environmental dynamics (e.g. native and non-native species, chemical pathways).

COMPREHENSIVE ADAPTIVE MANAGEMENT

In the face of climate change and other drivers of large-scale variability, adaptive management offers an approach to improve solutions and reduce uncertainties in Delta management without delaying action. However, better coordination and integration of adaptive management is needed, as the process is not widely understood nor easily executed (Delta ISB, 2016; Wiens et al., 2017). System-wide support of adaptive management is needed for implementation, while also assessing its limitations (Ebberts et al., 2018). Additional dedicated funding and staff to carry out adaptive management efforts is also needed.

Organization of the Delta Science Plan

The remaining chapters in the Delta Science Plan describe the critical science needs in the Delta. Actions that will achieve the Plan's objectives include new initiatives and continuation of existing efforts. Each of the four thematic chapters provide background information and boxes that highlight "Efforts to Build On." These existing efforts are included as examples and are not comprehensive. For each action, the primary responsibility (i.e. facilitating or leading) and action participants (i.e. joint development or implementation responsibilities) are identified. Table E-1 provides a summary of actions identified in this document and the objectives they address.

CHAPTER 2:

Shared Mechanisms to Inform Policy and Management

Effective policy-science interactions require early engagement, continuous dialogue, learning each other's language, and embracing opportunities to develop and use best available science.

This chapter identifies mechanisms and tools to support regular and effective interactions among decision-makers, scientists, and stakeholders to provide a holistic understanding of the shared needs within the Delta system. Collectively, the actions in this chapter aim to identify connections among ongoing efforts, highlight where both coordination and collaboration can fill gaps, and strengthen a shared understanding of the Delta.

Develop guidelines to improve policy-science interactions

Alhough many collaborative efforts exist in the Delta involving the management, science, and stakeholder communities (see Efforts to Build On), there are no shared processes across venues to communicate expectations and link scientific knowledge to management issues. More science co-production is needed, where decision-makers, scientists, and stakeholders work collaboratively to identify management issues and brainstorm research questions and strategies for the appropriate use of science (Beier et al., 2017). Continued and expanded interactions at the policy-science-management interface will result in a common understanding of management expectations and to what extent science efforts can address them.

EFFORTS TO BUILD ON:

- Delta Plan Interagency Implementation Committee/ Delta Agency Science Workgroup
- Collaborative Science and Adaptive Management Program/ Collaborative Adaptive Management Team
- Interagency Ecological Program Directors, Coordinators, and Science Management teams
- The 2016 Science Enterprise Workshop
- Delta Nutrient Research Stakeholder Advisory Group
- Delta Regional Monitoring Program
- San Francisco Estuary Partnership's Estuary Blueprint

ACTION

2.1 | Develop guidelines and best practices for policy-science forums

These guidelines will present best practices to identify scientific uncertainties, prioritize management questions, and facilitate exchange among programs and entities to promote science communication among decision-makers, scientists, and stakeholders. These guidelines should build on lessons learned from past discussions on policy-science forums[43] and recommendations from the white paper, *Funding Science to Meet Tomorrow's Challenges.*[44]

Primary Responsibility: Collaborative Science and Adaptive Management Program/Collaborative and Adaptive Management Team, Interagency Ecological Program[45]

Action Participants: Delta Science Program, Delta Plan Interagency Implementation Committee, Delta Agency Science Workgroup,[46] Delta Nutrient Stakeholder and Technical Advisory Group, Delta Regional Monitoring Program, academic and agency scientists, and agency directors and coordinators with an interest in facilitating knowledge exchange among scientists and decision-makers, local and regional stakeholders

Align research with management needs

Although many challenging management issues exist in the Delta, some issues are not addressed because they are not clearly defined, fall outside the mission and goals of any single entity, or cannot be easily tracked. The Science Action Agenda was developed to provide a common agenda for needed and collectively identified, management relevant science actions (see pages 6–9 and Appendix D). In this way, the Science Action Agenda serves as a tool to bring the Delta science community together to jointly tackle complex and cross-cutting science issues. Actions identified in the Science Action Agenda should be used to guide integrated science planning and funding. Future updates will include a focus on emerging issues to promote more forward-thinking planning and proactive approaches to addressing these issues.

ACTION

2.2 | Update and continue to implement the Science Action Agenda

Update the Science Action Agenda in 2021 using inclusive processes to identify critical science activities across agencies and programs that address key management challenges and better prepare for those in the future (see Appendix D). The Science Action Agenda identifies high-level science needs while also serving as a starting point for developing detailed and integrated science work plans to address more focused topics, which will be described in Chapter 5.

Primary Responsibility: Delta Science Program, Delta Agency Science Workgroup

Action Participants: Wider Delta science community

Summarize the current state of scientific knowledge and implications for management

Clear communication of scientific understanding is essential to ensure the best available science is used in management decisions and that future research targets priority knowledge gaps. The State of Bay-Delta Science is a publication intended to inform science and policy audiences about current scientific understanding of the Bay-Delta system. The effort is an important piece of the overall synthesis effort with an emphasis on strengthening the linkages between policy and science (see Chapter 3). The 2008 book (Healey et al., 2008) and 2016 collection of papers[47] that form the recent State of Bay-Delta Science provide updates on a wide range of topics, highlight important innovations that develop and support the advancement of knowledge, and identify key remaining questions for Delta science.

ACTION

2.3 | Regularly update and publish the State of Bay-Delta Science

The next edition will include a strong focus on communicating effectively to a wide audience to promote shared understanding across decision-makers, scientists, and stakeholders of the state of science and knowledge in the Bay-Delta system (Appendix E). See Chapter 3 for additional discussion on science synthesis and communication.

Primary Responsibility: Delta Science Program

Action Participants: Delta Plan Interagency Implementation Committee, relevant experts and stakeholders

43. E.g. suggestions from the Delta Science Program's Science Advisory Committee.
44. https://deltacouncil.ca.gov/accessibility.html
45. This includes the agencies that are part of the Interagency Ecological Program.
46. Science managers appointed by the Delta Plan Interagency Implementation Committee to provide guidance in implementing Delta Science Plan actions including the Science Action Agenda.
47. http://stateofbaydeltascience.deltacouncil.ca.gov/

Support effective communication of scientific information

Often, important scientific information is underutilized due to ineffective communication. Several factors contribute to this challenge—reports can be too technical and not directed to the right audience, or web-based channels may be difficult to navigate or have inadequate visibility. A more coordinated approach to science communication is needed so that scientists, decision-makers, stakeholders, and the public become aware of important information on the Delta. In addition to continuing and improving the broad range of existing communication avenues, novel approaches to science communication should be explored. Existing and new approaches include print and online publications, conferences and related forums, a wide range of social media, and other educational efforts (see Appendix F).

EFFORTS TO BUILD ON:

- Scientific conferences (e.g. Bay Delta Science and State of the Estuary Conferences)
- Essays in journals (e.g. San Francisco Estuary and Watershed Sciences)
- Exploring digital communication technologies and increasing use of social media
- Forming partnerships with museums, academia, and the media to showcase the Delta and increase public awareness around the State

ACTIONS

2.4 | Develop, compile, and share methods for science communication to leverage existing efforts

Establish a publically accessible repository of existing science communication methods from agencies and entities involved with the Delta and beyond. The goal of the repository is to identify effective communication strategies for different audiences and allow individual groups to compare their efforts and adopt improved science communication methods.

Primary Responsibility: Delta Science Program

Action Participants: Communication experts, federal, state, and local agencies, interagency groups (e.g. Interagency Ecological Program and California Water Quality Monitoring Council), academic science programs, other science programs, non-governmental organizations, and professional societies

2.5 | Support and enhance communication efforts and tools

Continue efforts such as symposia, "brown bag seminars," and web outreach to bring together decision-makers, scientists, stakeholders, and the public to discuss current and future science and management issues in the Bay-Delta. Improve web search visibility and provide training for interactive web-based visualization tools. Provide opportunities for community feedback including surveys and other assessment methods to learn whether these tools and strategies are useful and to identify areas for improvement.

Primary Responsibility: Delta Science Program, State Water Resources Control Board, and academic science programs

Action Participants: Federal, state, and local agencies, members of the public, private, and nonprofit organizations

2.6 | Support opportunities for training that enhances science communication skills of Delta scientists

Encourage and provide opportunities (including financial support) for scientists and staff to attend science communication training programs, workshops, and obtain guidance from communication experts.

Primary Responsibility: All science programs and divisions in the Delta

Action Participants: All science programs in the Delta

Ensure the quality and integrity of science used in decision-making

The independent scientific peer-review and advice process plays a critical role in ensuring the quality and integrity of science in the Delta. Qualified experts are called upon to objectively review a contentious issue or product or to provide advice at key points in the process of applying science to decision making. Entities that facilitate or provide scientific peer review and advice in the Delta include the Delta Science Program, the Delta Independent Science Board, and the National Research Council. The Delta Science Program has taken a leadership role in coordinating independent scientific review and advice for programs, plans, processes, and individual reports (see Appendices H and I). The Delta Independent Science Board provides periodic reviews, as defined in statute of the "scientific research, monitoring, and assessment programs that support adaptive management of the Delta" (Water Code section 85280 (a)(3), also see Appendix G of this document). Upon request, the National Research Council has been asked to review issues with broad implications for natural resource management (NRC, 2011; 2012).

EFFORTS TO BUILD ON:

- Delta Science Program policy and procedures for independent scientific review
- Delta Science Program policy and procedures for independent scientific advice
- Delta Independent Science Board reviews
- National Academy of Science's review approach and role

To be most effective, build trust, and ensure high-quality scientific information is incorporated into the decision-making process, peer review and advice must be conducted in an objective, rigorous, and transparent way. This requires deliberate and careful evaluation of each step in the process, something that can be a challenge to provide in a consistent and timely manner.

ACTION

2.7 | Ensure consistent application of scientific peer review and independent science advisors

Seek broad support for the use of a well-defined and transparent process for conducting scientific peer review and scientific advice that is consistent across programs and can be applied to research, planning, and management documents in the Delta. Appendices H and I provide the policies and procedures the Delta Science Program uses to ensure high-quality independent scientific review.

Primary Responsibility: Delta Science Program

Action Participants: Delta Independent Science Board, federal, state, and local agencies, stakeholders, collaborative groups, and academia

CHAPTER 3:

Modernize, Integrate, and Build the Delta Science Infrastructure

Science that effectively informs policy and management decisions is built on a foundation of monitoring, research, data management, models, synthesis, and communication.

These fundamental elements comprise the "science infrastructure" necessary to understand local Delta functions, and how the Delta relates to broader watershed and estuarine dynamics. This chapter addresses efforts to improve science infrastructure and necessary additions to modernize this system. A well-functioning science enterprise must be able to respond quickly to, and learn from unexpected events (e.g. new non-native species, extreme climatic events) and address large-scale challenges such as climate change. Such rapid response and flexibility requires that all elements of the science enterprise be organized and linked to promote efficient transfer from data generators to decision-makers and the broader public (see Chapter 2 for supporting mechanisms).

Modernize science infrastructure to meet current and future needs

Rapid advances are needed in how we collect and analyze information about the environment to provide timely information to decision-makers. In addition to technological issues, there is also a growing recognition (and thus a modernization to our thinking) that socio-economic and political elements are critical factors in resource management. Early and continuous inclusion of social scientists in Delta planning, research, and prioritization efforts will help increase the appreciation of how human values are directly linked to environmental processes and management actions. The importance of integrating social science to promote effective resource management has been a topic of discussion at numerous venues including the 2016 Science Enterprise Workshop and a focus of the Delta Independent Science Board's review of research on the Delta as an Evolving Place (Delta ISB, 2017a).

ACTIONS

3.1 | Host a summit to identify useful emerging data science and technology[48]

Bring together international experts to demonstrate the value of incorporating emerging data science methods, technology, and techniques in research and monitoring to improve understanding and management of water use and supply, water quality, ecosystem dynamics, and climate change related impacts. Information generated at the summit will support initiatives linked to Assembly Bill 1755 (the Open and Transparent Water Data Act[49]), innovations in knowledge discovery, and management.

Primary Responsibility: Delta Science Program, California Department of Fish and Wildlife, California Department of Water Resources, California Natural Resources Agency, California Water Quality Monitoring Council, California Technology Agency, State Water Resources Control Board

Action Participants: California Council of Science and Technology, Delta Conservancy, Delta Regional Monitoring Program, Interagency Ecological Program, U.S. Bureau of Reclamation, U.S. Geological Survey, other federal, state, and local agencies and programs responsible for managing environmental data and advancing knowledge discovery, academia, consultants, and non-governmental organizations

3.2 | Establish a social science task force and a strategy to engage and integrate social science research in the Delta.

The Social Science Task Force[50] will develop a strategy with recommendations for the Delta science community to engage social science researchers and strengthen integration with the natural sciences. The strategy will identify critical steps to establish and integrate social

science research to address complex questions in the Delta, improve stakeholder and management processes, and guide effective decision-making processes that consider tradeoffs when distributing limited resources among human uses and ecosystems. These recommendations will provide a foundation for strategic plans and future competitive research solicitations, and guide future updates of the Delta Science Plan and the Science Action Agenda.

Primary Responsibility: Delta Science Program, any interest groups involved in or working on social science issues in the Delta

Action Participants: Delta Protection Commission, Delta Conservancy, Delta Independent Science Board, Collaborative Adaptive Management Team, Delta Plan Interagency Implementation Committee, Delta Regional Monitoring Program, Interagency Ecological Program, and other policy and management leaders in the Delta

Enhance and integrate the monitoring enterprise

Delta monitoring[51] programs provide data[52] and information[53] on a wide range of management topics. Most of these monitoring programs were established as regulatory requirements and generate long-term monitoring datasets. These data are important for adaptive management, help distinguish long-term trends from short-term variability, and provide critical insights for current and future management issues (Delta ISB, 2013; Cloern, 2018). However, there has been limited evaluation of whether these programs efficiently provide the suite of information needed for current management uncertainties. In its review of water quality science, the Delta Independent Science Board noted "collaboration among agencies conducting monitoring in the Delta is neither systemic nor well organized" (Delta ISB, 2018b). The Delta is also not an isolated system; it connects physically, ecologically, sociologically, economically, and politically to a broad geographic area from the upper watershed to the Golden Gate.

The 2013 Delta Science Plan called for a comprehensive Delta monitoring strategy to facilitate an integrated watershed program. This need has also been expanded upon in the most recent Interagency Adaptive Management Integration Team white paper. While increased geographic coordination is critical, an important first step is to assess the design of Delta monitoring efforts at sufficient detail to evaluate their management relevance and any need for updates. Such an assessment would improve current monitoring programs and ensure efficient use of resources. The next steps would be to identify opportunities for integrating monitoring programs across the Delta with networks in the upstream watershed and downstream in the San Francisco Bay.

EFFORTS TO BUILD ON:

- California Water Quality Monitoring Council
- Delta Independent Science Board's review of the Delta Monitoring Enterprise
- Delta Independent Science Board's review of water quality science in the Delta
- Delta Regional Monitoring Program
- Interagency Ecological Program
- San Francisco Bay Regional Monitoring Program
- Surface Water Ambient Monitoring Program
- Wetland and Riparian Area Monitoring Plan
- Sacramento and Central Valley Chinook Salmon monitoring efforts

48. Whether this will be a reoccurring event will be based on the outcomes of the first summit, which is currently in the early planning stages as this document is being published.
49. https://water.ca.gov/Programs/All-Programs/AB-1755
50. http://deltacouncil.ca.gov/delta-social-science-task-force
51. The term "monitoring" covers a wide variety of sampling, analysis, measurement, and survey activities that reveal ecological, physical, social, and economic conditions and trends.
52. Data is defined in this document as recorded symbols (e.g. words, numbers, and images) and sensory readings that capture a set of facts about an event (Liew, 2007). Examples include measures of precipitation, flow, and population abundance.
53. A message with relevant meaning used to make decisions, solve problems, or realize an opportunity.

ACTIONS

3.3 | Routinely evaluate monitoring programs in the Delta to identify gaps, redundancies, and management relevance

Building on recommendations in the the white paper *Funding Science to Meet Tomorrow's Challenges* (funding initiative paper) and using the Delta Independent Science Board's review of the Delta monitoring enterprise and the Interagency Ecological Program's current and past programmatic reviews[54] as blueprints, implement a formal process to identify high-priority monitoring gaps, opportunities to coordinate and leverage monitoring resources, and linkages between monitoring efforts and water and ecosystem management questions. Evaluation of monitoring efforts to address social characteristics of the Delta, such as insight on risks (e.g. human health, environmental hazards), habitat, and sense of place will also be critical for effective decision-making and tracking programmatic outcomes (Delta ISB, 2017a).

Primary Responsibility: Interagency Ecological Program, California Water Quality Monitoring Council and its workgroups, Delta Regional Monitoring Program

Action Participants: Delta Science Program, Delta Independent Science Board

3.4 | Develop a working group to facilitate monitoring program coordination and integration

Based on the outcomes of the evaluations above, establish an interagency working group to improve program coordination and integration of efforts in the Delta, the watershed, and the Bay. The workgroup should identify: mechanisms to maintain feedback loops between data users and data collectors to ensure management-relevant data is gathered, opportunities for instrument co-location, establishment of shared sampling protocols, development of coordinated calibration efforts, and approaches for maintaining and updating current programs. Existing documents to utilize include the California Water Quality Monitoring Council's statewide strategy (CWQMC, 2010), the Delta Conservancy's Monitoring Compendium, Interagency Adaptive Management Integration Team white paper, and emerging system-wide efforts (e.g. salmon and sturgeon monitoring and modeling, see Heublein et al., 2017; Windell et al., 2017).

Primary Responsibility: Interagency Ecological Program, California Water Quality Monitoring Council and its workgroups, Delta Regional Monitoring Program

Action Participants: Delta Science Program, Delta Conservancy, Delta Independent Science Board

Support Research

Effective ecosystem management hinges on robust scientific understanding of underlying processes and the ability to address cause-effect relationships underlying uncertainties. Current research efforts in the Delta are inadequately funded and lack coordination; with these constraints, they do not generate sufficient information to inform current decision-making needs. Continued advances in new scientific discoveries and a longer time horizon for science are needed to address growing management challenges, such as climate change, non-native species, and water supply reliability (Delta ISB, 2019).

ACTION

3.5 | Establish sustainable funding for forward-looking science

Implement recommendations from the funding initiative paper and adopt the coordinated strategies, which will be discussed in Chapter 5, to expand the capacity to conduct research. Support should be provided to research that explores current management priorities as well as emerging issues and new technologies, which may be risky to implement but, could "fast-forward" scientific knowledge. Funding should include resources for staff scientists, and the tools and facilities needed to conduct research. Implementing mechanisms identified in Chapter 2 to co-produce science will ensure the scientific information will address a range of critical management needs.

Primary Responsibility: California Department of Fish and Wildlife, Delta Science Program,

Action Participants: Delta Nutrient Research Program, Interagency Ecological Program, and other science programs of federal, state, and local agencies, and non-governmental organizations

Improve the organization and accessibility of scientific data and information

In 2014, a summit was convened in response to an action in the 2013 Delta Science Plan to identify data sharing needs. The ensuing report, *Enhancing the Vision for Managing California's Environmental Information* (DSOC 2015),[55] served as a foundational document for Assembly Bill 1755.[56] Although passage of this Bill was an important step for improving data accessibility,[57] data management efforts still do not match the complexity and growing magnitude of Delta management issues (Delta ISB, 2018b). Other elements of the data lifecycle (Figure 3-1) need to be addressed so that data collected in the Delta yields useful and usable information[58] for decision-makers.

Additional challenges include access to scientific information in journal articles, software, and other proprietary technologies. Improving access to information and technology helps to ensure the most relevant and timely information are used for synthesis and decision-making and enables data sharing among agencies, institutions, stakeholders, and the public.

