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Second Draft Delta Science Plan

One Delta, One Science

August 22, 2013

Delta Science Program
Delta Stewardship Council

SECOND DRAFT DELTA SCIENCE PLAN

This is the second draft of three versions of the Delta Science Plan, which will be presented to the Delta Stewardship Council (Council) in the following order:

June 2013: First Draft Delta Science Plan

August 2013: Second Draft Delta Science Plan

October 2013: Final Draft Delta Science Plan

At each stage of the development of the Delta Science Plan, the Delta Lead Scientist will publicly present the latest draft to the Council for the purpose of receiving information and comments from the Council and the public. All Council meetings are public and simulcast on the Council website at www.deltacouncil.ca.gov.

SUBMITTING PUBLIC COMMENT

Public comments are welcome during the entire Delta Science Plan development process. The Delta Science Program encourages written public comments to be submitted to science@deltacouncil.ca.gov. Please organize written comments by chapter title, heading, appendix, page number, line number and box/figure number.

For public comment on the Second Draft Delta Science Plan to be considered for incorporation in the Final Draft Delta Science Plan, comments must be received no later than Monday, September 16, 2013.

THE FOLLOWING POINTS ARE RELEVANT TO THIS PRELIMINARY DRAFT DELTA SCIENCE PLAN

List of Contents is not in final format and there are notations of items throughout the text that need to be completed or otherwise noted.

Glossary of terms is under development and will be inserted as it is completed.

Technical editing for all information in the Draft Delta Science Plan versions, including grammatical and style changes, will be ongoing.

All figures and tables are preliminary. New and updated figures will be inserted as they are completed.

Citations and references are under development and will be inserted as they are completed.

Audiences and Participants of the Delta Science Plan

Achieving the vision of One Delta, One Science requires a new culture of cooperation and stewardship among policymakers, scientists, managers and interested public. To build this community, the following audiences and participants of this plan include[1]:

Audiences and Participants	Use the Delta Science Plan to:
Delta Science Program	☐ Guide Delta Science Program activities including leading numerous Delta Science Plan actions (i.e., Develop, Update and Implement the Science Action Agenda)
Delta Stewardship Council	☐ Inform best available science, adaptive management, early consultation and consistency determinations for covered actions and provide oversight of scientific aspects of Delta implementation activities to achieve the coequal goals ☐ Provide the context and shared approach for supporting science actions to provide a knowledge base that is transparent, easily accessible and flexible for use to implement and update the Delta Plan
Science programs in the Delta (i.e., Interagency Ecological Program, Bay Delta Conservation Plan, State and Federal Contractors Water Agency)	☐ Guide coordination and integration among programs to leverage science efforts ☐ Provide the context and shared approach for implementing priority science actions ☐ Develop and implement science work plans tiered from the Science Action Agenda ☐ Utilize improvements to science infrastructure
Delta science community	☐ Foster and enhance science networking and collaboration ☐ Integrate synthetic thinking into project and program activities ☐ Enhance connections with Delta policy and management communities
Delta managers (i.e., those implementing actions such as water operators, habitat restoration practitioners, levee engineers)	☐ Recognize and provide input on priority science needs ☐ Identify the context for implementation approach and elements of the Delta Science Plan ☐ Utilize science conflict management mechanisms ☐ Enhance connections with the Delta science community
Delta policymakers	☐ Guide participation in the Policy-Science Forum and ensure science is targeted to support decisions ☐ Guide coordination and integration among programs for implementing the Delta Science Plan ☐ Obtain high quality science to inform decision-making ☐ Enhance connections with the Delta science community
Interested public (including scientists, local agencies and communities and individuals)	☐ Provide input on priority Delta science activities ☐ Engage with the Delta science community and its activities ☐ Enhance connections among Delta policy, management and science communities
Delta Independent Science Board	☐ Inform oversight of scientific research, monitoring and assessment of programs that support adaptive management of the Delta through periodic reviews of scientific research, monitoring and assessment of programs at least once every four years (Water Code §85280(3)) ☐ Inform recommendations for strategic science planning and activities

[1] Entities with primary responsibilities and participation roles are identified per action or suite of actions in the Delta Science Plan.

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List of Acronyms

BDCP	Bay Delta Conservation Plan
CAMT	Coordinated Adaptive Management Team
CDFW	California Department of Fish and Wildlife
CSAMP	Collaborative Science and Adaptive Management Program
CVP/SWP	Central Valley Project/State Water Project
CWEMF	California Water and Environmental Modeling Forum
CWQMC	California Water Quality Monitoring Council
DRERIP	Delta Regional Ecosystem Restoration Implementation Plan
DSC	Delta Stewardship Council
DSP	Delta Science Program
DWR	Department of Water Resources
ERP	Ecosystem Restoration Program
FRPA	Fish Restoration Program Agreement
IEP	Interagency Ecological Program
MAST	Management Analysis and Synthesis Team
NGO	Non-Governmental Organization
NMFS	National Marine Fisheries Service
NRC	National Research Council
OCAP	Operations Criteria and Plan
PSP	Proposal Solicitation Package
RFP	Request For Proposal
SBDS	The State of Bay-Delta Science
SFCWA	State and Federal Contractors Water Agency
SWRCB	State Water Resources Control Board
USBR	United States Bureau of Reclamation
USFWS	United States Fish and Wildlife Service

Executive Summary

Why a Delta Science Plan?

The California Delta is part of a complex estuarine system that has been subject to major landscape changes in the past two centuries. The resulting system is dynamic and continues to respond to its history as well as the effects of climate change and ongoing management actions. In 2009 legislation was passed that established new requirements for the use of science in the development and implementation of policies and management that affect the Delta. This means that decision-makers tasked with taking actions will need increased science support to address large-scale, difficult policy and management issues ("grand challenges"). However, the current organization and communication of Delta science are inadequate for providing the timely, relevant decision support needed for policy and management actions for achieving the coequal goals of a healthy ecosystem and water supply reliability.

In its review of the sustainability of water and environmental management in the California Bay-Delta, the National Research Council (NRC) found that "only a synthetic, integrated, analytical approach to understanding the effects of suites of environmental factors (stressors) on the ecosystem and its components is likely to provide important insights that can lead to enhancement of the Delta and its species" (National Research Council 2012). The Delta Plan acknowledged this recommendation and calls for the Delta Science Program to work with others to develop a Delta Science Plan (Delta Stewardship Council 2013). In response to NRC's recommendation and recent court rulings, water and environmental management in California is entering a new era with agencies exploring collaborative approaches to addressing the complex issues surrounding the coequal goals. The Delta Science Plan provides organization and the science infrastructure to support this new paradigm.

A Vision for Delta Science

This plan lays the foundation for achieving a shared vision for Delta science; 'One Delta, One Science' – an open Delta science community that works together to build a shared body of scientific knowledge. Transitioning from a paradigm of scientists operating in agency and program silos, an open science community will have the capacity to adapt and inform future water and environmental decisions across multiple organizations and programs. It does not mean that the mandates of agencies are compromised, regulatory responsibilities are diminished, or bottom-up mechanisms for shaping the science community are lost. In fact, it is an essential intention of the Delta Science Plan to augment and build on existing efforts and improve the existing science infrastructure where synergies within the science community can be achieved. The concept is to develop a culture that accelerates knowledge discovery through shared priorities, data, and models. Alternative hypotheses, genuine differences in scientific opinion, new technologies, and a range of modeling approaches are embraced and explored in a structured and transparent manner.

What is the Delta Science Plan?

The Delta Science Plan is the first element of a three-part planning, implementation, and reporting strategy. The overall Delta Science Strategy includes:

1. The Delta Science Plan – A shared vision for Delta science and a living framework for guiding, organizing, and integrating science in the Delta. It establishes the major elements, organizational structures, and key actions for improving the efficiency, utility, and application of Delta science across many agencies and institutions.

2. The Science Action Agenda (Action Agenda) – This prioritizes near-term actions to inform management actions and achieve the objectives of the Delta Science Plan. The Action Agenda identifies priorities for research, monitoring, data management, modeling, synthesis, communication, and building science capacity. Under the leadership of the Delta Science Program, the Action Agenda will be developed collaboratively with federal and State agencies, local government, science programs, academic institutions, stakeholders, and a Science Steering Committee.

3. The State of Bay-Delta Science (SBDS) – A summary synthesis of the current scientific knowledge for the Delta. Specifically, SBDS communicates the state of knowledge to address the "grand challenges," including progress made on key research questions and remaining knowledge gaps, which are used to guide updates to the Action Agenda. It is updated by relevant science experts with guidance from the Science Steering Committee.

What Does the Delta Science Plan Achieve?

The Delta Science Plan lays out 28 actions that organize and communicate science to provide timely and relevant decision-support for policy and management actions. Ultimately, implementation of this plan will result in a community of scientists working in the Delta in an integrated manner contributing to the increased reliability of the State's water supply and an improved Delta ecosystem that is more resilient and favors native species.