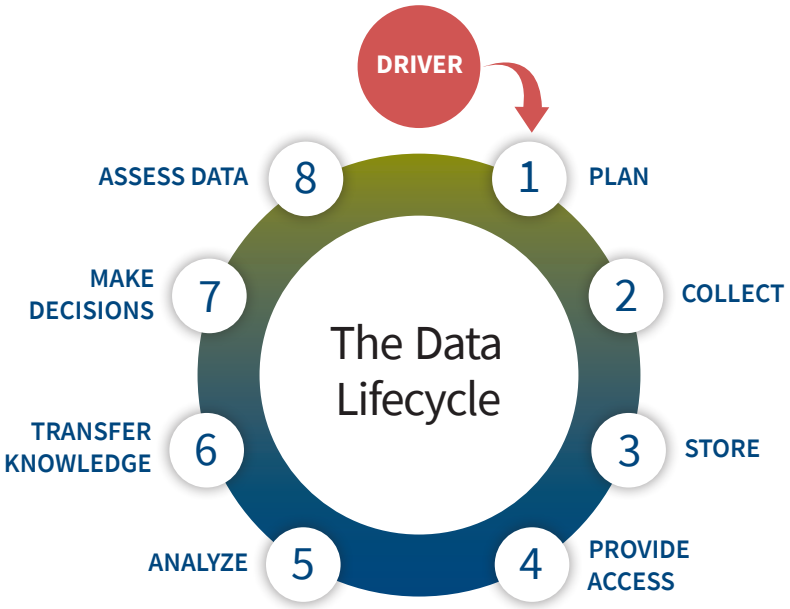


Figure 3-1 | Major steps involved the data lifecycle.[59] A management action or a hypothesis drive the data lifecycle. While the eight steps present a natural progression, the process is not always linear and feedback loops can be important. The eight steps consist of (1) Plan: identify the type of data needed, how they will be collected, managed, and made accessible; (2) Collect: gather observations and apply checks and inspections to ensure quality of the data. Collection methods may change over time to address the same driver; (3) Store: submit data (and meta-data that include a description of data quality) to an appropriate long-term archive; (4) Provide access (AB 1755 focus): make data accessible to external users to inform various purposes including decision-making and learning; (5) Analyze: combine data from disparate sources to form one homogeneous data set and analyze together; (6) Knowledge transfer: communicate results using interactive maps, graphs, dashboards, etc.; (7) Make decisions: base management decision on knowledge gained through the data cycle; and (8) Assess data: ensure that data collection continues to provide relevant information.

54. This includes the ongoing programmatic review of phytoplankton monitoring and past reviews such as the Interagency Ecological Program's Science Advisory Group review of the Delta Juvenile Monitoring Program in 2013–2014.
55. The data summit and white paper fulfill actions 4.3.1 and 4.3.2 of the 2013 Delta Science Plan, respectively.
56. Assembly Bill 1755, passed in 2016, requires the Department of Water Resources, in consultation with the California Water Quality Monitoring Council, the State Water Resources Control Board, and the California Department of Fish and Wildlife, to "create, operate, and maintain a statewide integrated water data platform; and to develop protocols for data sharing, documentation, quality control, public access, and promotion of open source platforms and decision-support tools related to water data."
57. By "accessible," the information is not only easily obtainable but the availability of the information is widely known, and the user is able to understand what the information means.
58. Information is a message with relevant meaning used to make decisions, solve problems, or realize an opportunity. Information can come from processed data but can also come from other forms of communication such as instructions (Liew 2007).
59. Gearhart, 2018 personal communication, Martorano, 2018 personal communication, DataOne.

ACTIONS

3.6 | Develop a shared framework that broadly addresses the data lifecycle to support the goals of Assembly Bill 1755 and beyond

Collaboratively establish a framework that incorporates common standards and protocols for data collection, data quality assessment, data storage, and data access so that data available through the planned Assembly Bill 1755 federated platform[60] will be useful in supporting regulatory and management decisions. Ensure existing online databases and web-based data storage systems that contribute to the federated platform (e.g. datasets hosted by the Office of Emergency Services, Reclamation Districts, and farmers) are well maintained, routinely updated, visible, accessible, and meet user needs. Strategies should consider benefits and mechanisms of incorporating these databases into the federated AB 1755 platform.

Primary Responsibility: Agencies and organizations involved in supporting Assembly Bill 1755 (e.g. California Water Quality Monitoring Council, Department of Water Resources, State Water Resources Control Board, Department of Fish and Wildlife)

Action Participants: Delta Science Program, data users and generators from federal, state, and local agencies, programs responsible for managing environmental data related to the Delta, academics, consultants, non-governmental organizations, and invited experts in the field of data management

3.7 | Promote accessibility to peer-reviewed scientific literature, data, and tools

Develop strategies for improving access to the latest scientific information for agency scientists and the public. This includes data and software as well as access to journal articles. Ensure that research funded by the State include requirements and incentives (e.g. additional funds) for open source[61] licensing and publishing in open access journals.

Primary Responsibility: California Department of Fish and Wildlife, Delta Conservancy, Delta Science Program, agencies and entities with active research grant programs

Action Participants: Delta Science Program, Central Valley Flood Protection Board, California Department of Water Resources, U.S. Bureau of Reclamation, U.S. Geological Survey, U.S. Fish and Wildlife Service, and academia

Build a collaborative modeling community

Models are integral to Delta science and adaptive management, but their development and application has occurred with limited coordination across projects. In some cases, separate divisions have developed and implemented different stages of individual models with little communication between groups. This fragmented approach reduces transparency and understanding of model applications, resulting in unnecessary duplication of efforts. These factors ultimately promote conflict over conclusions and mistrust of models by decision-makers (Medellín-Azuara et al., 2017). As recommended by the Delta Independent Science Board's review on Flows and Fishes (Delta ISB, 2015) the 2016 Science Enterprise Workshop, and other efforts, more collaborative[62] approaches are needed with a focus on integrated modeling, forecasting (including climate change scenarios), and incorporating uncertainty and risk assessment.[63] These efforts should leverage technical expertise and resources of participating groups and promote open information sharing (DSC, 2016), similar to collaborative efforts in other regions, such as the Chesapeake Bay Modeling Workgroup (Box 3-1). Improved communication and coordination will increase appreciation and understanding of models, and improve efficient use of limited resources.

EFFORTS TO BUILD ON:

Local Efforts

- Bay-Delta Structured Decision Making team and related efforts
- California Water and Environmental Modeling Forum
- Integrated Modeling Steering Committee

External Efforts

- Chesapeake Bay Modeling Workgroup
- Louisiana Coastal Master Plan Modeling

BOX 3-1

EXAMPLE OF SUCCESSFUL COMMUNITY MODELING EFFORTS

The Chesapeake Bay Program Modeling Workgroup provides the Chesapeake Bay Program (CBP) with "state-of-the-art decision-support modeling tools that are built through community and participatory principles." These principles include integrating and applying the best available science to support independence, embracing innovation, and committing to an open and transparent process. "[The] integrated models assess effects of current and proposed watershed management on changes in nutrient and sediment loads delivered to the Bay and the effect those changing loads have on water quality and living resources. The CBP models assist CBP decision-makers in estimating the collective actions needed to achieve federal and state water quality standards necessary to restore the Bay."

https://www.chesapeakebay.net/who/group/modeling_team

60. A centralized system that gathers multiple data repositories. The source databases remain unmodified.
61. Open source is any software, project, and/or products, that people can inspect, modify, enhance, and share because its design is publically accessible (https://opensource.com/resources/what-open-source).
62. "Collaborative modeling" means the modeling community comes together to jointly identify issues and work towards developing tools to address these issues using an iterative process that involves effective communication at all levels (Wright et al., 2016).
63. Integrated modeling involves linking models that represent different parts of a system (e.g. physical, social, biological) to allow a more holistic understanding and provides insights on how an action can have potential cascading effects on other elements of the system (Carpenter et al., 2009; Peters, 2010).

ACTIONS

3.8 | Develop and implement a strategy to grow the collaborative modeling community

Building on the Integrated Modeling Steering Committee's[64] efforts, the objectives of the strategy should be to 1) facilitate a collaborative approach to integrating existing physical, biological, and social models for the Delta, 2) more effectively articulate model capabilities and outputs to decision-makers, and 3) identify approaches to sustainably fund these efforts. The strategy should emphasize the importance of data sharing protocols and provide guidance to improve feedback loops between data collectors, model developers, and end users of the model outputs (Figure 3-2).

Primary Responsibility: California Water and Environmental Modeling Forum, Integrated Modeling Steering Committee, Delta Nutrient Research Program, Delta Regional Monitoring Program, Delta Science Program, San Francisco Bay Nutrient Management Strategy

Action Participants: All parties interested in or who participate in data collection, analysis, and modeling

3.9 | Support high-priority[65] model development across agencies and programs

Foster the development of interdisciplinary and inter-institutional clusters of scientists around model themes (e.g. CASCaDE project[66]), encourage efficient community model development through shared tools and other recommendations from the strategy in Action 3.8, and ensure continuity of support for these initiatives. Mechanisms to promote high-priority models include proposal solicitations, fellowships, workshops, and conferences. Of equal importance are efforts to evaluate the utility of recent and historical datasets to provide benchmarks for model calibration and validation.

Primary Responsibility: California Water and Environmental Monitoring Forum, Integrated Modeling Steering Committee, Delta Science Program

Action Participants: All parties interested in or who participate in data collection, analysis, and modeling

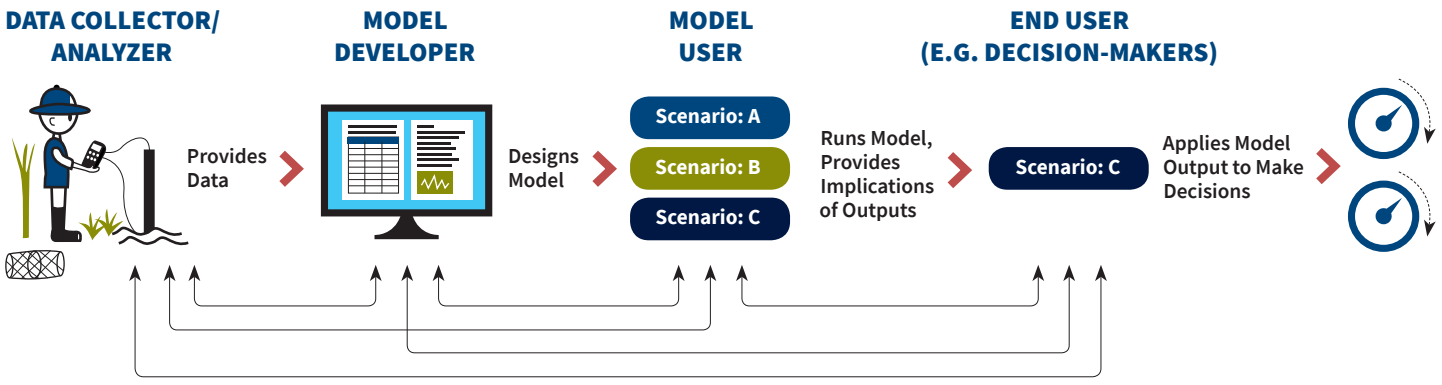


Figure 3-2 | Conceptual model of a collaborative modeling community. Feedback loops (slim arrows) both between and within groups are critical to strengthen coordination and reduce redundancies. This includes communication among modelers of different disciplines and among modelers and data users to facilitate the translation of needs and information. This process is integral to supporting structured decision making.

64. The Integrated Modeling Steering Committee, an effort led by the Delta Science Program, was established in response to the need for a collaborative modeling community and the use of integrated models in the Delta. The Integrated Modeling Steering Committee charge is to develop a detailed strategy and plan for integrating Delta ecosystem modeling that will incorporate model developers and model users to support the collaboration and communication needed to make use of models for decision-making in the Delta.

65. Models used to support structured decision-making and answer immediate management questions that need to be addressed in the short-term (1–2 years) or models that have been collectively identified as important and necessary to develop in the short term.

66. Computational Assessments of Scenarios of Change for the Delta Ecosystem is a research project to develop and apply a model-based approach of ecological forecasting to project future states of the Delta ecosystem, and to communicate the outcomes to resource managers. The objectives of this project are to develop and verify a set of models of climate, watershed hydrology, sediments, and water quality, and link these models to forecast how the Delta ecosystem will change.

Guide and support synthesis for system-wide perspectives

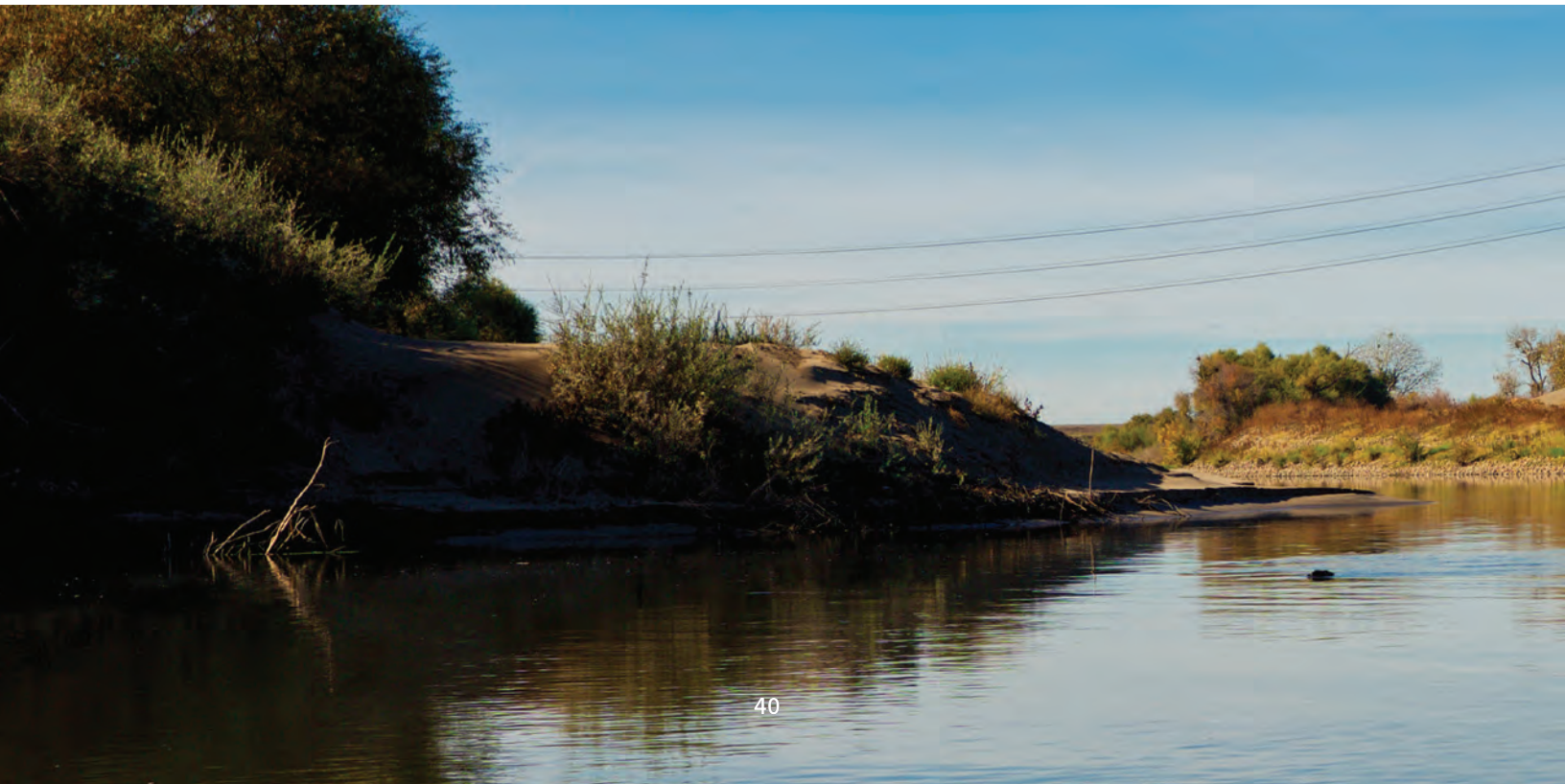
The National Research Council identified integrated synthesis[67] as a key element in the process of understanding the Delta ecosystem and providing useful insights for management actions (NRC, 2011). However, the amount and range of scientific information that exists in the Delta is beyond the capacity of any single agency to consolidate for synthesis. Coordinated synthesis efforts, such as those under the Interagency Ecological Program, have generated useful products (see Introduction for examples), but additional strategies are needed across agencies. Resources for synthesis are also insufficient; the number of positions dedicated to synthesis has grown but remains low, and access to data and modeling tools is limited. Given constraints for synthesis, science staff often work outside their allocated working hours to contribute to synthesis. All of these challenges compromise the timelines of synthesis products.

In addition, many previous synthesis products are technical and lengthy. While this format is useful to scientists and experts, detailed technical reports also need to be distilled into user-friendly management tools (Delta ISB 2015), such as policy briefs and fact sheets. A shared set of processes and protocols is needed to guide synthesis efforts so they are scientifically rigorous, transparent, and available in a timeframe and format that is useful to decision-makers and stakeholders.

EFFORTS TO BUILD ON:

- The State of Bay-Delta Science 2016
- Synthesis products in San Francisco Estuary and Watershed Science
- IEP Management Analysis and Synthesis Teams
- Delta Nutrient Research Plan Science Workgroup white papers
- Delta Regional Monitoring Program synthesis and modeling efforts
- National Center for Ecological Analysis and Synthesis
- Delta Science Program synthesis efforts

67. Scientific synthesis is the act of bringing together complex sets of information that are often scattered among various repositories, reports, and journals, and integrating this information to yield new knowledge, insights, and explanations.



ACTIONS

3.10 | Establish a shared set of best practices and protocols for focused synthesis

Building off the Interagency Ecological Program's Synthesis Framework, the goal of these best practices and protocols should be to accelerate the transfer of scientific knowledge to inform policy and management decisions and reduce science conflict (see Appendix J for an example protocol used by the Delta Science Program for synthesis workshops). Key aspects include formalized engagement with stakeholders and decision-makers to ensure useable and timely products, opportunities for public review of draft documents, and shared strategies for the development and communication of synthesis products.[68] In addition, synthesis efforts should be coordinated across agencies to avoid duplication of efforts.

Primary Responsibility: Collaborative Adaptive Management Team, Delta Science Program, Interagency Ecological Program

Action Participants: Other federal, state, and local agencies, and the Delta Regional Monitoring Program

3.11 | Provide and support opportunities for synthetic thinking across the Delta science and management communities

Train Delta scientists in methods for synthesizing new knowledge and enable partnerships to work on future synthesis projects (e.g. conferences, training workshops, workgroup meetings). Existing venues that provide opportunities to conduct collaborative synthesis include the National Socio-Environmental Synthesis Center,[69] the National Center for Ecological Analysis and Synthesis,[70] and U.S. Geological Survey Powell Center.[71] Job statements and work plans should provide staff scientists with specific time and financial resources (including support for training opportunities) to work on synthesis projects. Providing support in proposal solicitations for synthesis projects is another way to promote such efforts.

Primary Responsibility: Delta Science Program, Interagency Ecological Program Management Analysis and Synthesis Team, and the Collaborative Adaptive Management Team

Action Participants: Delta Regional Monitoring Program, Interagency Ecological Program, State Water Resources Control Board, other federal, state, and local agencies, and academia

68. One source that may provide useful examples is the guidelines for systematic synthesis developed by the Collaboration for Environmental Evidence http://www.environmentalevidence.org/information-for-authors.
69. https://www.sesync.org/
70. https://www.nceas.ucsb.edu/
71. https://powellcenter.usgs.gov/

CHAPTER 4:

Support Effective Decision-Making Through Science-Based Adaptive Management and Decision Support Tools

Adaptive management is a science-based strategy for making management decisions under uncertain conditions rather than delaying action until more information is available

(Holling, 1978; Westgate et al., 2013; Wiens et al., 2017). The process is a form of structured decision making[72] with a focus on continuous and iterative processes (Williams, et al., 2009). The iterative approach allows critical management uncertainties to be addressed in an organized manner with continuous learning. Outcomes of this approach are more efficient use of resources for individual projects and more effective implementation of future efforts. A high degree of coordination and collaboration, information accessibility, dedicated and formalized use of decision-support tools,[73] and clear communication among all parties at each step is all integral to effective adaptive management (Figure 4-1; Wiens et al., 2017; Ebberts et al., 2018).

EFFORTS TO BUILD ON:

Local Efforts

- Delta Conservation Framework
- Interagency Adaptive Management Integration Team Delta Conservation Adaptive Management Action Strategy

External Efforts

- Glenn Canyon Adaptive Management Program
- Missouri River Science and Adaptive Management Plan
- Columbia River Estuary Ecosystem Restoration Program

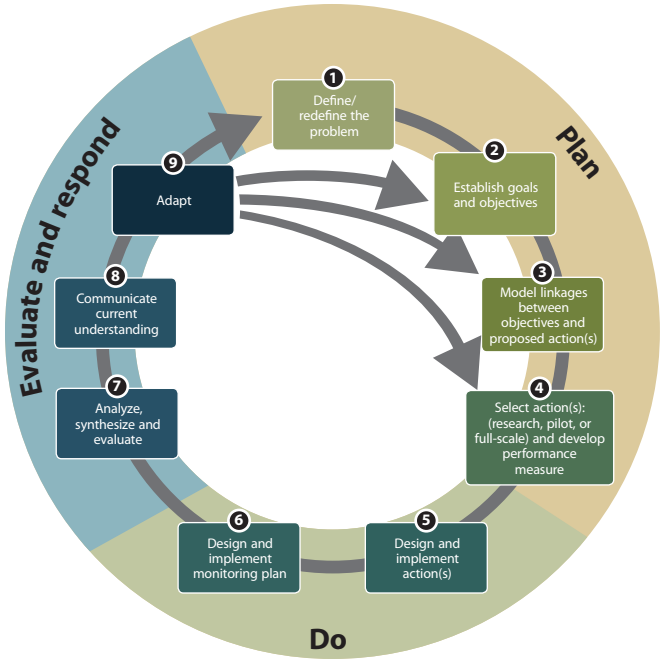


Figure 4-1 | Delta Plan's nine-step Adaptive Management Framework.

72. Structured decision-making is a systematic approach to understanding and assessing a set of problems. Management actions (alternatives) are explicitly linked to well-defined, quantifiable objectives through models that incorporate both these linkages and the underlying uncertainty associated with actions and responses. Structured decision-making adds transparency to the decision-making processes in natural resource management by defining a repeatable process. In this way, stakeholders can see what steps are being taken to arrive at a decision. This process is particularly important when decisions lead to less desirable outcomes.

73. Decision-support tools are approaches designed to facilitate making choices among actions that differentially achieve a set of potentially competing objectives. They are usually in the form of interactive software such as models and visualization tools.

Many Delta ecosystem resource planning and policy efforts have adopted adaptive management as the way forward for managing complex natural resource programs and projects—integrating adaptive management in restoration and water management efforts is a regulatory requirement under the 2009 Delta Reform Act and Delta Plan. However, implementation of the full adaptive management cycle remains challenging, especially considering the necessary time frame and spatial scale for management actions to have an effect. The Delta Independent Science Board identified multiple challenges in implementing adaptive management including, lack of resources, limited financial support to incorporate adaptive management, and the need for large-scale acceptance and implementation of the process (Delta ISB; 2013, 2016). This chapter focuses on advancing acquisition of new knowledge in water and ecosystem management through adaptive management. Full implementation of actions in this chapter relies on building the structures and processes identified in chapters 2 and 3 including models, monitoring support, and synthesis.

ACTIONS

4.1 | Implement adaptive management and structured decision-making approaches more fully and consistently in the Delta

Implement adaptive management approaches consistently and in an integrated and coordinated way across the various entities supporting adaptive management in the watershed (e.g. EcoRestore, Interagency Implementation and Coordination Group of the California WaterFix, the Collaborative Adaptive Management Team, and the Interagency Adaptive Management Integration Team). Adaptive management should incorporate experiments into ecosystem restoration and water management projects to test hypotheses and more effectively identify cause and effect benefits of potential actions (Wiens et al., 2017). These efforts should also utilize the guidance documents currently under development to support and communicate science-based strategies consistent with the Delta Plan's adaptive management framework.[74]

Primary Responsibility: Delta Science Program and Delta Stewardship Council Planning Division, EcoRestore Program, federal, state, and local agency staff involved in planning, funding, regulating, or implementing ecosystem restoration projects (including participants of the Interagency Adaptive Management Integration Team), Collaborative Science and Adaptive Management Program and the Collaborative Adaptive Management Team

Action Participants: Federal, state, and local agencies, and organizations involved in planning and implementing adaptive management

4.2 | Provide Adaptive Management Liaisons

Sustain Delta Science Program staff members with expertise in adaptive management and its application in Delta water management and ecosystem restoration projects. Adaptive Management Liaisons provide advice to agencies and organizations that are planning and implementing adaptive management, including but not limited to, Delta Plan covered actions. Adaptive Management Liaisons also provide advice to the Council on quasi-judicial proceedings and appeals of covered actions' certifications of consistency.

Primary Responsibility: Delta Science Program

Action Participants: Delta Science Program staff, federal, state, and local agencies, and organizations involved in planning and implementing adaptive management

4.3 | Convene regular Adaptive Management Forums

Convene regular Adaptive Management Forums with national and international experts and local proponents to provide adaptive management training for a broad range of agency staff and build capacity to plan and implement adaptive management. These forums provide a venue at which participants can discuss adaptive management approaches to ecosystem restoration and water management, share lessons learned from the Delta and elsewhere, and identify potential impediments to adaptive management activities.

Primary Responsibility: Delta Science Program

Action Participants: Federal, state, local agencies, national and international experts on adaptive management, non-governmental organizations, private organizations, and academia involved in implementing adaptive management

74. An example is the Interagency Adaptive Management Integration Team's Delta Conservation Adaptive Management Action Strategy. http://deltacouncil.ca.gov/docs/delta-conservation-adaptive-management-action-strategy-2019

CHAPTER 5:

Collectively Support Implementation of the Delta Science Plan

Collective action by the Delta science community is necessary to achieve the vision of *One Delta, One Science.*

The key participants in the Delta science enterprise must work together to develop effective, science-based approaches to address multiple and often conflicting management goals. This will rely heavily on enthusiasm across the Delta science community, strong leadership, sustainable financial resources, and a technically competent workforce to implement the actions. This chapter identifies processes and strategies to promote joint implementation of the Delta Science Plan.

EFFORTS TO BUILD ON:

Communication and funding strategies employed by:

- Chesapeake Bay Program
- Comprehensive Everglades Restoration Program
- National Ecological Observatory Network
- National Estuaries Program
- Laser Interferometer Gravitational-Wave Observatory

Identify and cultivate resources to support integrated science actions and science infrastructure

Although the Delta Plan calls for the Delta Science Plan, it does not identify financial support to implement actions within the Science Plan. The Delta science community will need to develop a case for consistent funding and engage political leaders to champion institutional change and spark further collective action to support science to address ongoing management challenges in the Delta. A forward-looking strategy to address climate change impacts and other emerging challenges will be essential and will require greater coordination and institutional capability (Delta ISB; 2013, 2019).

While the Delta Science Plan provides principles for collaborative science and the Science Action Agenda identifies key management-relevant science actions, the Delta science community recognizes the importance of identifying more specific science activities and creating coordinated and detailed implementation plans that nest within the broad vision of these guiding documents. Efforts have been underway to develop implementation plans for some science topics; however, resources for development and coordination of these plans are lacking.

ACTIONS

5.1 | Establish shared mechanisms and processes to enhance science funding

This collaborative approach requires the Delta science community to speak with one voice, articulate critical science needs and their benefits, and clearly document current allocations of science funding to justify the need for increased financial resources for science activities. Recommendations from the white paper, *Funding Science to Meet Tomorrow's Challenges,* will provide a good starting point for this effort, with the specific objectives for developing standardized accounting mechanisms, evaluating research and monitoring efforts to ensure they support current and future management needs, and identifying opportunities to leverage resources to support research to inform decision-making. Appendices K and L also provide examples of funding processes used by the Delta Science Program and conflict of interest policies that promote transparent and open process to support science in the Delta.

> **Primary Responsibility:** Delta Agency Science Workgroup, Delta Plan Interagency Implementation Committee
>
> **Action Participants:** Delta Science Program, and collaborative research groups (e.g. Delta Regional Monitoring Program)

5.2 | Develop, coordinate, and implement topic-specific Delta science implementation plans

Using the Science Action Agenda and the State of Bay-Delta Science as starting points, these topic-specific plans should address priority management questions and identify existing funding and science priorities based on input from a range of managers, decision-makers,

stakeholders, and scientists. Rather than creating new workgroups, leverage existing venues including the Delta Regional Monitoring Program, Delta Nutrient Research Program, and Collaborative Adaptive Management Team. Examples of current topic-specific plans include the Delta Smelt Science Plan and the Delta Nutrient Research Plan (Cooke et al., 2018). Coordination among specific plans will be needed to ensure coherent and integrated activities across inter-related topics and plans.

Primary Responsibility: Collaborative Adaptive Management Team, Delta Agency Science Workgroup, Interagency Ecological Program, Delta Regional Monitoring Program, Delta Nutrient Research Program

Action Participants: Natural Resources Agency, Delta Plan Interagency Implementation Committee, Sacramento-San Joaquin Delta Conservancy, Natural Resources Agency, and other organizations with interests in developing a strategy for increased science funding

5.3 | Develop a web-based tracking system of science activities in the Delta

Build a comprehensive internet-based science project tracking tool that will provide information for ongoing Delta science activities to identify opportunities for coordination and collaboration. The Delta Independent Science Board's review of the monitoring enterprise will provide foundational information on activities related to monitoring. This tool will also efficiently assesses financial investments in Delta science across multiple funders. This web based system will serve as a valuable tool for prioritizing emerging environmental issues and inform future policy and funding decisions. Dashboards and visualization tools will ensure the tracking system is user-friendly.

Primary Responsibility: Delta Science Program

Action Participants: Interagency Ecological Program, California Water Quality Monitoring Council, Sacramento Regional County Sanitation District, and other science programs of federal, state, and local agencies

Invest in a high-quality technical workforce

Of equal importance to shepherding collaborative efforts are individuals who carry out the initiatives identified in the Delta Science Plan. However, the State has faced challenges in both recruiting and retaining skilled individuals with technical backgrounds (Delta ISB, 2012). These staffing needs are compounded by the wave of retirements in recent years, which will continue. Currently, there are no widely-accepted mechanisms to maintain institutional knowledge and document best practices, which are often lost as senior staff retire. This is critical in the Delta where historical knowledge is important for avoiding duplicative efforts and inefficiencies, and in navigating the nuances of natural resource management and interactions between different interest groups. Innovative approaches are needed to address staffing challenges and to provide opportunities for current employees to grow and maintain their technical expertise and continue to support long-term science efforts.

5.4 | Maintain and grow the scientific expertise workforce needed to support Delta Science Plan implementation

Establish shared processes and mechanisms to provide Delta scientists with opportunities for professional development, improvement of leadership and communication skills, networking, and access to the latest scientific information. These include facilitating attendance at scientific seminars, conferences, and symposia, building relationships across science sectors, and improving access to scientific information (see action 3.7). Plans should be developed to maintain institutional knowledge including ongoing training, regular documentation of lessons learned, and opportunities for junior staff to purposefully interact with and learn from senior colleagues (CalEPA, 2007).

Primary Responsibility: All agencies and organizations involved in conducting science in the Delta

Action Participants: Federal and state agency directors, State legislature, Department of Finance, Delta Independent Science Board, stakeholders, California Sea Grant, academia, and entities with an interest in the science of the Delta

Assess Delta Science Plan performance

Currently, there are no performance metrics or mechanisms to track Delta Science Plan implementation and outcomes. Performance measures of the Delta Science Plan will provide a reflection of how implementing the actions in the document has improved the development, organization, and communication of science in the Delta; how the collective accomplishments of each chapter contribute to achieving the six overarching objectives, and guidance for where improvements can be made.

5.5 | Develop and report performance measures for the Delta Science Plan

Evaluate progress in meeting the six objectives to achieve the vision of *One Delta, One Science.* Metrics will be developed for each objective, and performance will be quantified through surveys provided to the Delta science and management community to assess the degree in which the six objectives and specific actions have been achieved. Insights on why some objectives and actions have not been achieved will be assessed through the surveys and focused interviews. The resulting information will be communicated as a narrative in updates to the Delta Science Plan or in scheduled progress reports.

Primary Responsibility: Delta Science Program

Action Participants: Delta Agency Science Workgroup and other users of the Delta Science Plan, federal, state, and local agencies, and the Delta science community

Moving Forward

During its review of the 2013 Delta Science Plan, the Delta Independent Science Board stated that this document has a rare opportunity to catalyze transformation of the prevailing ". . . legal, institutional, and cultural inertia in the system . . ." that tends to promote a paradigm of scientists and resource managers operating in agency and program silos. Such change was initiated in 2013 with the original Delta Science Plan, and the vision of *One Delta, One Science*.

Change will continue through collective implementation of the actions identified in the updated Delta Science Plan. Action areas highlighted throughout the plan include the need to incorporate climate change issues into a longer-term horizon for both science and decision making, the incorporation of social sciences into Delta science and management, and improvements to the policy-science interface. There is also a need to address science governance to foster effective implementation of science, and this will rely on consistent funding to support a robust science enterprise within the Delta. Robust science governance and management activities will, in turn, rely on the Delta science community embracing the importance of coordination with upper watershed and Bay efforts. Linking research and monitoring programs across these regions will result in improved management responses to climate change and other growing challenges.

Glossary

Accessibility—The ability to obtain data (e.g. digital access, phone application) and the extent to which the information is understandable and useable by the user.

Action participants—Agencies, other groups, and individuals involved in carrying out actions identified in the Delta Science Plan and Science Action Agenda.

Adaptive management—A framework and flexible decision-making process for ongoing knowledge acquisition, monitoring, and evaluation leading to continuous improvement in management planning and implementation of a project to achieve specified objectives.

Adaptive Management Liaisons—Delta Science Program staff members with expertise in the science supporting adaptive management and the process. Their role is to provide advice on availability of models, regional monitoring, relevant research, and integrating individual adaptive management projects, plans, and programs across the Delta system. These staff members serve as liaisons to their counterparts in agencies and organizations that are planning and implementing adaptive management programs and projects including Delta Plan covered actions.

Best available science—Information and data generated through the application of a transparent and repeatable scientific process for informing management and policy decisions at a given point in time (Sutherland and Woodroof 2009). Best available science shall be consistent with the guidelines and criteria found in Appendix 1A of the Delta Plan.

Biological Opinion—A document stating the opinion of the U.S. Fish and Wildlife Service or the National Marine Fisheries Service as to whether or not federal action is likely to jeopardize the continued existence of a threatened or endangered species, or result in the destruction or adverse modification of critical habitat.

CASCaDE project—Computational Assessments of Scenarios of Change for the Delta Ecosystem is a research project to develop and apply a model-based approach of ecological forecasting to project future states of the Delta ecosystem, and to communicate the outcomes to resource managers. The objectives of this project are to develop and verify a set of models of climate, watershed hydrology, sediments, and water quality, and link these models to forecast how the Delta ecosystem will change.

Climate change—Any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer). Climate change may result from (1) natural factors, including changes in the sun's intensity or changes in the Earth's orbit around the sun, (2) natural processes within the climate system (such as changes in ocean circulation), or (3) human activities that change the composition of the atmosphere (for example, through burning fossil fuels) and land surfaces (for example, deforestation, reforestation, urbanization, and desertification).

Collaboration—Sharing information and resources and modifying activities based on a common interest or objective that parties involved jointly define.[75]

Collaborative modeling—The modeling community comes together to jointly identify issues and work towards developing tools to address these issues using an iterative process that involves effective communication at all levels.[76]

Coequal goals—The two goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place.[77]

Conceptual model—An explicit description of theoretical linkages, knowledge, and hypotheses about the structure and function of a system or process.

---

75. Wright et al., 2016.
76. Carpenter et al., 2009.
77. Liew, 2007.

Cooperation—Sharing information and sometimes resources while each party pursues its own goals.[78]

Coordination—Sharing information and resources with parties pursuing a common interest or objective. The interest or objective, however, is defined independently by each party.

Credibility—Technical trustworthiness of the process and product.

CSAMP/CAMT—The Collaborative Science and Adaptive Management Program and Collaborative Adaptive Management Team are groups formed to coordinate adaptive management pursuant to the remand of the National Marine Fisheries Service and U.S. Fish and Wildlife Service biological opinions for listed fish species in the Delta. Both groups comprise agency and stakeholder representatives.

CWEMF—The California Water and Environmental Modeling Forum is a non-profit, non-partisan organization whose mission is to increase the usefulness of models for analyzing California's water-related problems.

Data—Recorded symbols (e.g. words, numbers, and images) and sensory readings that capture a set of facts about an event.[79] Examples include measures of precipitation, flow, and population abundance.

Delta—The Sacramento-San Joaquin Delta as defined in CA Water Code section 12220 and the Suisun Marsh, as defined in CA Public Resources Code section 29101.

Delta Agency Science Workgroup—Science managers appointed by the Delta Plan Interagency Implementation Committee to provide guidance in implementing Delta Science Plan actions including the Science Action Agenda.

Decision-maker—Includes both managers and agency directors and can also include stakeholders. Managers include individuals responsible for overseeing day-to-day functions (e.g. operations), implementing programs, research, policies, strategic planning, coordination and communication of the organization. Examples include participants of the Collaborative Adaptive Management Team, Interagency Ecological Program Science Management Team, and Delta Regional Monitoring Program Steering Committee. Directors are individuals who oversee agencies and large divisions (e.g. United States Geological Survey Bay-Delta region). Examples include members of the Collaborative Science and Adaptive Management Program, Delta Plan Interagency Implementation Committee and Interagency Ecological Program Director's Team participants.

Delta Plan—The comprehensive, long-term management plan for the Delta to further the achievement of the coequal goals, as adopted by the Delta Stewardship Council in accordance with the Sacramento-San Joaquin Delta Reform Act of 2009.

Delta science community—The group of scientists, including federal, state, and local agencies; academics, consultants, NGOs, and interested public who are actively participating in scientific and management activities in the Delta.

Ecosystem—A biotic community and its physical environment, considered as an integrated unit. Implied within this definition is the concept of a structural and functional whole unified through life processes. An ecosystem may be characterized as a viable unit of community and interactive habitat. Ecosystems are hierarchical and can be viewed as nested sets of open systems in which physical, chemical, and biological processes form interactive subsystems. Some ecosystems are microscopic, and the largest comprises the biosphere. Ecosystem restoration can be directed at different-sized ecosystems within the nested set, and many encompass multiple states, more localized watersheds, or a smaller complex of aquatic habitats.

Ecosystem restoration—The application of ecological principles to restore a degraded or fragmented ecosystem and return it to a condition in which its biological and structural components achieve a close approximation of its natural potential, taking into consideration the physical changes that have occurred in the past and the future impact of climate change and sea-level rise (Water Code section 85066).

Estuary—A place where fresh and salt water mix, such as a bay, or where a river enters an ocean.

Federated platform—A centralized system that gathers multiple data repositories, where the source databases remain unmodified.

78. DSC, 2016.
79. Liew, 2007.

Forum—A place, meeting, or medium (e.g. newspaper, website) where discussions take place on a particular issue.

Framework—A set of standards and principles from which to build a more detailed plan, program, or strategy.

Habitat restoration—The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning the majority of natural functions to the lost or degraded native habitat.

Horizon scanning—A process to identify emerging trends, issues, and opportunities that managers and scientists should be aware of so they are better prepared to take advantage of or to react to in a well thought out and timely manner.[80]

Human dimensions of natural resources—The ways in which humans value, use, and depend on the natural environment and how they affect and are affected by natural resource management decisions.[81]

Independent scientific review—Assessment of a scientific or management product or program by scientists with appropriate expertise and no personal or institutional stake in the outcome of the review.

Information—A message with relevant meaning used to make decisions, solve problems, or realize an opportunity. Information can come from processed data but can also come from other forms of communication (e.g. instructions).[82]

Integrated modeling—Taking models that provide information on different parameters (e.g. hydrodynamics, fish movement, crop yield) and different sources of data and tying them together to provide a more holistic understanding of the system.

Interoperability standards—Standards that allow systems, devices and models to exchange data, interpret this shared data and ultimately be useful to users.

Introduced species—A non-native species that has been accidentally or deliberately transported to the new location by human activity.[83]

Legitimacy—The scientific process is being applied impartially and without partisan bias or prejudice.

Local agency—Any public agency other than a State or federal agency, board, or commission. A local agency may include, but is not limited to, cities, counties, districts, and public water agencies, and boards, commissions, or organizational subdivisions of a local agency.

Machine learning—A method to teach computers to identify patterns from data and make decisions rather than relying on a predetermined equation. The decision performance (such as predictive ability) improves as the amount of data fed into the computer increases and expands the pool to "learn" from.[84]

Machine Readable—Data or information that is in a format that can be processed by a computer. For example, scanned PDFs, photographs, and handwritten documents are not machine readable and require human intervention in order to be reformatted.

Manager—Includes both "science manager" and "natural resource manager." Upper level staff within an agency division responsible for overseeing day-to-day functions (e.g. operations), strategic planning, coordination and communication of the organization. Science managers may have expertise in a technical field and may partake in data analysis, monitoring design efforts, and authoring scientific publications.

Management question—In this document, management questions will refer predominantly to more high-level questions posed by natural resource managers (e.g. how does this variable effect the ecosystem? As opposed to when is the best time to treat for certain vectors?).

Mechanism—A way of getting something done. This includes both institutional (e.g. organized entities) and procedural (e.g. bylaws and memorandum of understanding) mechanisms.

Model—An abstract simplification of the real world that formalizes hypotheses and current scientific understanding about how the modeled system works.

Monitoring—Ongoing sampling, analysis, measurement, and survey activities used by scientists and managers to assess status and trends of natural resources in the Delta system.

---

80. Bengston, 2013; Sutherland & Woodroof, 2009
81. https://my.usgs.gov/hd/about
82. Liew, 2007
83. Science Daily, 2018
84. MathWorks, 2018

Open source—Any software, project, products, that people can inspect, modify, enhance, and share because its design is publically accessible.[85]

Peer review—The scientific process of subjecting research proposals or products, or management programs, to assessment by independent scientific experts.

Performance measures—A quantitative or qualitative tool to assess progress toward an outcome or goal.

Policymaker—Individuals who develop policies for their agencies and departments and also those who participate at the legislative level who develop state-wide and nation-wide regulations.

Policy-Science Forum—A forum where decision-makers, scientists, and stakeholders come together to facilitate learning to promote discussion of key issues and coalesce around a unified idea of high priority needs and questions, maintain connections throughout the development of a management decision, research project, modeling effort, or synthesis process, and build relationships among members of the Delta science community.

Process—A series of steps taken to get a result/ achieve a goal.

Public—The general citizenry that may not fall in the category of "scientist," "stakeholder," or "decision-maker."

Relevance—Close alignment of research to management information needs.

Science—The use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process.[86] Science can be (a) experimental where natural phenomena are described by observations, (b) theoretical where models or generalizations are formed, (c) computational where complex theoretical formulations are resolved and (d) data explorative (or e-Science) where theory, experiment and simulation are unified. New knowledge is also discovered through data mining, visualization of complex processes and other emerging computational methodologies.[87]

Science Action Agenda—A document produced by the Delta Science Program in cooperation with the science community that prioritizes near-term actions to inform management actions and achieve the objectives of the Delta Science Plan.

Science activities—A broad range of efforts including compliance monitoring, modeling, exercises to identify science issues that may be of management concern in the near future, research focused on supporting decision-making, as well as more basic research that can support future management issues.

Science co-production—Participation of managers or stakeholders in the design, execution, and interpretation of scientific studies.[88]

Science enterprise—The collection of science programs and activities that exist to serve managers and stakeholders in a regional system.

Science governance—A form of collaborative governance that involves collectively prioritizing research questions, setting goals for science efforts, determine best practices for how science is conducted and results of these efforts (Sutherland and Woodroof 2009).[89]

Science infrastructure—The equipment, tools, resources, and systems that support the production, facilitation, organization, and communication of scientific knowledge. These include laboratories, offices, monitoring equipment, expert staff, computer and monitoring networks to transfer and share information, modeling networks that allow better multidisciplinary analysis, datasets, repositories, libraries, synthesis efforts, and web pages.

Science work plans—The set of near-term research activities and priorities carried out by the Delta Science Program in consultation and collaboration with an agency or other entity.

State of Bay-Delta Science—A summary and synthesis of the current state of scientific knowledge for the Delta, focused on the grand challenges of policymakers. The State of Bay-Delta Science was first published in 2008 by the CALFED Science Program. It is targeted to be updated by the Delta Science Program every four years.

---

85. Opensource.com
86. National Academy of Sciences, 2008.
87. Hey et al., 2009.
88. Beier et al., 2017; Lemos & Morehouse, 2005.
89. Lebel et al., 2005; Raik & Decker, 2007.

Stakeholder—Anyone or any entity who can influence, or will be affected by the issue, set of findings, or action.[90]

Synthesis—The combining of often diverse information from multiple sources into one concept, model, finding, or report.

Tool—Something used to perform a job or task (e.g. computer, guidebook, checklist, boat).

Use case—Descriptions of how the information will be used, for what purpose, and the desired interactions between the user and the output interface (e.g. website, dashboard, interactive map, etc.).

Watershed—The land area that drains into a stream, river, lake, or sea at a given point. The watershed for a major river may encompass a number of smaller watersheds.

90. Haddaway et al., 2017.

References

Beier, P., Hansen, L., Helbrecht, L., Behar, D. 2017. "A How-to Guide for Coproduction of Actionable Science." *Conservation Letters* 10 (3): 288–96. https://doi.org/10.1111/conl.12300.

Bengston, D.N. 2013. "Horizon Scanning for Environmental Foresight: A Review of Issues and Approaches." *General Technical Report NRS-121. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station*. https://doi.org/10.2737/NRS-GTR-121.

Brown, L.R., Baxter, R., Castillo, G., Conrad, L., Culberson,S., Erickson, G., Feyrer, F., Fong, S., Gehrts, K., Grimaldo, L., Herbold, G., Kirsch, J., Mueller-Solger, A., Slater, S.B., Sommer, T., Souza, K., Van Nieuwenhuyse, E. 2014. "Synthesis of Studies in the Fall Low-Salinity Zone of the San Francisco Estuary, September-December 2011." *U.S. Geological Survey Scientific Investigations Report 2014-5041.* https://doi.org/10.3133/SIR20145041.

California Environmental Protection Agency (CalEPA). 2007. "The Quality and Role of Science in Cal/EPA."

California Natural Resources Agency (CNRA). 2016. "Delta Smelt Resiliency Strategy." http://resources.ca.gov/docs/Delta-Smelt-Resiliency-Strategy-FINAL070816.pdf.

———. 2017. "Sacramento Valley Salmon Resiliency Strategy." http://resources.ca.gov/docs/Salmon-Resiliency-Strategy.pdf.

California Water Quality Monitoring Council (CWQMC). 2010. "A Comprehensive Monitoring Program Strategy for California." https://mywaterquality.ca.gov/monitoring_council/docs/comp_strategy_report.pdf.

Carpenter, S.R., Armbrust, V., Arzberger, P.W., Chapin, S.F., Elser, J.J., Hackett, E.J., Ives, A.R., Kareiva, P.M., Leibold, M.A., LUndberg, P., Mangel, M., Merchant, N., Murdoch, W.W., Palmer, M.A., Peters, D.P.C., Pickett, S.T.A., Smith, K.K., Wall, D.H., Zimmerman, A.S. 2009. "Accelerate Synthesis in Ecology and Environmental Sciences." *BioScience* 59 (8): 1–3. https://doi.org/10.1525/bio.2009.59.8.11.

Cloern, J. 2018. "Patterns, Pace, and Processes of Water-Quality Variability in a Long-Studied Estuary." *Limnology and Oceanography* 64 (S1): S192–208.

Coastal and Marine Sciences Institute (CMSI). 2018. "Disease in Pacific Salmonids: Research, Monitoring, and Management Workshop." 2018. https://cmsi.ucdavis.edu/events/salmon_disease_ecology_worksho_march2018/index.html.

Cooke, J., Joab, C., Lu, Z. 2018. "Regional Water Quality Control Board, Central Valley Region: Delta Nutrient Research Plan." https://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_nutrient_research_plan/20180713_dnrp.pdf.

Data Summit Organizing Committee (DSOC). 2015. "Enhancing the Vision for Managing California's Environmental Information."

Delta Independent Science Board (Delta ISB). 2010. "Flows and Fishes in the Sacramento-San Joaquin Delta."

———. 2012. "Key Issues for Delta Science: A Report of the Delta Independent Science Board."

———. 2013. "Habitat Restoration in the Sacramento-San Joaquin Delta and Suisun Marsh: A Review of Science Programs."

———. 2015. "Flows and Fishes in the Sacramento-San Joaquin Delta."

———. 2016. "Improving Adaptive Management in the Sacramento-San Joaquin Delta."

———. 2017a. "Review of Research on the Sacramento-San Joaquin Delta as an Evolving Place."

———. 2017b. "Review of the Final Environmental Impact Report/Environmental Impact Statement for California WaterFix."

———. 2018. "Water Quality Science in the Sacramento-San Joaquin Delta: Chemical Contaminants and Nutrients."

———. 2019. "Urgency and Opportunities for Improving Interagency Science and Technical Integration for the Sacramento-San Joaquin Delta: A Letter to the Delta Plan Interagency Implementation Committee."

Delta Reform Act. 2009.

Delta Science Program (DSP). 2015. "2015 High-Impact Science Actions."

Delta Stewardship Council (DSC). 2016. The Science Enterprise Workshop: Supporting and Implementing Collaborative Science. Conference Proceedings. Sacramento, CA. https://mavensnotebook.com/wp-content/uploads/2017/03/SEW_Complete-Proceedings-Day-1-2.pdf.

Department of Water Resources (DWR). 2013. *California Water Plan.*

Ebberts, B.D., Zelinsky, B.D., Karnezis, J.P., Studebaker, C.A., Lopez-Johnson, S., Creason, A.M., Krasnow, L., Johnson, G.E., Thom, R.M. 2018. "Estuary Ecosystem Restoration: Implementing and Institutionalizing Adaptive Management." *Restoration Ecology* 26 (2): 360–69. https://doi.org/10.1111/rec.12562.

European Commission. 2009. "Global Governance of Science." *Report of the Expert Group on Global Governance of Science to the Science, Economy, and Society Directorate, Directorate-General for Research.,* 2009. https://doi.org/10.2777/31776.

Haddaway, N.R., Kohl, C., Rebelo da Silva, N., Spök, A., Steward, R., Sweet, J.B., Wilhelm, R. 2017. "A Framework for Stakeholder Engagement during Systematic Reviews and Maps in Environmental Management." *Environmental Evidence* 6 (1): 11. https://doi.org/10.1186/s13750-017-0089-8.

Hanak, E., Lund, J., Dinar, A., Gray, B., Howitt, R., Mount, J., Moyle, P., Thompson, B. 2011. "Managing California's Water: From Conflict to Reconciliation." San Francisco, CA. http://www.ppic.org/publication/managing-californias-water-from-conflict-to-reconciliation/.

Healey, M., Dettinger, M., Norgaard, R. 2008. *The State of Bay-Delta Science,* 2008. Sacramento, CA: CALFED Science Program.

———. 2016. "Perspectives on Bay–Delta Science and Policy." *San Francisco Estuary and Watershed Science* 14 (4). https://doi.org/10.15447/sfews.2016v14iss4art6.

Heublein, J., Bellmer, R., Chase, R.D., Doukakis, P., Gingras, M., Hampton, D., Israel, J.A., Jackson, Z.J., Johnson, R.C., Langness, O.P., Luis, S., Mora, E., Moser, M.L., Rohrbach, L., Seesholtz, A.M., Sommer, T. 2017. "Improved Fisheries Management through Life Stage Monitoring: The Case for the Southern Distinct Population Segment of North American Green Sturgeon and the Sacramento-San Joaquin River White Sturgeon." *NOAA Technical Memorandom NMFS,* 2017. https://doi.org/10.7289/V5/TM-SWFSC-588.

Hey, T., Tansley, S., Tolle, K. 2009. *The Fourth Paradigm: Data-Intensive Scientific Discovery.* https://www.immagic.com/eLibrary/ARCHIVES/EBOOKS/M091000H.pdf.

Holling, C. S. 1978. *Adaptive Environmental Assessment and Management.* Wiley. http://pure.iiasa.ac.at/id/eprint/823/.

Interagency Ecological Program Management, Analysis and Synthesis Team (IEP MAST). 2015. "An Updated Conceptual Model of Delta Smelt Biology: Our Evolving Understanding of an Estuarine Fish." https://www.water.ca.gov/LegacyFiles/iep/docs/Delta_Smelt_MAST_Synthesis_Report_January 2015.pdf.

Lebel, L., Anderies, J.M., Campbell, B., Folke, C., Hatfield-Dodds, S., Hughes, T.P., Wilson, J. 2005. "Governance and the Capacity to Manage Resilience in Regional Social-Ecological Systems." Ecology and Society 11 (1): 19. https://doi.org/10.5751/ES-01606-110119

Lemos, M.C., Morehouse, B.J. 2005. "The Co-Production of Science and Policy in Integrated Climate Assessments." *Global Environmental Change* 15: 57–68. https://doi.org/10.1016/j.gloenvcha.2004.09.004.

Liew, A. 2007. "Understanding Data, Information, Knowledge And Their Inter-Relationships." *Journal of Knowledge Management Practice* 8 (2). http://www.tlainc.com/articl134.htm.

Luoma, S., Dahm, C.N., Healey, M., Moore, J.N. 2015. "Water and the Sacramento-San Joaquin Delta: Complex, Chaotic, or Simply Cantankerous?" *San Francisco Estuary and Watershed Science* 13 (3). https://doi.org/10.15447/sfews.2015v13iss3art7.

MathWorks. 2018. "What Is Machine Learning? How It Works, Techniques & Applications." https://www.mathworks.com/discovery/machine-learning.html.

Medellin-Azuara, J., Lund, J., Goodwin, P., Enright, C., Bray, B., Argent, R., Ariyama, J., Bratton, J.F., Burau J., Chotkowski, M., Escriva-Bou, A., Lee, J., Lindley, S., McWilliams, M., Peckman, S., Quinn, N., Senn, D., Siegel, S., Wolfe, J. 2017. "Integrated Modeling of Estuarine Systems: Lessons for the Sacramento-San Joaquin Delta." https://watershed.ucdavis.edu/files/content/files/Integrated_Environmental_Modeling_Policy_Brief_20170222r1.pdf.

Murphy, D., Weiland, P.S. 2016. "Guidance on the Use of Best Available Science under the U.S. Endangered Species Act." *Environmental Management* 58 (1): 1–14. https://doi.org/10.1007/s00267-016-0697-z.

National Academy of Sciences. 2008. *Science, Evolution, and Creationism.* Washington, D.C.: National Academies Press. https://doi.org/10.17226/11876.

National Marine Fisheries Service (NMFS). 2017. Sacramento River Winter-run Chinook Salmon Life Cycle Model, issued 2017. https://swfsc.noaa.gov/publications/CR/2017/2017Hendrix.pdf.

National Research Council (NRC). 2011. *A Review of the Use of Science and Adaptive Management in California's Draft Bay Delta Conservation Plan.* Washington, D.C.: National Academies Press. https://doi.org/10.17226/13148.

———. 2012. *Sustainable Water and Environmental Management in the California Bay-Delta.* Washington, D.C.: National Academies Press. https://doi.org/10.17226/13394.

Opensource.com. 2018. "What Is Open Source Software?" 2018. https://opensource.com/resources/what-open-source.

Peters, D.P.C. 2010. "Accessible Ecology: Synthesis of the Long, Deep, and Broad." *Trends in Ecology & Evolution* 25 (10): 592–601. https://doi.org/10.1016/j.tree.2010.07.005.

Raik, D.B., Decker, D.J. 2007. "A Multisector Framework for Assessing Community-Based Forest Management: Lessons from Madagascar." *Ecology and Society* 12 (1): art14. https://doi.org/10.5751/ES-02022-120114.

Ryder, D.S., Tomlinson, M., Gawne, B., Likens, G.E. 2010. "Defining and Using Best Available Science: A Policy Conundrum for the Management of Aquatic Ecosystems." *Marine and Freshwater Research.* https://doi.org/10.1071/MF10113.

Science Daily. 2018. "Introduced Species." 2018. https://www.sciencedaily.com/terms/introduced_species.htm.

Sullivan, P.J., Acheson, J.M., Angermeier, P.L., Faast, T., Flemma, J., Jones, C.M., Knudsen, E.E., Minello, T.J., Secor, D.H., Wunderlich, R., Zanetell, B.A. 2006. "Defining and Implementing Best Available Science for Fisheries and Environmental Science, Policy, and Management." *Fisheries* 31 (9): 460–65. https://www.fws.gov/wafwo/fisheries/Publications/Fisheries3109.pdf.

Surface Water Ambient Monitoring Program (SWAMP). 2017. "Constituents of Emerging Concern in Aquatic Ecosystems." 2017. https://www.waterboards.ca.gov/water_issues/programs/swamp/cec_aquatic/cec_workshop_2017may.html.

Sutherland, W.J., Woodroof, H. 2009. "The Need for Environmental Horizon Scanning." *Trends in Ecology & Evolution* 24 (10): 523–27. https://doi.org/10.1016/j.tree.2009.04.008.

Ta, J., Anderson, L., Christman, M., Khanna, S., Kratville, D., Madsen, J., Moran, P., Viers, J. 2017. "Invasive Aquatic Vegetation Management in the Sacramento–San Joaquin River Delta: Status and Recommendations." *San Francisco Estuary and Watershed Science* 15 (4). https://doi.org/10.15447/sfews.2017v15iss4art5.

Westgate, M.J., Likens, G.E., Lindenmayer, D.B. 2013. "Adaptive Management of Biological Systems: A Review." *Biological Conservation* 158: 128–39. https://doi.org/10.1016/j.biocon.2012.08.016.

Wiens, J.A., Zedler, J.B., Resh, V.H., Collier, T.K., Brandt, S., Norgaard, R.B., Lund, J.R., Atwater, B., Canuel, E., Harindra, F.J. 2017. "Facilitating Adaptive Management in California's Sacramento–San Joaquin Delta." *San Francisco Estuary and Watershed Science* 15 (2). https://doi.org/10.15447/sfews.2017v15iss2art3.

Williams, B.K., Szaro, R.C., Shapiro, C.D. 2009. "Adaptive Management: The U.S. Department of the Interior Technical Guide." Washington, D.C.: U.S. Department of the Interior.

Windell, S., Brandes, P.L., Conrad, L., Ferguson, J.W., Goertler, P.A.L., Harvey, B.N., Heublein, J., Israel, J.A., Kratville, D.W., Kirsch, J.E., Perry, R.W., Pisciotto, J., Poytress, W.R., Reece, K., Swart, B.G., Johnson, R. 2017. "Scientific Framework for Assessing Factors Influencing Endangered Sacramento River Winter-Run Chinook Salmon." https://doi.org/10.7289/V5/TM-SWFSC-586.

Wright, D.L., Nichols, C.R., Cosby, A.G., Danchuk, S., D'Elis, C.F., Mendez, G.R. 2016. Trans-disciplinary Collaboration to Enhance Coastal Resilience: Envisioning a National Community Modeling Initiative. Coastal Resiliency Workshop. Paper 1.

Appendices

Appendix A | Status of original actions in 2013 Delta Science Plan and relevant outcomes

This appendix provides an overview of the status of each of the actions identified in the 2013 Delta Science Plan. Footnotes are provided if substantial changes have been made to an action in this current document (e.g. merged with another action, put in another chapter). (*) indicates the action has been removed from the current Delta Science Plan.

ACTION NUMBER	SHORT TITLE	ACTION STATUS	EXAMPLE RELATED OUTCOMES
CHAPTER 2: Organizing Science to Inform Policy and Management			
2.1	Establish a Policy-Science Forum	Ongoing[91]	Delta nutrient research plan, Delta RMP, CAMT Salmon Scoping Team report, CAMT outflow work plan, CAMT/NOAA salmonid workshop
2.2	Develop, implement, and update a Science Action Agenda	Completed and Ongoing[92]	2017–2021 Science Action Agenda, 2015 High-Impact Science Actions Interim Science Action Agenda
2.3	Sustain a web-based tracking system of science activities[93]	Initiated[94]	
2.4	Establish a Science Advisory Committee*	Completed	Delta Science Program Science Advisory Committee
2.5	Enable and identify resources for focused science synthesis[95]	Ongoing	
2.6	Publish and update the State of Bay-Delta Science	Completed and Ongoing	2016 State of Bay-Delta Science
2.7	Deliver annual state-of-Delta science address*	No longer relevant[96]	
2.8	Develop and report performance measures[97]	Not initiated	
CHAPTER 3: Adaptive Management for a Complex System			
3.1	Provide Adaptive Management Liaisons	Completed and Ongoing	
3.2	Develop and use adaptive management frameworks	Ongoing	Delta Conservation Adaptive Management Action Strategy
3.3	Model future scenarios[98]	Ongoing	Many focused studies (e.g. effects of WaterFix)
3.4	Hold an annual Adaptive Management Forum	Completed and Ongoing	
CHAPTER 4: Building the Infrastructure for Science			
4.1	Support research	Ongoing	Prop 1 related research efforts, Operation Baseline-related studies, Delta Science Fellows
4.2.1	Support and sustain a web-based information system for monitoring activities[99]	Not initiated	

91. Ongoing: Effort is funded and currently underway.
92. Completed and Ongoing: Efforts that are recurring but were initiated in the 2013 Delta Science Plan.
93. Moved to joint implementation chapter in current document (chapter 5, action 5.3).
94. Initiated: Effort is funded and in early stages of implementation.
95. Language modified and moved to science infrastructure chapter in current document (chapter 3, action 3.11).
96. No longer relevant: The way the action is phrased is no longer relevant to the overarching goals of the Delta Science Plan. The action will have been either removed or combined with another action.
97. Moved to joint implementation chapter (chapter 5, action 5.5).
98. Incorporated into chapter 3 modeling language.
99. Modified and combined in infrastructure chapter (chapter 3).

ACTION NUMBER	SHORT TITLE	ACTION STATUS	EXAMPLE RELATED OUTCOMES
4.2.2	Build a comprehensive Delta monitoring strategy for an integrated program	Not initiated	
4.3.1	Host a data summit*	Completed	Data summit white paper, AB 1755 and related efforts
4.3.2	Develop guidelines for data sharing[100]	Ongoing	AB 1755 related efforts
4.4.1	Develop a collaborative community modeling framework	Ongoing	IMSC efforts
4.4.2	Develop, update, and maintain conceptual models*	Ongoing	IEP workgroup on tidal wetlands monitoring has conceptual models related to fish and food web
4.4.3	Support high-priority model development	Ongoing	UCD/Watermaster study comparing Delta consumptive use estimates
4.4.4	Embrace alternative modeling approaches*[101]	Ongoing	
4.5.1	Foster integrative synthetic thinking throughout the Delta science and management communities	Ongoing	FLaSH, SAIL, MAST, NCEAS-POD, tidal-wetland monitoring work group, other IEP workgroup efforts
4.5.2	Establish mechanisms and protocols for ongoing synthesis	Not initiated	
4.6.1	Seek broad support and use of a standard process for conducting scientific peer review	Ongoing	WaterFix aquatic science review, Delta RMP monitoring design review, Yolo Bypass habitat restoration and fish passage review, long-term operations Biological Opinions science review
4.6.2	Develop a response mechanism to scientific peer review*	No longer relevant	
4.7.1	Develop and implement a communication strategy	Ongoing	
4.7.2	Develop and maintain new web-enabled content	Ongoing	Estuaries Portal, EcoAtlas, Bay-Delta live, social media
CHAPTER 5: Resouces to Implement the Delta Science Plan			
5.1	Develop a joint funding strategy for the Delta Science Plan	Not initiated	
5.2	Adequately staff the Delta Science Program*	No longer relevant	
5.3	Supplement the Delta Science Program with rotators*	No longer relevant	
5.4	Implement and sustain the science infrastructure*	Ongoing	

LIST OF ACRONYMS

AM: Adaptive Management

MAST: Management Analysis and Synthesis Team

AB: Assembly Bill

NCEAS: National Center for Ecological Analysis and Synthesis

CAMT: Collaborative Adaptive Managing Team

NOAA: National Oceanic and Atmospheric Administration

Delta RMP: Delta Regional Monitoring Program

POD: Pelagic Organism Decline

FLaSH: Fall Low Salinity Habitat

SAIL: Salmon and Sturgeon Assessment Indicators by Life stage

UCD: University of California, Davis

IMSC: Integrated Modeling Steering Committee

100. Modified to action 3.6 and 3.7.

101. Merged into language for inter-comparison and collaborative modeling (chapter 3 section 3.5).

Appendix B | The 2018 Delta Science Plan Review and Update Process

The 2018 review and update of the Delta Science Plan was conducted to incorporate additional concepts and actions reflecting the current science and management landscape in the Delta. For the content to be relevant to the regional needs of the Delta and to ensure broad acceptance of the Delta Science Plan as a useful and valuable framework, the update process involved early and continuous engagement from the wider Delta science community and public. Although the Delta Science Program has taken the role of leading the review and update effort, improvements to the Delta Science Plan rely on the regional science community to shape the content along with additional input and guidance from the Delta Independent Science Board, the Delta Science Program's Science Advisory Committee, and individuals with expertise in coordinating other complex systems.

Beginning in January 2018, the Delta Science Program engaged in early outreach efforts by approaching collaborative science groups such as the Collaborative Adaptive Management Team, the Delta Regional Monitoring Program, and the Interagency Ecological Program. At these meetings, the participants were requested to provide feedback on how they had used the Delta Science Plan in the past and to give initial suggestions on any concepts or topics that should be included in the updated document. During this time, the Delta Science Program conducted an internal refinement of the Delta Science Plan, where updated information was added and outdated information was flagged for removal.

On April 6, 2018, the Delta Science Program hosted a workshop where the science community and public convened to discuss specific areas of the Delta Science Plan, provide recommendations for additional material, and offer feedback on how the document could be improved. A total of 58 participants attended, representing 28 different entities.

Highlights of additional concepts in this updated Delta Science Plan based on feedback from the early outreach and workshop included:

- Expanding the scope of the Science Action Agenda to include horizon scanning[102]
- Nurturing and integrating social sciences with the natural sciences, and modernizing the science infrastructure
- Identifying strategies to promote data organization and accessibility focusing on steps prior to data publication
- Incorporating more detail and emphasis on coordinated monitoring
- Developing strategies for joint implementation of the Delta Science Plan

Following the public workshop, the Delta Science Plan was revised based on the discussion and suggestions received at the workshop. From May 22–June 4, 2018, the Delta Science Program conducted an internal review, and a Delta Stewardship Council Executive division review occurred between June 18 and July 30, 2018. The draft updated Delta Science Plan was posted publically for review and comment from August 22 to September 20, 2018. Comments from the public review were incorporated into a subsequent draft, which was then provided to the Delta Independent Science Board for review from October 12–December 31, 2018.

102. Horizon scanning: A process to identify emerging trends, issues, and opportunities that managers and scientists should be aware of so they are better prepared to take advantage of or react to in a well thought out and timely manner (Haddaway et al., 2017).

Appendix C | Science Governance and the Collaborative Delta Science-scape

INTRODUCTION

This appendix provides a more extended discussion and analysis of the network diagram displayed in Chapter 1. The analysis focuses on the existing structure of the collaborative Delta science-scape and serves as a starting point for visualizing and understanding the complexity inherent in collaboratively governing the science of a complex social-ecological system. Future analyses will investigate the nature of these relationships and the processes contributing to decisions across collaborative organizations. These include identifying levels of engagement and commitment, scope and responsibility of each venue, and the need for resources (see section on future investigations). The goal for these analyses is to serve as a tool to improve collaborative science governance in the Delta.

COLLABORATIVE SCIENCE GOVERNANCE

Governance refers to the interactions among structures, processes, rules, and traditions that determine how people in societies make decisions and share power, exercise responsibility, ensure accountability, and give stakeholders a say in the management process (Sutherland & Woodroof, 2009). The interactions among structures, rules, and traditions provide the social context that allows collective action, rule-making, and institutions for social coordination (Dietz et al., 2003). In a complex social-ecological system like the Delta, governance is not about one individual or organization making a decision but rather multiple individuals within organizations and systems of linked organizations making decisions to advance the collective good.

Collaborative science governance is a form of governance that involves engaging people constructively across the boundaries of public agencies, levels of government and/or the public, private and civic spheres to collectively prioritize research questions, determine how science is conducted, and to review and distribute the results. Collaborative science governance covers a range of science activities including how funding is directed to research programs aimed at achieving high priority science goals, how best practices for carrying out research are established and communicated, and how the results of science undergo review and are distributed to decision-makers and other users. The network analysis described here focuses on the organizations involved in collaborative science governance as a first step.

COLLABORATIVE DELTA SCIENCE VENUES

The collaborative Delta science-scape is comprised of the formal, collaborative elements of the Delta science enterprise. This Appendix maps out the network of connections between the 12 main collaborative Delta science venues that contribute to science governance via the wide range of organizations participating in those venues. Taken together, the venues coordinate across a diverse range of actors working on the full set of science activities and study topics in the Delta. It is important to note that this network does not capture the full range of collaborative science efforts in the Delta; those represented are limited to formal, ongoing, and multi-party venues. Table C-1 provides the list of 12 collaborative venues including a description of their roles and the primary participants within each venue.

WHO PARTICIPATES?

The set of organizations participating in collaborative Delta science venues include actors from multiple levels of government as well as non-governmental organizations, public research institutions, and private consultants. The primary actors are federal and state agencies with responsibilities related to water supply, water quality, wildlife management and habitat restoration. See Table C-2 for more information on the role these federal and state agencies play.

The six main federal agencies that participate in collaborative science governance in the Delta include the National Oceanic and Atmospheric Administration's National Marine Fisheries Service, the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, and the U.S. Geological Survey. There are multiple state agencies responsible for managing water resources and/or wildlife and habitat restoration. These include, but are not limited to, the Department of Fish and Wildlife, the Department of Water Resources, and the State Water Resources Control Board.

A number of city and county general government actors appear in the Delta collaborative science-scape, while the private sector is involved peripherally. Water special districts are governmental entities usually associated with a local government jurisdiction and perform at least one of four specific duties: water delivery (e.g. public water agencies), waste disposal/sanitation (e.g. publically owned treatment works), flood management, and water conservation. Water districts participate in the network individually or through larger member associations such as the Metropolitan Water District of Southern California (Metropolitan) or the State and Federal Contractors Water Agency (SFCWA[103]).

103. Although SFCWA no longer exists, the organization has been a major player in the Delta science-scape and will be included in this set of analyses.

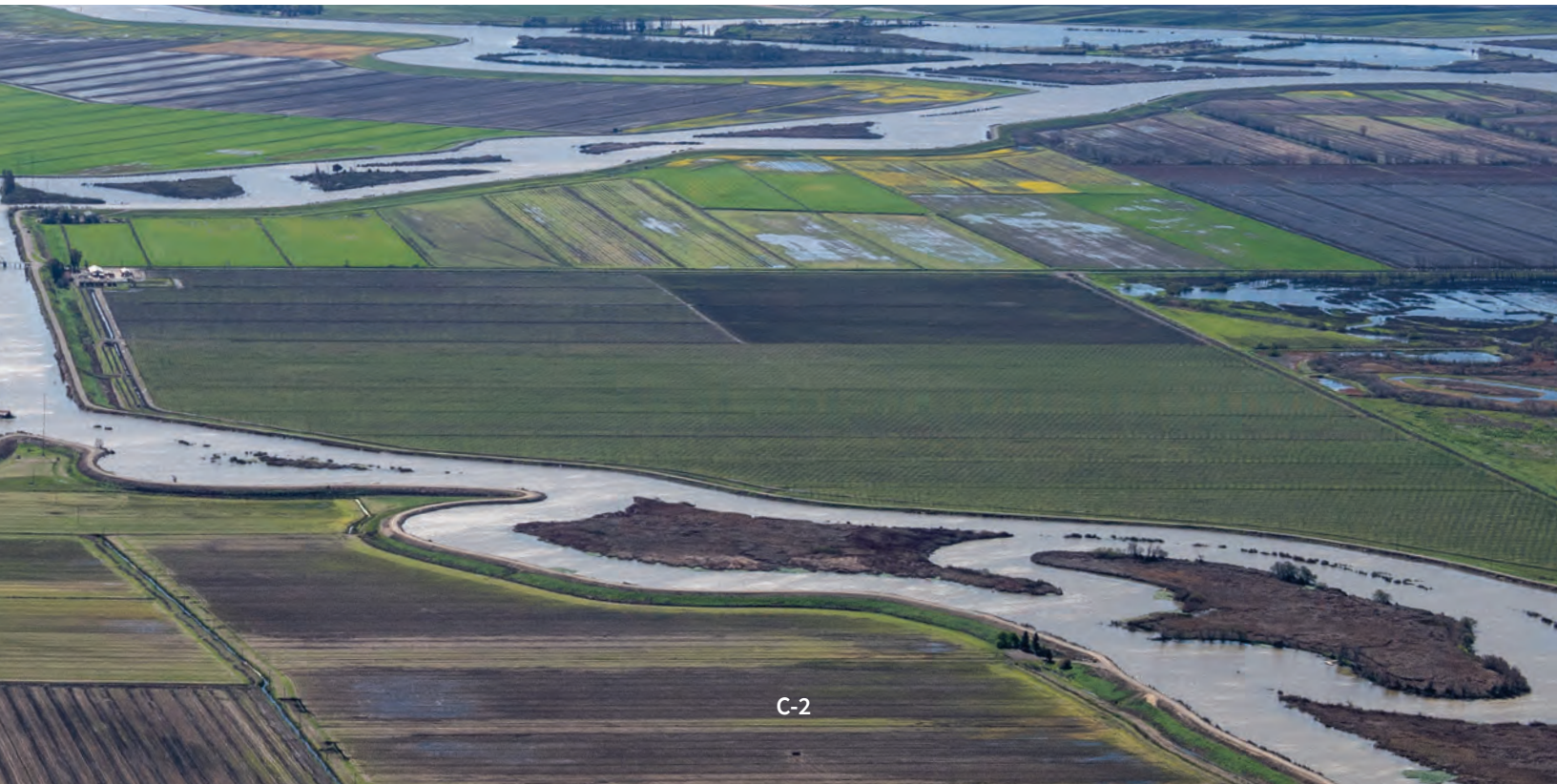


Table C-1 | The 12 main collaborative science and policy venues in the Delta

ACRONYM	FULL NAME	ROLE/PURPOSE	PRIMARY PARTICIPANTS
CSAMP/ CAMT	Collaborative Science and Adaptive Management Program/Collaborative Adaptive Management Team Legislative Mandate: None (2008/2009 BiOps Judicial Mandate)	Collaboratively produce information and evaluate science and management actions associated with protection of species of concern and actions related to the State Water Project and Central Valley Project to improve performance of ecological systems and water supply	Federal and state entities and stakeholders involved in the court ordered remand schedule for completing revisions to Delta Smelt and salmonid Biological Opinions (2008 and 2009 BiOps)
CWEMF	California Water and Environmental Modeling Forum Legislative Mandate: None	Increase usefulness of models for analyzing California's water-related problems, facilitate exchange of information, resolve technical disagreements, ensure technical work takes into account stakeholder and management needs. Also non-partisan clearing house for models and peer review	Federal and state entities, other entities with interests in water, universities, environmental organizations, private consultants, and general public (over 100 individual member entities)
CWQMC	California Water Quality Monitoring Council Legislative Mandate: SB 1070 (2006)	Develop specific recommendations to improve the coordination and cost-effectiveness of water quality and ecosystem monitoring and assessment, enhance the integration of monitoring data across departments and agencies, and increase public accessibility to monitoring data and assessment information	Federal and state entities, citizen monitoring groups, the public, and scientific, agriculture, regulated water, and water supply communities
DPIIC/DASW	Delta Plan Interagency Implementation Committee/Delta Agency Science Workgroup Legislative Mandate: Delta Reform Act (2009)	Bring together directors and technical staff of agencies associated with the Delta Plan to coordinate their agency efforts to support goals of the Delta Plan	18 federal and state entities involved in Delta Plan implementation
DIISC	Delta Interagency Invasive Species Coordination Team Legislative Mandate: None	Foster communication and collaboration among California state agencies that detect, prevent, and manage invasive species and restore invaded habitats in the Sacramento-San Joaquin Delta	Federal, state, and local entities, academics and other stakeholders
DRMP	Delta Regional Monitoring Program Legislative Mandate: None	Produce objective, cost-effective scientific information gathered in a streamlined way that provides a comprehensive understanding of water quality conditions and trends in the Delta	Central Valley Regional Water Quality Control Board, publically owned treatment works, storm water programs, irrigated agriculture, water suppliers, natural resource and science managers, agency scientists
IAMIT	Interagency Adaptive Management Integration Team Legislative Mandate: None	Work in support of integrated Adaptive Management for habitat restoration in the Yolo Bypass, Delta, and Suisun Marsh	Federal, state and local entities, and stakeholders involved in planning, funding, implementing, or that have regulatory oversight of Delta habitat restoration projects

ACRONYM	FULL NAME	ROLE/PURPOSE	PRIMARY PARTICIPANTS
IEP	Interagency Ecological Program Legislative Mandate: None	Collaboratively monitor, research, model, and synthesize information for adaptive management, water project operations, planning, and regulatory purposes relative to endangered fish and the aquatic ecosystem in the Bay-Delta	Nine federal and state entities
IICG	Interagency Implementation and Coordination Group Legislative Mandate: None	Coordinate and implement the Adaptive Management Program for the California WaterFix and current Biological Opinions on the coordinated operations of the Central Valley and State Water Projects	Representative from each of the five federal and state water operations and fisheries agencies, a State Water Project contractor and Central Valley Project contractor
Nutrient STAG	Nutrient Stakeholder and Technical Advisory Group Legislative Mandate: None	Responsible for providing productive input representing the range of different interests involved in, and who may be affected by, the development and implementation of a Delta nutrient management strategy	Federal, state and local entities involved in water resources management (supply, quality, stormwater, irrigation etc.), non-governmental organizations, and industry stakeholders
WOMT	Water Operations Management Team Legislative Mandate: None	Considers recommendations of technical teams, water supply costs, and other factors to provide water operations guidance to DWR and USBR	Federal and state entities associated with the Central Valley and State Water Projects

Note: This table includes only the formal, ongoing Delta collaborative science venues and is not an exhaustive list of all collaborative Delta science activities

Table C-2 | Federal and State Government Organizations

NAME	ACRONYM	FOCUS TOPICS[1]	REGULATORY (Y/N)?
FEDERAL			
National Aeronautics and Space Administration	NASA		N
National Marine Fisheries Service—Southwest Fisheries Science Center	NMFS—SWFSC		Y
U.S. Army Corps of Engineers	USACE		Y
U.S. Department of Agriculture[3]	USDA		Y
U.S. Department of Interior[3]	USDOI		
U.S. Bureau of Reclamation	Reclamation		N
U.S. Environmental Protection Agency	USEPA		Y
U.S. Fish and Wildlife Service	USFWS		Y
U.S. Geological Survey	USGS		N
STATE			
California Department of Food and Agriculture	CDFA		Y
California Environmental Protection Agency	CalEPA		
Central Valley Regional Water Quality Control Board	CVRWQCB		Y
Office of Environmental Health Hazard Assessment	OEHHA		Y
State Water Resources Control Board	SWRCB		Y
California Natural Resources Agency	Resources		
California State Parks and Recreation	State Parks		Y
Central Valley Flood Protection Board	Flood Board		Y
Department of Fish and Wildlife	DFW		Y
Department of Water Resources	DWR		N
Delta Protection Commission	DPC		Y
Delta Science Program	DSP		N
Delta Stewardship Council	DSC		Y
Sacramento-San Joaquin Delta Conservancy	Delta Conservancy		N

Agriculture
BiOps[2]
Flood Control
Land Use
Monitoring
Recreation
Restoration
Science Coordination
Water Quality
Water Rights
Water Supply
Wildlife

1. These columns represent agency activities specific to the Bay-Delta region.
2. Refers to the 2008/2009 Biological Opinions on operations of the SWP and CVP.
3. Present in table due to Department-level representation in DPIIC.

Note: The California Water Plan has more information about state agency responsibilities (pages 3–14 through 3–17 of the California Water Plan)

SCIENCE-SCAPE NETWORK DIAGRAMS AND SUMMARY OF RELATIONSHIPS

Understanding the composition of the venues with respect to other venues is important to determine who the key players are and where in the science-scape organizations can be expected to have a role in science communication and decision-making. This section provides a more detailed description of various collaborative venue compositions. Again, this analysis does not take into account the nature of these relationships (e.g. whether one organization informs another, any hierarchical relationships).

The Delta science-scape network is composed of two types of entities (or nodes):

1. **Venues:** the collaborative science venues where multiple organizations engage in science governance, that is, organizations that coordinate activities, develop research goals and select the means to meet those goals, and/or synthesize, review and communicate the results.
2. **Organizations:** the collection of government and stakeholder organizations participating in these venues, classified by type of organization.

The network models below (Figures C-1 and C-2) were formed by compiling a list of the 12 major collaborative Delta science venues (see Table C-1) and the list of participating organizations for each venue.[104]

Figure C-1 is a visualization of the full network, which includes the collaborative venues and all of the organizations that participate in at least one of these venues. This is the "big picture" network and shows the full range of participants in collaborative Delta science. There are 94 organizations that participate in the full network.

Figure C-2 shows the collaborative science core network. This network was formed by removing organizations that participate in only one collaborative venue with the assumption that they are more peripherally involved. The resulting core network of 33 organizations affords a more focused examination of the set of organizations embedded in the collaborative Delta science system. It also provides a basis of comparison that reveals which venues coordinate heavily involved actors versus those that provide a point of engagement for the broader collaborative Delta science community.

One measure of influence in a network is known as *degree centrality,* which is defined as the number of links that connect a given node to other nodes in the network. Thus the more venues a given organization participates in, the more centrally it is located in the network. Similarly, the more organizations participate in a given venue, the more central that venue is. Due to their participation in a relatively large number of collaborative venues, there are a number of federal (green) and state (yellow) agencies in the center of the diagram.

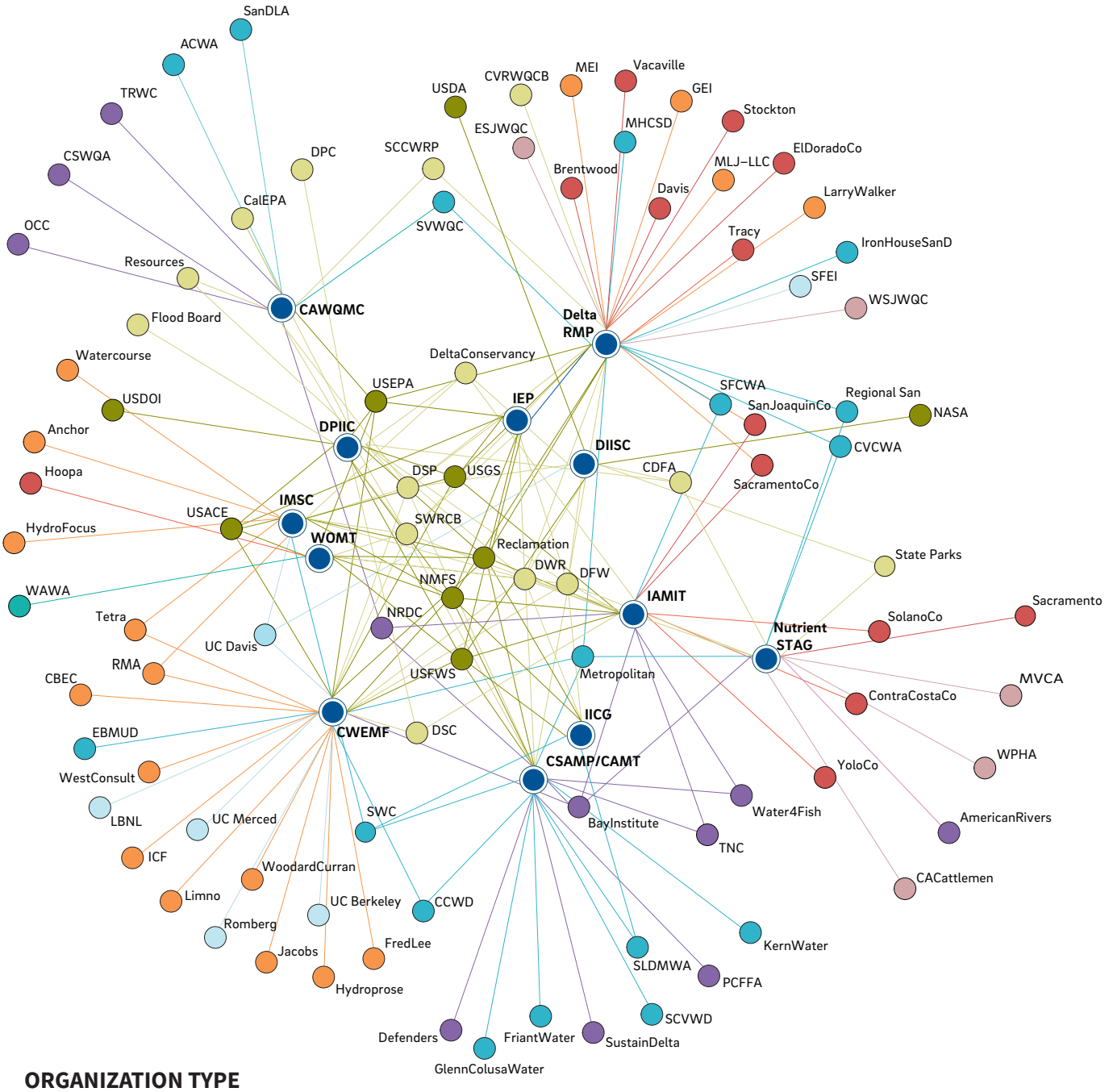
Table C-3 provides the number of organizations participating in the full network and core network, and the average number of venues in which each type of organization participates. Six of the nine federal agencies in the network participate in more than one venue and federal agencies on average participate in more venues (4.9) in the full network than any other organization type. State agencies comprise the next most central sector. Most of the state agencies (11 out of 15) attend more than one venue and on average participate in 3.9 venues. Many venues share the same organizational participants. These venues are not necessarily redundant, as they differ in scope and role. Identifying common participants between venues may provide insights such as how information is shared and commutated among different groups.

By contrast, only 2 of the 13 general local government agencies participate in more than one collaborative venue. Water special districts have the most representation in the full network with 19 organizations, but only eight of these participate in more than one venue. Identifying venues with a large number of participants (Table C-4) and organizations that participate in only one venue provides insight into the importance of some venues as they are the only places where select organizations participate. Removing these venues, therefore, may affect stakeholder dynamics and should be a consideration during any decisions regarding consolidation or removal of collaborative groups.

104. The list of participants were collected from official venue websites and thus may not fully capture all those who are affiliated with these venues.

FUTURE INVESTIGATIONS

This initial analysis laid out the basic geography of the Delta science-scape. Future investigations are needed to answer questions about how the structure of the network could be altered to more effectively achieve "good governance" of the Delta Science enterprise and to better understand the specific niches and roles in generating, communicating, and using science, as well as flows of resources such as funding or information across the network. Another important area for further inquiry to build off the current analysis involves assessing the effectiveness of the collaborative science governance network. While it can be difficult to measure network-level outcomes, one way of evaluating the science governance system involves eliciting the perceptions of individuals engaged in the system, and tracking these perceptions over time. This can be accomplished through quantitative surveys and qualitative interviews targeting key participants and venue leadership.



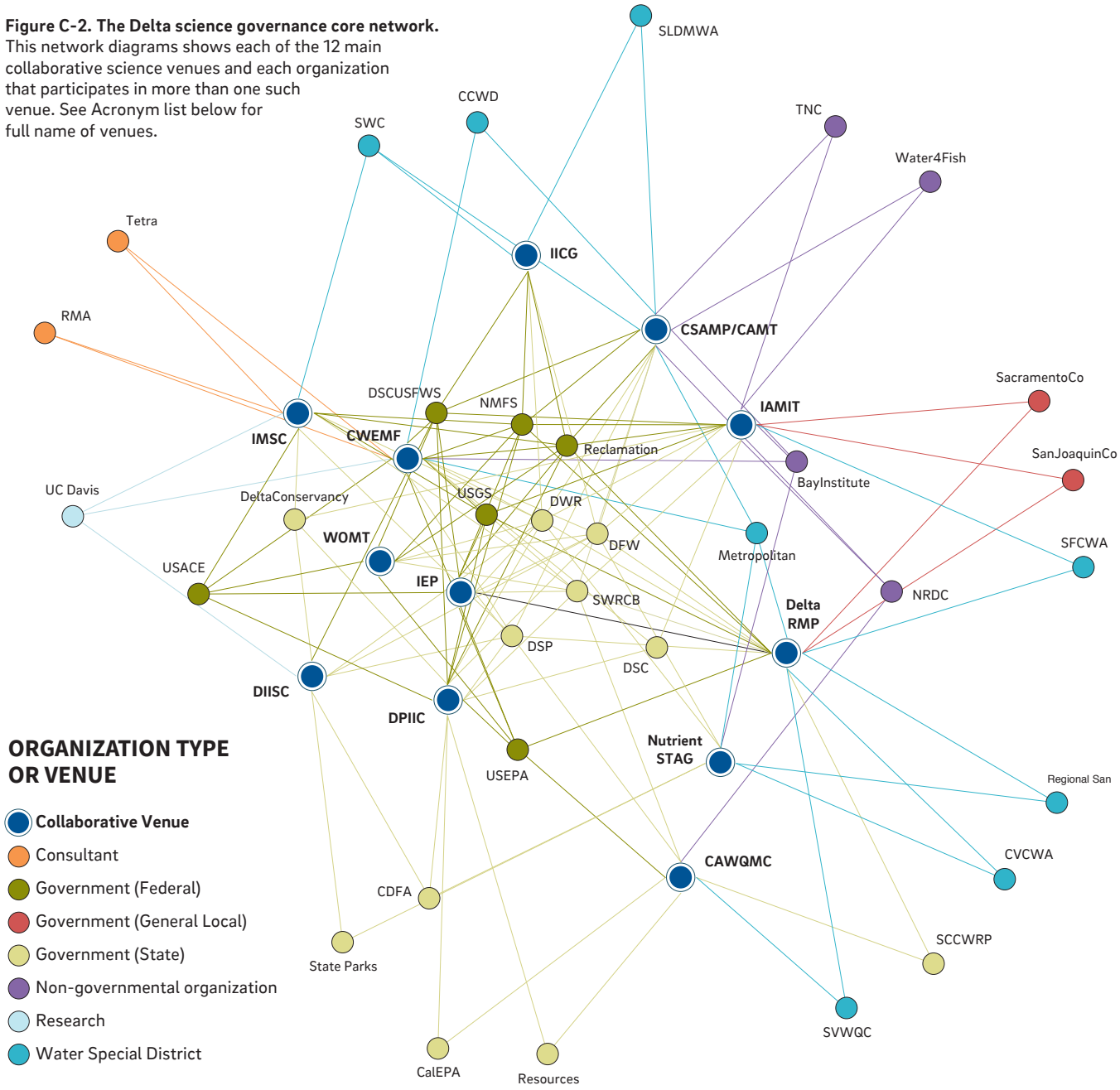
ORGANIZATION TYPE OR VENUE

- **Collaborative Venue**
- Consultant
- Government (Federal)
- Government (General Local)
- Government (State)
- Non-governmental organization
- Research
- Water Special District
- Consortium

Figure C-1. The Delta science governance full network, showing the main 12 Delta science collaborative venues (ringed circles) and all of the organizations (colors) that participate in at least one such venue. Organizations are connected with lines to venues if they participate in that venue.[105] Both organizations and venues are more centrally located in the diagram the more connections they have. See acronym list on pages C-9 and C-10 for full name of venues.

105. Note that in the case of CSAMP/CAMT, the participation structure is actually simpler, with multiple organizations represented by a single individual.

Figure C-2. The Delta science governance core network. This network diagrams shows each of the 12 main collaborative science venues and each organization that participates in more than one such venue. See Acronym list below for full name of venues.



LIST OF ACRONYMS

CalEPA: California Environmental Protection Agency

CSAMP/CAMT: Collaborative Adaptive Management Team

CAWQMC: California Water Quality Monitoring Council

CBEC: CBEC Engineering

CCWD: Contra Costa Water District

CDFA: California Department of Food and Agriculture

CDWP: California Drinking Water Program

ContraCostaCo: County of Contra Costa

CSustDelta: Coalition for a Sustainable Delta

CSWQA: California Stormwater Quality Association

CVCWA: Central Valley Clean Water Association

CVRWQCB: Central Valley Regional Water Quality Control Board

CVWD: Coachella Valley Water District

CWEMF: California Water and Environmental Modeling Forum

Davis Defenders: City of Davis Defenders of Wildlife

Delta RMP: Delta Regional Monitoring Program

DeltaConservancy: Sacramento-San Joaquin Delta Conservancy
DFW: Department of Fish and Wildlife
DIISC: Delta Inter-agency Invasive Species Coordination Team
DPC: Delta Protection Commission
DPIIC: Delta Plan Interagency Implementation Committee
DSC: Delta Stewardship Council
DSP: Delta Science Program
DWR: Department of Water Resources
EBMUD: East Bay Municipal Utility District
ElDoradoCo: County of El Dorado
ESJWQC: East San Joaquin River Watershed Coalition
Flood Board: Central Valley Flood Protection Board
FredLee: G. Fred Lee and Associates
FriantWater: Friant Water Authority
GCID: Glenn-Colusa Irrigation District
GEI: GEI Consultants
GGSA: Golden Gate Salmonid Association
GlennColusaWater: Glenn-Colusa Irrigation District
Granite: Granite Canyon Marine Pollution Studies Lab
Hoopa: Hoopa Valley Tribe
Hydroprose: Hydroprose Consulting
IAMIT: Interagency Adaptive Management Integration Team
ICF: ICF Consulting
IEP: Interagency Ecological Program
IICG: Interagency Implementation and Coordination Group
IronHouseSanD: Ironhouse Sanitary District
Jacobs: Jacobs Engineering
KCWA: Kern County Water Agency
KernWater: West Kern Water District
LarryWalker: Larry Walker Associates
LBNL: Lawrence-Berkeley National Labs
Limno: LimnoTech
MEI: McCord Environmental, Inc.
Metropolitan: Metropolitan Water District of California
MHCSD: Mountain House Community Services District
MLJ-LLC: Michael L. Johnson, LLC
MLML: Moss Landing Marine Laboratories
MVCA: Mosquito and Vector Control Associations
NASA: National Aeronautics and Space Administration
NMFS: National Marine Fisheries Service
NOAA: National Oceanic and Atmospheric Administration
NRDC: Natural Resource Defense Council
Nutrient STAG: Nutrient Stakeholder Technical Advisory Group
OCC: Orange County Coastkeeper
OEHHA: Office of Environmental Health Hazard Assessment
PCFFA: Pacific Coast Federation of Fishermen's Associations
Reclamation: US Bureau of Reclamation
Regional San: Sacramento Regional County Sanitation District
Resources: California Natural Resources Agency
RMA: RMA Companies
Romberg: Romberg Tiburon Center for Environmental Studies
Sacramento: City of Sacramento
SacramentoCo: County of Sacramento
SanDLA: Sanitary Districts of LA
SanJoaquinCo: County of San Joaquin
SCCWRP: Southern California Coastal Water Research Project
SCSMC: Southern California Stormwater Monitoring Coalition
State Parks: California State Parks and Recreation
Stockton: City of Stockton
SustainDelta: Coalition for a Sustainable Delta
SVWQC: Sacramento Valley Water Quality Coalition
SWAMP: Surface Water Ambient Monitoring Program
SWC: State Water Contractors
SWPCA: State Water Project Contractors Authority
SWRCB: State Water Resources Control Board
Tetra: Tetra Tech
TNC: The Nature Conservancy
Tracy: City of Tracy
TRWC: Truckee River Watershed Council
UC Berkeley: University of California, Berkeley
UC Davis: University of California, Davis
UC Merced: University of California, Merced
USACE: U.S. Army Corps of Engineers
USDA: U.S. Department of Agriculture
USDOI: U.S. Department of the Interior
USEPA: U.S. Environmental Protection Agency
USFWS: U.S. Fish and Wildlife Service
USGS: U.S. Geological Survey
Vacaville: City of Vacaville
Water4Fish: Water4Fish
Watershed: The Watershed Project
WAWA: Western Area Water Administration
WestConsult: West Consultants, Inc.
Westlands: Westlands Water District
WOMT: Water Operations Management Team
WoodardCurran: Woodard & Curran, Inc.
WPHA: Western Plant Health Association
WSJWQC: Westside San Joaquin River Watershed Coalition
YoloCo: County of Yolo
Yurok: Yurok Tribe

Table C-3 | Participation by Organization Type

NAME	NUMBER OF PARTICIPANTS	MEAN NUMBER OF VENUES
FULL NETWORK		
Government—Federal	9	5.1
Government—Local General	13	1.2
Government—State	15	4.2
Non-Governmental Organization	11	1.6
Research	8	1.3
Water Special Districts	9	1.6
Consortium	14	1.0
Consultant	5	1.1
CORE NETWORK		
Government—Federal	6	7.2
Government—Local General	2	2.0
Government—State	11	5.1
Non-Governmental Organization	4	2.8
Research	2	3.0
Water Special Districts	8	2.4
Consortium	0	0.0
Consultant	0	2.0

Table C-4 | Participation by Venue

VENUE	ACRONYM	NUMBER OF PARTICIPANTS	
		FULL	CORE
Delta Regional Monitoring Program	Delta RMP	33	17
California Water and Environmental Modeling Forum	CWEMF	30	17
Collaborative Adaptive Management Team	CAMT/CSAMP	22	15
Interagency Adaptive Management Integration Team	IAMIT	18	16
Delta Plan Interagency Implementation Committee	DPIIC/DASW	18	15
California Water Quality Monitoring Council	CAWQMC	13	8
Nutrient Stakeholder Technical Advisory Group	Nutrient STAG	12	8
Integrated Modeling Steering Committee	IMSC	15	12
Interagency Ecological Program	IEP	11	8
Water Operations Management Team	WOMT	10	8
Delta Interagency Invasive Species Coordination Team	DIISC	10	8
Interagency Implementation and Coordination Group	IICG	7	7

Appendix D | Process for Updating the Science Action Agenda

SCIENCE ACTION AGENDA

The Science Action Agenda identifies prioritized science activities to fill gaps in knowledge, achieve key objectives in the Delta Science Plan, and build science capacity to address decision-makers' challenges and management issues. The Science Action Agenda does not cover every important science activity in the Delta but focuses on those that serve as "gaps and glue:" science actions that are recognized as cross-agency and multi-group priorities and promote collaborative efforts, but fall between the mission statements and priorities of any single organization.

The first Science Action Agenda was released in September 2017 following interim efforts in 2014 and 2015. The Science Action Agenda will be updated every four years to reflect the ever-evolving Delta science landscape, although the process will retain flexibility to conduct science around unanticipated events (e.g. flood, earthquake, drought, levee failure, salt-water intrusion into the Delta). In these cases, the Delta Science Program will lead the effort to adjust the prioritized actions by working with the Delta science, management, and policy communities in an open and transparent manner. This approach enables the Science Action Agenda to be nimble and responsive to new conditions without compromising the near-term investments necessary to yield desired long-term dividends.

UPDATING THE SCIENCE ACTION AGENDA

Major thematic areas and specific science actions in the Science Action Agenda will be updated and identified every four years through an open process led by the Delta Science Program. Input from the Delta science community, including federal and state agencies, local agencies, academics, and interested public, will be received through outreach efforts (e.g. forums and workshops), surveys, and directed interviews, while additional information will be sourced from web-based inventories of science activities and strategic documents developed by various collaborative science groups in the Delta. The Delta Agency Science Workgroup, science advisory groups, and the lead scientists from Delta Science Program and IEP will provide guidance on refining and prioritizing the updated list of science actions and overarching action areas through applying a set of screening and prioritization criteria. The screening and prioritization criteria can be found in Boxes D-1 and D-2. The Delta Lead Scientist is responsible for articulating the rationale for the updated actions.

The Science Action Agenda may be updated more regularly in response to major changes in the Delta (e.g. major flood or invasion of non-native species) that require science support.

The 2021 updated Science Action Agenda will include two additional sections:

HORIZON SCANNING

Horizon scanning involves using a systematic process of assessing emerging trends such as changes in ecological processes, updated scientific understanding, new technology, and socio-economic dynamics that may be on the margins of today's management focus but may be important in the future. Future updates to the Science Action Agenda will include a horizon scanning exercise to determine these emerging trends and potential actions to support timely management decisions and reduce the likelihood of unwanted surprises in the future (Haddaway et al., 2017). Horizon scanning requires early input and interactions between experts from social, natural, and physical sciences and decision-makers to determine how to address upcoming issues that may be of importance to management decisions. Methods for assessing possible future issues may include focused interviews, literature searches, workshops, web mining, and surveys (Haddaway et al., 2017).

For the Science Action Agenda, horizon scanning topics should focus on:

a. Emerging science and technology identified in updates to the State of Bay-Delta Science

b. Ecological and physical processes and trends (e.g. new water quality contaminants, introduced species, population dynamics, climate change induced patterns) having a high likelihood of becoming an important management issue in the near future

c. Other anticipated long-term science needs

TOP DELTA SCIENCE QUESTIONS OF HIGH MANAGEMENT RELEVANCE

Another element that will be included in the next update of the Science Action Agenda will be a list of the top 50-100 science questions that have high management relevance. These will be in addition to the "gaps and glue" science actions. A potential method of identifying these additional science questions is to include the top 50-100 science actions that address key management needs selected through the application of both the screening and prioritization criteria used in developing the Science Action Agenda actions. These could be presented at policy-science forums for discussion between scientists and decision-makers regarding how appropriate the questions are in answering management needs.

REVIEW PROCESS

The Science Action Agenda will be reviewed by the public and Delta Independent Science Board, consistent with its responsibility to provide oversight of the scientific research, monitoring, and assessment programs that support adaptive management of the Delta.

JOINT IMPLEMENTATION OF THE SCIENCE ACTION AGENDA

The Science Action Agenda will be the shared science priority actions for the Delta science enterprise. It will provide the overarching agenda and direction for developing and updating individual science programs' work plans. The Delta Science Program and Delta Plan Interagency Implementation Committee agency directors will coordinate the implementation of the Science Action Agenda through an open process that connects agencies and interested parties to collectively fund priority actions. Collective implementation of the Science Action Agenda will build the knowledge base and science tools necessary to address decision-makers' needs. New knowledge gained through implementation of the Science Action Agenda will inform updates to the State of Bay-Delta Science as well as the Science Action Agenda.

The final document will be presented to the Delta Stewardship Council for acceptance and the Delta Plan Interagency Implementation Committee for endorsement. Similar to implementation of the Delta Science Plan, joint implementation of the Science Action Agenda will involve coordination among the Delta Plan Interagency Implementation Committee's agencies and stakeholders to carry out the actions through solicitations, coordinating projects, and identifying where current resources can be leveraged.

BOX D-1

SCREENING CRITERIA FOR INCLUDING SCIENCE ACTIONS IN THE SAA

1. **Science Topics/Actions Not Fully Addressed**
   a. Science action will contribute to forthcoming decisions that require additional information to evaluate the best alternatives (i.e. current information is only partially supported or the alternatives and associated uncertainties have not been fully explored).
   b. Management need is only partially addressed by an agency, set of agencies, or groups and requires further attention from the Delta community.
   c. Science action is only being partially funded or addressed by an agency or group and requires cross-agency support or is currently not being addressed by any group. Science actions that are well supported or in the final stages of implementation do not fall under this criterion.

2. **Cross-Agency and Multi-Group Priority**
   a. Management need is relevant to multiple agencies and organizations throughout the Delta and/or fulfills the mission of multiple groups.
   b. Science action is not site-specific or single agency focused and integrates the research and science goals of the larger Delta science community.
   c. The science action is linked to a high-priority policy issue that has cross-agency implications such as the California Water Action Plan, EcoRestore, WaterFix, the Delta Plan, or a new Governor's initiative.
   d. Executing the science action will help address achievement of the coequal goals in the Delta Plan.
   e. The outputs of the action will be directly used in water management or ecosystem management; the action has broad agency and stakeholder support.
   f. The action is included in multiple priority lists by science programs that carry out research and monitoring in the Delta.

3. **Feasible**
   a. The action can likely proceed given legal, fiscal, and institutional considerations.
   b. The capacity to carry out the research successfully is well established and described.

4. **Promotes Collaborative Efforts**
   a. Implementing the science action will provide opportunities to serve the needs of multiple agencies and organizations.
   b. The science action is synergistic with existing efforts and will support multi-agency collaboration.

BOX D-2

PRIORITIZATION CRITERIA FOR ACTIONS IN THE SAA

1. **Scientific Merit**
   a. The action is based on a sound rationale (e.g. has a high degree of support from relevant science communities and high potential to advance knowledge).
   b. Recommended by the Delta Lead Scientist, IEP Lead Scientist, Delta Independent Science Board, or an independent peer review panel.

2. **High-Impact**
   a. The action is useable by one or more key agencies within a four-year time frame.
   b. Identifies and addresses current or anticipated gaps in knowledge relevant to multiple agencies.
   c. Involves integrating existing data from individual agencies spanning various geographical locations.
   d. Identifies emerging issues requiring a rapid Delta-wide assessment to develop management needs.
   e. Supports synthesis activities that cross multiple existing programs or agency missions.
   f. Supports science infrastructure needs (the action supports the Delta science enterprise, and provides tools, facilities, or professional development for scientists).
   g. Has a high potential to address and resolve areas of scientific conflict.

3. **Timeliness/Need**
   a. The action is ready for further development and the opportunity for progress is high.
   b. The project has partial support and commitments that can be greatly enriched by focused short-term attention.

4. **Risk Assessment/ Opportunity Cost**
   a. Not taking this action today would pose a severe risk to core scientific, technical, and organizational capabilities to address management needs today and in the future.
   b. Addressing this scientific topic is an immediate opportunity for innovation and scientific advancements with high potential for critical new knowledge of the Delta.

Appendix E | The State of Bay-Delta Science

OBJECTIVE

Regularly summarize and communicate the state of current scientific knowledge for the Delta to inform policy, management decisions, and associated challenges. This includes assessing progress made on key research questions and identification of knowledge gaps.

CONTENT AND USE

The State of Bay-Delta Science is a collection of synthesis reports summarizing the latest scientific understanding of the Delta. Scientific information is distilled and presented in a manner that can be used to support policy and management decisions and inform future science endeavors. Future editions of the State of Bay-Delta Science will focus on drawing strong connections between management and policy needs to the science presented in all chapters and will be used to guide updates to the Science Action Agenda.

PRODUCTION TIMELINE

Two volumes of the State of Bay-Delta Science have been produced, the first in 2008 and the second in 2016. Following the release of the second volume in 2016, consideration was given to making the State of Bay-Delta Science a living document with a full summary report published at least once every four years. There would more frequent publication of topical synthesis reports and periodic online updates released as new knowledge becomes available. The four-year production cycle of the State of Bay-Delta Science will be aligned with the Biennial Bay-Delta Science Conference (offset from development of the Science Action Agenda). During production years, public gatherings of the Delta science community (e.g. the Biennial Bay-Delta Science and State of the Estuary Conferences, annual Interagency Ecological Program Workshop, and other synthetic workshops such as those hosted by the UC Davis Coastal and Marine Science Institute) will be used to gather additional input on the topics addressed in the State of Bay-Delta Science.

AUTHORS AND PUBLISHERS

The State of Bay-Delta Science will be written by relevant science experts with guidance from an editorial board. The Delta Science Program will be responsible for publishing the State of Bay-Delta Science.

REVIEW PROCESS

Individual reports that are part of the State of the Bay Delta Science will be published in a peer-reviewed, open-access journal (i.e. San Francisco Estuary and Watershed Science). The process by which the State of Bay-Delta Science is produced will be reviewed by the Delta Independent Science Board, after completion of the full summary report, at least once every four years.

Appendix F | Science Communication

This is an outline of existing and potential science communication tools being used by the Delta Science Program that could be included in science communication strategies.

a. Continue support for activities using existing communication tools

b. Continue support for the open access journal, *San Francisco Estuary and Watershed Science,* and expand its visibility and effectiveness as a communication tool within the community and beyond

c. Continue support for the San Francisco Estuary Partnership's *Estuary News* publication

d. Facilitate the transfer of information (research and monitoring designs, data, review papers, etc.) among scientists working in the Delta on a real-time basis using existing, expanded, and/or future web portals

e. Continue support for existing scientific conferences including the biennial Bay-Delta Science Conference and the State of the Estuary Conference. These venues are opportunities to discuss research findings, explore new initiatives, create collaborations, promote interactions among scientists, managers, policy-makers, educators, and media personnel, and unite as a community

f. Expand the number of workshops, seminars, and symposia currently being conducted—including brown bag luncheon seminars and symposia hosted jointly with the University of California, Davis, which are open to the public and free of charge

g. Improve the existing Delta Science Program website to make it a more effective science communication tool

h. Develop outreach materials summarizing recent scientific research results and findings specifically directed to policy and decision-makers

i. Continue regular summaries of science events and recent research results communicated at non-expert levels during public meetings (such as the Delta Stewardship Council meetings and the Delta Independent Science Board meetings)

j. Expand science communication efforts on social media outlets

k. Participate in educational opportunities

l. Establish shared guidelines for policy-science forums (Chapter 2, action 2.1)

m. Develop information sharing with other large water and ecosystem management programs in the U.S. and internationally

n. Identify mechanisms that allow agency scientists to access peer-reviewed scientific literature that is not available through online open access journals.

o. Develop an online repository for all open-access Delta science on the internet—the repository would aggregate and organize the best scientific and educational information, making it available to scientists, policy-makers, resource managers, the general public, educators, and students

Appendix G | Delta Independent Science Board Review

BACKGROUND

The Delta Independent Science Board (Delta ISB) has the following responsibilities under the California Water Code:

1. Provide oversight of the scientific research, monitoring, and assessment programs that support adaptive management of the Delta through periodic reviews of each of those programs (Water Code §85280(a)(3));
2. Provide independent science advice to the Delta Stewardship Council on the Delta Plan (Water Code §85308(a)); and
3. Provide a recommendation to the Delta Stewardship Council as to whom to appoint as the Delta Lead Scientist ((Water Code §85280(b)).

The Delta ISB is comprised of 10 members from different disciplines and across the United States, and its reviews and meetings are conducted in accordance with the Bagley-Keene Open Meeting Act. A member of the Delta ISB is appointed by the Delta Stewardship Council and can serve up to 10 years on the Delta ISB. Although the Delta Stewardship Council's Delta Science Program provides funding and staff services to the Delta ISB, the Delta ISB is an independent body and will exercise its independent judgement.

Like all technical expert bodies, the Delta ISB does not make policy decisions but does provide the scientific foundation for such decisions. The comments, findings and recommendations from the Delta ISB are expected to increase scientific credibility, improve research clarity, advance the debate about Delta issues, and seek better connectivity between science, management, and policy.

REVIEW OF PROGRAMS THAT SUPPORT ADAPTIVE MANAGEMENT

Given the numerous programs that support adaptive management in the Delta, reviewing each individually would not be feasible. Moreover, this would artificially fragment the Delta ISB's assessments of efforts that address the same issues. Delta science cuts across the boundaries of water and habitat projects and the many government agencies, universities, consultants, and interest groups involved. Accordingly, the Delta ISB reviews programs by thematic areas, which tends to follow the organization of the Delta Plan:

- Adaptive Management (Chapter 2)
- Water Supply (Chapter 3)
- Ecosystem (Chapter 4)
- Delta as an Evolving Place (Chapter 5)
- Water Quality (Chapter 6)
- Risk Reduction (Chapter 7)

However, the Delta ISB has also reviewed thematic areas outside of the chapters of the Delta Plan. These thematic reviews are selected by the Delta ISB based on input from the public. In the past, the Delta ISB has submitted a survey to the Delta community on what thematic reviews to undertake and held a planning retreat with science and policy leaders to discuss ideas for reviews.

Prior to undertaking an internally generated thematic review, the Delta ISB will prepare a brief prospectus describing the review purpose and process. This prospectus will undergo a formal public review period of at least two weeks, after which the Delta ISB will consider comments received before finalizing the purpose and process of the review.

The methods for developing the findings and recommendations differ by thematic review. However, the Delta ISB will usually review existing documents, organize workshops/panel discussions, attend conferences of interest, conduct one-on-one interviews with program personnel, and release a questionnaire to help inform the review.

Reports for thematic reviews are usually written for decision-makers, such as the Delta Stewardship Council. Reviews are finalized when a majority of the members approve the draft report at a public meeting. Prior to finalizing, a draft report will undergo a formal public review period. Upon completion of the review, the findings and recommendations are presented to the Delta Stewardship Council and at other venues (e.g. Bay-Delta Science Conference).

REVIEW OF SPECIFIC PRODUCTS

In addition to the review of "programs," the Delta ISB also reviews specific products (e.g. environmental impact reports/statements, science plans, etc.) related to adaptive management and the Delta Plan. These reviews are either self-initiated or based on a specific request from an individual or entity. The Delta ISB will take on requests if it has time, and if the subject matter is within its jurisdiction and expertise. All products reviewed by the Delta ISB are made public, discussed at public meetings, and posted on the Delta ISB website.

Depending on the scope of the review, the Delta ISB may draft a comment letter, memo or report. Comment letters or memos by the Delta ISB are addressed to the entity who developed the product that is being reviewed, or to the entity who requested the review. Reviews are finalized when a majority of the members approve a draft at a public meeting. Alternatively, the Delta ISB may choose to have individual members submit comments (rather than a full Delta ISB review) if there is a need for a short turnaround.

CORRESPONDENCE WITH THE DELTA ISB

Any person, group, or organization may send a letter to the Delta ISB by addressing it to either the Delta ISB Chair, Delta Stewardship Council Chair, or to the Lead Scientist, or by delivering the letter during a public meeting. All correspondence will be posted on the Delta ISB website.

CONFLICT OF INTEREST POLICY AND OPERATING GUIDELINES

As stated in Water Code §85280(a)(2), the members "shall not be directly affiliated with a program or agency subject to the review activities of the Delta Independent Science Board." Delta ISB members will disclose any professional activities in which they are engaged that may be perceived as being related to any program or agency subject to the review activities of the Delta ISB at its public meetings.

For the full operating guidelines and the conflict of interest policy, visit: http://deltacouncil.ca.gov/docs/delta-independent-science-board-operating-guidelines-0.

Appendix H | Policy and Procedures for Independent Scientific Review

BACKGROUND

As part of its mission to provide the best available scientific information to guide management and inform policy in the Bay-Delta system, the Delta Science Program promotes and provides independent scientific review of processes, programs, plans, and products. The policies and procedures below describe how the Delta Science Program conducts and facilitates independent scientific review.

DECISION TO PROVIDE REVIEW

Independent scientific review may be requested by any agency or other interested party. The review will focus on one or more written documents. The Delta Science Program's decision to provide a review will depend on other, sometimes competing, commitments of the Delta Science Program and the relevance of the review with respect to the goals and objectives of it and the Delta Stewardship Council. Moreover, the Delta Science Program will only agree to provide a review if there is sufficient funding available for the review, if the proposed materials are complete and ready for review, and if there is sufficient time available to complete the review and deliver a report. The ultimate decision to provide a review rests with the Delta Science Program's Lead Scientist.

PLANNING MEETINGS

The Review Planning Committee (Planning Committee) typically meets several times prior to the review. Participants in the review planning meetings may include members of the requesting party, authors of the document(s) subject to review, and interested agency/stakeholder representatives, as determined by the Delta Science Program and the review-requesting party. Participants in the Planning Committee may communicate their expectations for the pending review, provide input on the Charge to the Panel, consider the review schedule and panel-member composition, and provide pertinent background documents or other instructional materials for the review through the Delta Science Program.

CHARGE TO THE PANEL

Charge questions will be technical (or analytical) in nature, and will not include policy prescriptions (however, it is recognized that responses and other information in a review report may be used in future decision-making by resource managers and policymakers). Accordingly, charge questions and tasks will be crafted to best draw applicable guidance but not to solicit explicit policy recommendations or prescriptions. Charge questions are developed with input from the Planning Committee. The Lead Scientist has the final authority for the Charge to the Panel.

The scope of the Charge to the Panel will include background information (including the legal, regulatory, and management background necessary to set the full policy context), questions and tasks for the panel, a description of the role of the panel and rules for its deliberations, the form and scope of the review product, and a schedule of deliverables.

INDEPENDENT SCIENCE REVIEW PANEL

Panels generally consist of no fewer than five members. Potential panel members may be identified through Delta Science Program staff input, the Delta Science Program's science expert database, publication records on relevant topics, recommendations from the Lead Scientist, and other professional recommendations (i.e. from other leading scientists and the Planning Committee). The Lead Scientist has the final authority for the selection of Independent Scientific Review Panel members and will consider input from the review planning committee. The selection of panelists will consider an individual's standing in the scientific community, expertise in disciplinary areas, technical skills relevant to the documents and issues subject to review, and absence of a demonstrated conflict of interest. Collectively, a panel is expected to have a broad range of expertise including some familiarity with the geographic region, physical processes, policy issues, ecosystems, and species-specific aspects of the review.

MATERIALS FOR REVIEW

Materials to be reviewed by the Independent Scientific Review Panel include the review document(s) and pertinent background materials. Background materials will not be limited to the (specific) technical questions and issues in the Charge to the Panel. Materials can include documents describing the legal and regulatory context of the review questions and tasks, providing the management implications of materials provided to the review panel, and any other documents relevant to the review report. Other study materials or information identified as pertinent to the review introduced by panel members during the panel meeting, can be used at the discretion of the panel. Panels are encouraged to request any additional information or other materials that might facilitate their deliberations and report production. Stakeholders and other interested parties may submit materials to be considered by the review panel; however, final decisions relating to any materials to be provided to the review panel rest with the Lead Scientist.

COMMUNICATION WITH THE PANEL

No direct communications by interested parties, including the agency that produced the document subject to review, should be made with panel members on issues pertinent to the review during the review period without the knowledge and consent of the Delta Science Program. The panel may be asked to disregard any communication received without the knowledge and consent of the Delta Science Program.

PUBLIC MEETINGS

The review process will be open and transparent to the extent possible. Unless there are compelling reasons to do otherwise, each independent scientific review will have a public meeting. While the review panel deliberates to develop their recommendations, the opportunity for public comment will be provided as a part of any open (public) sessions of each review.

PUBLIC COMMUNICATION

A webpage accessible through the Delta Stewardship Council and Delta Science Program website will present background information on each independent Scientific Review undertaken, meeting agendas, membership of panels convened, all background materials and documents to be reviewed, and the final review document. To the extent possible, all materials for panel review will be posted on the website at the same time that they are provided to the panel; at a minimum, 10 days in advance of the first meeting of the review panel. Scheduling and other information about that meeting and the availability of review report(s) will be sent to the Delta Stewardship Council's listserv.

The Delta Science Program will compile and retain a record of the review, including the materials described above as well as any additional materials provided to the panel including presentations from the public sessions of meetings.

PANEL REPORT(S)

The Delta Science Program may suggest grammatical or formatting edits of a draft report to improve it but will not otherwise substantively amend a review panel report. The content, substance, and recommendations of a review panel report are those of the review panel, not the Delta Science Program or Delta Stewardship Council. The Delta Science Program will post the report after approval of the panel. The Delta Science Program may provide a courtesy copy of the report to the agency that produced the materials subject to review in advance of posting the report. If the agency that produced the materials subject to review chooses to develop a written response, the response will be posted along with the review at the time it becomes available.

Appendix I | Policy and Procedures for Independent Science Advisors

BACKGROUND

As part of its mission to provide the best available scientific information to guide management and inform policy in the Bay-Delta system, the Delta Science Program promotes and provides independent scientific advisors. Advisors are typically requested to give input on the development of processes, programs, plans or products; whereas, review panels (the most common panels organized by the Delta Science Program) are used to evaluate completed processes, programs, plans, and products. The policies and procedures below describe how independent scientific advisory services provided by the Delta Science Program will be conducted.

DECISION TO PROVIDE ADVISORS

Independent science advisors may be requested by any agency or other interested party. The Delta Science Program's decision to provide advisors will depend on other, sometimes competing, commitments of the Delta Science Program and the relevance of the advisors with respect to the goals and objectives of it and the Delta Stewardship Council. Moreover, the Delta Science Program will only agree to provide a science advisory panel if there is sufficient funding available for the advisory services and if there is sufficient time available to complete the advisory work and deliver one or more written products. The ultimate decision to provide science advisors rests with the Delta Science Program's Lead Scientist.

PLANNING MEETINGS

Planning meetings for science advisors typically occur several times prior to and throughout the science advisors effort. The Delta Science Program will work directly with members of the requesting party and the authors of the document(s) being prepared with advisory input (if different from the requesting party). The requesting party and/or authors of the document(s) to be prepared with advisor input may:

- Communicate their expectations for the pending scientific advice
- Provide input on the Charge to the Science Advisors
- Inform the advisor schedule
- Identify desired expertise and make recommendations for selecting individual and/or a panel of advisors, inform the composition of advisors, and
- Provide pertinent background documents or other instructional materials to review through the Delta Science Program

CHARGE TO THE ADVISORS

Charge questions are developed with input from the requesting party. The Lead Scientist has the final authority for the charge to the science advisors. Charge questions will be technical (or analytical) in nature, and will not include policy prescriptions (however, it is recognized that responses and other information in a review report may be used in future decision-making by resource managers and policymakers). Accordingly, charge questions and tasks will be crafted to best draw applicable technical guidance but not to solicit explicit policy recommendations or prescriptions.

The scope of the Charge to the Advisors will include background information (including the legal, regulatory, and management background necessary to set the full policy context), questions and tasks for the advisors, a description of the role of the advisors and rules for their deliberations (if the science advisors are working as a panel), any required or relevant reading materials, and a schedule of deliverables.

ADVISORS

Independent Science Advisors provide written responses to advisory questions specified in their charge. Comments and advice are often provided over more than one exchange with the requesting party and/or author(s) of the product for which advice is sought. Advisors may work independently or collectively as a panel to provide scientific advice. One or more science advisor(s) may be selected depending on the scope and scale of the services requested. If a panel of independent science advisors is requested and deemed appropriate by the Lead Scientist, between three and seven panel members will be selected by the Lead Scientist in consultation with the requesting party. Potential science advisors for individual or panel advisory services may be identified through Delta Science Program staff input, the Delta Science Program's science expert database, publication records on relevant topics, recommendations from the Lead Scientist, and other professional recommendations (i.e. from other leading scientists and the advisor requesting party). The Lead Scientist has the final authority for the selection of independent science advisors and will consider input from the advisor requesting party. The selection of panelists will consider an individual's standing in the scientific community, expertise in disciplinary areas and with technical skills relevant to the documents and technical issues subject to advice, and absence of a demonstrated conflict of interest. Advisors are expected to have a broad range of expertise including some familiarity with the geographic region, physical processes, policy issues, ecosystems, and species-specific aspects for which scientific advice is sought.

MATERIALS FOR COMMENT

Materials under advice and subject to comment by independent science advisors include draft documents and pertinent background materials. Background materials will not be limited to the (specific) technical questions and issues in the charge to the advisors, but can include documents describing the legal and regulatory context of the advisory questions and tasks, and consider the management implications of materials provided to the advisors relevant to the objectives of the charge questions. Other study materials, or information identified as pertinent to the advisory effort introduced by advisors during their advisory work, can be used at the discretion of the advisors. Advisors are encouraged to request any additional information or other materials that might facilitate their deliberations and written comments. Stakeholders and other interested parties may submit materials to be considered by the advisory panel; however, final decisions relating to any materials to be provided to the advisory panel rest with the Lead Scientist.

COMMUNICATION WITH ADVISORS

No direct communications by interested parties, including document authors or the advisor requesting party, should be made with advisors on issues pertinent to the advisory effort during the time of advisor services without the knowledge and consent of the Delta Science Program. The advisors may be asked to disregard any communication received without the knowledge and consent of the Delta Science Program.

PUBLIC MEETINGS

Independent science advisors efforts may or may not involve public meetings. Decision to include a public meeting as part of the science advisor effort will depend on the scope, scale, and stage of the effort under comment. The decision to include a public meeting will be up to the Lead Scientist in consultation with the requesting party. If the Lead Scientist determines there is a compelling reason to have a public meeting, advisors will communicate their comments, and an opportunity for public comment will be provided as a part of any open (public) sessions of each meeting.

PUBLIC COMMUNICATIONS

A webpage accessible through the Delta Stewardship Council and Delta Science Program website will present background information on independent science advisor efforts undertaken, meeting agendas (if applicable), and identification of advisors convened, relevant materials, and advisory comments. If a public meeting is to be held, relevant materials and the agenda will be posted on the website at a minimum of 10 days in advance of the advisory meeting. Scheduling and other information about that meeting and the availability of relevant advisory materials will be sent to the Delta Stewardship Council's listserv.

The Delta Science Program will compile and retain a record of the advisory effort, including the materials described above as well as any additional materials provided to the advisors including presentations from the public sessions of meetings.

ADVISOR COMMENTS, MEMOS, AND/OR REPORTS

The Delta Science Program may suggest grammatical or formatting edits of independent science advisor draft comments, memos, and/or reports to improve them but will not otherwise substantively amend input from advisors. The content, substance, advice, and recommendations of a science advisory product are those of the advisor(s), not the Delta Science Program or Delta Stewardship Council. The Delta Science Program will post the final comments, memos, and/or reports after approval of the advisor(s). The Delta Science Program may communicate initial comments, memos, and/or reports to the advisor requesting party and/or document author(s) at any time during the advisory service. A copy of any final products by the advisor(s) and the exchange between advisors and the advisor-requesting party may be provided as a courtesy to the advisor-requesting party in advance of public posting.

Appendix J | Policy and Procedures for Independent Science Workshops

BACKGROUND

As part of its mission to provide the best available scientific information, to guide management and inform policy making in the Bay-Delta system, the Delta Science Program (DSP) promotes and coordinates independent synthesis workshops to communicate the state of scientific knowledge on topics of importance to decision-makers. The purpose of a synthesis workshop is to obtain a synthesis of the scientific information, on an important topic with major management or policy implications, based on published papers, reports, and other information—including professional judgment and experience, in a short period of time. The policies and procedures below describe how science workshops provided by the Delta Science Program will be conducted.

DECISION TO HOLD A WORKSHOP

A science workshop may be requested by an agency or other interested party. The workshop will focus on the scientific information related to an important topic with management or policy implications. The Delta Science Program's decision to conduct a workshop will depend on other, sometimes competing, commitments of the Delta Science Program and the relevance of the workshop of the goals and objectives to the Delta Stewardship Council. Moreover, the Delta Science Program will only agree to conduct a workshop if there is sufficient funding available, sufficient time available to complete the workshop and deliver a report, and sufficient scientific information to justify a workshop. The ultimate decision to conduct a workshop rests with the Lead Scientist for the Delta Science Program.

PLANNING MEETINGS

Meetings to plan for a workshop may be held with members of the requesting party and interested agency/stakeholder representatives (Workshop Planning Group) prior to initiation of the workshop. Participants in a Workshop Planning Group communicate their expectations for the pending workshop, provide input on the Charge to the Panel, consider the workshop agenda and panel-member composition, and provide pertinent background documents or other instructional scientific materials for the workshop through the Delta Science Program.

CHARGE TO THE PANEL

Charge questions are developed with input from the Workshop Planning Group. The Lead Scientist has the final authority for the Charge to the Panel. Charge questions will be technical (or analytical) in nature, and will not include policy prescriptions (however, it is recognized that responses and other information in a workshop report may be used in future decision-making by resource managers and policymakers). Accordingly, charge questions will be crafted to best draw applicable guidance, but not to solicit explicit policy recommendations or prescriptions.

The scope of the Charge to the Panel will include background information (including the legal, regulatory, and management background necessary to set the full policy context), questions and tasks for the panel, a description of the role of the panel and rules for its deliberation, the form and scope of the workshop product, and a timeline of deliverables.

INDEPENDENT SCIENCE WORKSHOP PANEL

Panels will include no fewer than three members. The Lead Scientist has the final authority for the selection of Independent Science Workshop Panel members and will consider input from the Workshop Planning Group. The selection of panelists will consider an individual's standing in the scientific community, expertise in disciplinary areas, technical skills relevant to the documents, presentations, and technical issues to be evaluated in the workshop, and absence of a demonstrated conflict of interest. A panel, as a whole, is expected to have a broad range of expertise including some familiarity with the geographic region, physical processes, policy issues, ecosystems, and species-specific aspects of the workshop topic.

WORKSHOP MATERIALS

Materials to be provided to the Independent Science Workshop Panel will include scientific literature relevant to the workshop topic and pertinent background materials. Workshop materials may also include a preliminary synthesis report prepared by or under the direction of Delta Science Program staff. Background materials will not be limited to the specific technical questions and issues in the Charge to the Panel, but can include documents describing the legal and regulatory context of the workshop questions and tasks, and consider the management implications of materials provided to the workshop panel and relevant to the workshop report. Other study materials or information identified as pertinent to the workshop introduced by panel members during the panel meeting can be used at the discretion of the panel. Panels are encouraged to request any additional information or other materials that might facilitate their deliberations and report production. Stakeholders and other interested parties may submit materials to be considered by the workshop panel; however, final decisions relating to any materials provided to the panel rest with the Lead Scientist.

WORKSHOP PRESENTATIONS

In addition to the written materials provided to the panel prior to the workshop, scientific presentations will be conducted as part of the public component of the workshop. As with written materials, presentations may provide necessary background and regulatory context, but most presentations will focus on recent and ongoing scientific research, synthetic efforts by local experts, and scientifically-based expert opinion. Stakeholders and other interested parties may propose topics and presenters to address the panel; however, final decisions related to any presentations rest with the Lead Scientist.

COMMUNICATION WITH THE PANEL

No direct communications by interested parties (including the agency or party that requested the workshop) with panel members on issues pertinent to the workshop should be made without the knowledge and consent of the Delta Science Program. The panel may be asked to disregard any communication received without the knowledge and consent of the Delta Science Program.

PUBLIC MEETINGS

The workshop process will be open and transparent to the extent possible. Unless there are compelling reasons to do otherwise, each independent scientific workshop will have a public meeting. The workshop panel will deliberate to develop their recommendations and an opportunity for public comment will be provided as a part of any open (public) sessions of each workshop.

PUBLIC COMMUNICATION

A webpage accessible through the Delta Stewardship Council and Delta Science Program website will present background information on each Independent Science Workshop, meeting agendas, membership of panels convened, all background materials and presentations, and the final panel document. To the extent possible, all materials will be posted on the website at the same time that they are provided to the panel; at a minimum, 10 days in advance of the first public meeting of the workshop panel. Scheduling and other information about that meeting and the availability of workshop report(s) will be sent through the Delta Stewardship Council's listserv.

The Delta Science Program will compile and retain a record of the workshop, including the materials described above, as well as any additional materials provided to the panel including presentations from the public sessions of meetings.

PANEL REPORT(S)

The Delta Science Program may suggest grammatical or formatting edits of a draft report to improve it but will not otherwise substantively amend a workshop panel report. The content, substance, and recommendations of a workshop panel report are those of the panel, not the Delta Science Program or Delta Stewardship Council. The Delta Science Program will post the report after approval of the panel. The Delta Science Program may provide a courtesy copy of the report to the agency or party that requested the workshop in advance of posting the report. If the agency that requested the workshop chooses to develop a written response, the response will be posted along with the report at the time it becomes available.

Appendix K | Policy and Procedures for Research Funding

Funding scientific research is a key means for the Delta Science Program to achieve its mission to "provide the best possible scientific information to inform water and environmental decision making in the Delta." There are three basic processes that the Delta Science Program uses to select research projects for funding: Proposal Solicitations, Requests for Proposals, and Directed Actions. The choice of which of these processes to use for research needs depends on the source of funding, the time frame for the scientific information needed, and the specificity of the information needed. Each of these three methods for funding research is described here. The decision about which funding process to use ultimately rests with the Delta Science Program's Lead Scientist in consultation with the Delta Stewardship Council's Executive Officer. All proposals will be subjected to administrative and scientific peer review as described below, under the direction of the Lead Scientist. All reviewers will be screened for potential conflicts of interest as described in Appendix L.

PROPOSAL SOLICITATIONS

This funding method is implemented through the development of a proposal solicitation package and is a competitive process for distributing available research funding. Proposal solicitations are used when the research needs (topics) are relatively broad and the funding is available to a broad range of potential recipients. Funding may come from several sources with differing constraints and priorities—for those funded fully or in part by the Delta Science Program, the competitive solicitation must be based on the guidance provided in the Science Action Agenda. Proposals submitted by the due date and in accordance with the proposal solicitation package instructions receive independent external scientific review with final recommendations for funding made by the Lead Scientist. Proposal solicitations will be conducted based on the following criteria.

PLANNING

While topics for a proposal solicitation may come from existing planning efforts, it is important to have up-to-date input from the agencies and institutions participating in the solicitation. A proposal solicitation planning group, organized by the Delta Science Program, will help to develop the solicitation topics and will make recommendations on other elements of the proposal solicitation package. Final approval of the proposal solicitation package rests with the Lead Scientist.

THE PROPOSAL SOLICITATION PACKAGE

The proposal solicitation package is a comprehensive package of information for applicants wishing to submit a proposal for research funding. The proposal solicitation package covers the priority research topics, eligible applicants, approximate amount of funding available, constraints on the available funding, instructions for proposal submission, due date, the review process, criteria for review, how proposals are recommended for funding, and how final funding decisions will be made. The proposal solicitation package may be supplemented with guidelines required by the funding legislation.

REVIEW OF PROPOSALS

Proposals first undergo administrative review to determine if they are responsive to the proposal solicitation package, are complete, were submitted on time, and the applicant is eligible. Administrative review may also include an assessment of past performance by the applicants on previously-funded research grants, if applicable. Applications that pass administrative review are distributed to subject matter experts for scientific review. All reviewers are given the same set of instructions and criteria for rating the proposals. Each proposal is reviewed by no less than two, and preferably three or more, individual reviewers. The Lead Scientist organizes a review panel meeting that consists of technical experts in fields relevant to the topics and proposals. The purpose of the review panel is to make funding recommendations to the Lead Scientist.

RECOMMENDATIONS FOR FUNDING

Based on the recommendations of the review panel, the Lead Scientist will make funding recommendations for consideration by the Delta Stewardship Council. These may include recommendations for partial or reduced funding for specific proposals. The Lead Scientist will consult with the Executive Officer of the Delta Stewardship Council on the recommendations for funding.

REQUESTS FOR PROPOSALS

Requests for proposals are used when the project scope is well developed but many individuals or entities may be qualified to do the work. That is, the "what" is known but not the "who." These situations arise when scientific research or planning activities are needed to support an important management decision, or to generate information essential to create the foundation for a proof-of-concept for larger projects. Many of these opportunities tend to occur outside the normal proposal solicitation package window. Requests for scientific research or planning needs to be consistent with the Science Action Agenda and/or be identified and documented as a key uncertainty by one or more collaborative science venues (e.g. Collaborative Adaptive Management Team, Bay or Delta Regional Monitoring Program) and/or create synergies with projects already underway or with a committed funding source in place. Requests for proposals follow well established State policies and guidelines and follow a formal competitive bidding process open to any eligible and qualified individual or team. For the Delta Science Program, the preferred process is as follows:

- The request for proposal is posted online (qualified individuals or teams may be notified of the request for proposal posting directly)
- Proposals including cost proposals are submitted
- Responsive proposals are reviewed and scored by an evaluation committee that will include appropriate discipline-relevant scientists determined by the Lead Scientist
- The contract is awarded to the highest scoring proposal

DIRECTED ACTIONS

Similar to the "Rapid Response Grants" process of the National Science Foundation, Directed Actions are appropriate when the scientific research or advice is needed quickly, and/or an important opportunity would be lost if the proposal waited for the standard competitive proposal solicitation package or request for proposal process. Typically, there is only one entity (individual or team) that is qualified and available to do the work within the desired timeframe. Examples might include scientific research in response to a natural event such as a flood or drought, detection and description of a new invasive species, or proposals addressing high priority management issues developed through a collaborative process. The Directed Action funding process is non-competitive but must comply with Delta

Stewardship Council rules. As with science request for proposal, requests for Directed Actions must be consistent with the Science Action Agenda and clearly be identified and documented as a key uncertainty by one or more collaborative science venues (e.g. Collaborative Adaptive Management Team, Bay or Delta Regional Monitoring Program) and create synergies with projects already underway or with a committed funding source in place. Rapid response may be necessary or justified when an unusual event occurs that provides an opportunity for learning and advancing the state of knowledge, such as an extreme natural event, human-caused disaster, or an adaptive management action that may serve as a controlled large-scale experiment with high probability of generating one or multiple measurable signals to test key hypotheses.

Funding decisions will be based on:

- Availability of funds
- Benefits that the grant would accrue to our understanding of the Bay-Delta system
- Urgency and unique nature of the problem to be addressed
- Expected contribution to supporting management actions or policy decisions
- Scientific and technical merit
- How the proposal was developed (Was it developed through an open transparent collaborative process that included stakeholder participation?)

THE REVIEW PROCESS AND DECISION

Timing will be critical for directed actions. The proposal should be submitted to the Delta Science Program. The Lead Scientist will decide whether the urgency and topic merits further consideration. If not, the proposal will be returned to the proposers with confidentiality of the proposal maintained and an explanation of why the proposal is not being considered further. Applicants are strongly encouraged to talk to Delta Science Program staff before submitting a proposal. The Lead Scientist will determine the specific set of proposal reviewers depending on the scope of the proposal and the magnitude of the problem. Unless the proposal has already been independently reviewed, the proposal will be reviewed by at least:

- Delta Science Program scientist(s)
- One discipline-relevant scientist from within the Bay-Delta community of scientists
- A state or local agency manager with direct knowledge of the relevance of the activity

The Lead Scientist may request additional reviews by external discipline-relevant scientists from outside the Bay-Delta science community. The Lead Scientist will make the final decision and may approve, approve with specific conditions, or reject the proposal. Because approved Directed Action proposals meet an urgent need, funding of approved proposals will be pursued as quickly as feasible and should be of limited duration, normally less than two years.

Appendix L | Conflict of Interest Policy for External Research Proposal and Fellowship Application Reviewers, Advisors, and Applicants

As part of its mission to provide the best available scientific information to inform water and environmental decision making int he Delta, the Delta Science Program takes steps to ensure the integrity of its work products and processes. To do so, it must take reasonable steps to guard against even the perception of conflict of interest. Of course, acts that are banned by State conflict-of-interest laws, regulations, and Delta Stewardship Council policies are prohibited. Actions or activities that could create the perception of bias, favoritism, or unfair funding decisions are the subject of this policy.

Situations that may have conflict-of-interest implications include:

- Reviewing proposals or applications
- Advising the Delta Science Program on proposal solicitations or Science Fellows applications
- Submitting a bid, proposal or application

PROPOSAL OR APPLICATION REVIEWS

The Delta Science Program avoids financial, professional, or personal conflicts of interest by selecting reviewers who have no financial, professional, or personal connection to the proposals that they review. In addition, the Program seeks to avoid selecting reviewers for whom there may be a perception of bias. Proposal reviewers are selected based on their scientific and technical expertise, not based on their affiliation with an agency or organization. Because potential conflicts of interest are not always apparent, the Delta Science Program expects potential reviewers to promptly disclose any direct or indirect financial, professional, personal or other connection to a proposal, so that the Program can make a determination about the suitability of that reviewer for the specific proposals at issue.

A reviewer has a disqualifying conflict of interest if the reviewer:

- Has assisted in the development of the proposal to be reviewed in any way
- Will receive a direct or indirect financial benefit from the funded project
- Has a conflict of interest under California law

A reviewer has an institutional, personal, or professional connection to a proposal applicant that may disqualify them if any of the following relationships were applicable during the past four (4) years:

- Collaboration on research
- Co-authorship of publication(s)
- Thesis or post-doctoral advisor/advisee relationship
- Supervisor/employee or independent contractor relationship
- Reviewer and an applicant are employees of the same federal, state, or local agency; university; or private firm—even if they are in different divisions
- Reviewer and applicant have a close personal relationship

Institutional, personal, or professional connections will not necessarily disqualify the reviewer. The Delta Science Program Lead Scientist will review the information submitted regarding such connections to the proposal to determine if the disclosed connections are sufficient to compromise the objectivity of the reviewer. If the Lead Scientist determines that any disclosed connection may result in bias, favoritism, or an unfair funding decision, the Delta Science Program will reassign the proposal.

INDEPENDENT SCIENCE REVIEWER

An independent science review panel member is contracted for their expertise relevant to the material to be reviewed. The consideration of an independent science expert for their role as a reviewer has a disqualifying conflict of interest if the expert:

- Has assisted in the development of the material to be reviewed
- Will receive a direct or indirect financial benefit from the funded project
- Has a conflict of interest under California law

PROVIDING ADVICE TO THE DELTA SCIENCE PROGRAM

Public Contract Code section 10365.5 provides in part as follows:

"(a) No person, firm, or subsidiary thereof who has been awarded a consulting services contract may submit a bid for, nor be awarded a contract for the provision of services, procurement of goods or supplies, or any other related action which is required, suggested, or otherwise deemed appropriate in the end product of the consulting services contract."

Because of this prohibition, any person, firm or subsidiary thereof who may be acting as an advisor to the Delta Science Program should consider whether such advising role would preclude them from subsequently submitting a bid or being awarded a contract. When commenting on topics or priorities for funding programs, Delta Science Program/Delta Stewardship Council contractors or participants in Delta Science Program/ Delta Stewardship Council committees or work groups may be acting as advisors and should consider how their participation might affect future funding opportunities.

SUBMITTING A BID, PROPOSAL, OR APPLICATION FOR FELLOWSHIP

Any person, agency, or institution that is considering submitting a bid, proposal, or application for funding or fellowship opportunity should disclose their personal, agency, or institution's participation in any Delta Science Program/Delta Stewardship Council committee or workgroup that has provided advice on topics or priorities for funding. To avoid the perception of bias, favoritism, or unfair funding decisions, the Delta Science Program may recommend against submittal of the bid, proposal, or application in question.

Coequal Goals

The Delta Stewardship Council was created in legislation to achieve the state mandated coequal goals for the Delta. "'Coequal goals' means the two goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place."

(CA Water Code §85054)