Specifically, the Delta Science Plan will achieve the following objectives:

Manage Scientific Conflict – When the stakes are high, conflicting conclusions can be presented about the causes and solutions for resource management problems. Open and unresolved conflicting scientific findings do not help agencies make difficult decisions and are often used as grounds for legal proceedings or delay. The Delta Science Plan seeks to manage scientific conflict through independent and transparent processes that provide the highest caliber science to support Delta water and environmental management decisions. A range of options are described depending on the complexity of the issue and the time available for the science to be useful in the decision-making process.

Coordinate and Integrate Delta Science in a Transparent Manner – Current fragmentation of science institutions hinders efficient development and use of a common and trusted body of science for Delta decision-making. A shared approach for organizing and integrating ongoing scientific research, monitoring, data management, analysis, synthesis, and communication is proposed through the Action Agenda and a web-based tracking system for Delta Science activities.

Enable and Promote Science Synthesis – The plan will establish a Science Steering Committee tasked with guiding science synthesis efforts to address decision-makers' "grand challenges" and identifies shared [or "collaborative"] approaches for synthesis.

Build Effective Policy-Science Interactions – This plan provides a new path forward for building effective interactions between resource decision-makers and scientists through establishing a Policy-Science Forum.

Strategic and Topical Support for Effective Adaptive Management – Implementation of adaptive management is achieved through a Restoration Framework and Water Management Framework and knowledge will be transferred across different activities through an annual Adaptive Management Forum and Delta Science Program Adaptive Management Liaisons.

Identify, Maintain and Advance the "State of Delta Knowledge" – The state of knowledge of the Delta system is advancing rapidly and is distributed across many institutions, which makes it difficult to integrate and communicate in a timely manner. This plan will facilitate the maintenance and growth of shared Delta-wide knowledge through the activities of the Policy-Science Forum, Science Steering Committee and the Delta Science Program working with the Delta science community.

1. INTRODUCTION

"Through our joint federal-state partnership, and with science as our guide, we are taking a comprehensive approach to tackling California's water problems..."[2]

What is the Problem?

The current organization and communication of Delta science are inadequate for providing the timely, relevant decision support needed for policy and management actions for achieving the coequal goals.

The Delta is lacking a common process for prioritizing and funding science activities, building its science infrastructure and supporting and developing the science community. Of the many science efforts in the Delta, few address more than a single objective. The Delta Plan summarizes this problem:

> "Currently, science efforts related to the Delta are performed by multiple entities with multiple agendas and without an overarching plan for coordinating data management and information sharing among entities. Increasingly, resource management decisions are made in the courtroom as conflicting science thwarts decision making and delays action. Multiple frameworks for science in the Delta have been proposed, but a comprehensive science plan that organizes and integrates ongoing scientific research, monitoring, analysis, and data management among entities has yet to be fully formulated." (p. 54)

Science will continue to occur in programmatic silos with limited integration in the absence of a common vision and strategy for Delta science. Without a strategy and sufficient resources for organizing and growing the capacity for science in the Delta, conflicts over science will continue without collaborative approaches for managing science conflict and moving toward shared understanding of problems and potential solutions. Collaborative mechanisms for synthesis are also needed to coordinate science and translate disparate information into usable knowledge in a timely manner.

Efforts to Build On:

- Collaborative science planning efforts by the IEP, BDCP, SWRCB, Biological Opinions Remand Process, California Water Plan Update Process and the South Delta Salmonid Research Collaborative
- Multi-agency sponsorship of Delta Science Fellows solicitations
- Recent SWRCB workshops
- Research needs identified by BDCP
- Delta Science Program and Ecosystem Restoration Proposal Solicitation Package processes for identifying research priorities
- IEP Management Analysis and Synthesis Team (MAST) pilot effort

Implementation of the Delta Reform Act and the Delta Stewardship Council's Delta Plan depend on science support (Water Code §85020(h)) to achieve the coequal goals of a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem (Water Code §85054). Significant scientific investments have been and continue to be made to

[2] From July 25, 2012 Governor Brown and Obama Administration joint announcement on the proposed path forward for the Bay Delta Conservation Plan and California's water future.

understand the Delta[3] system to inform water management and environmental decisions. However, despite a rich history of scientific study and more than 40 years of monitoring the aquatic system, insufficient integration, coordination, cooperation and communication weaken efficient development and effective use of best available science to inform decision-making.

How does the Delta Science Plan Address the Problem?

This Delta Science Plan builds on existing efforts to provide a new path forward to achieve the vision of One Delta, One Science (Box 1-1). It articulates a broad and adaptable framework for organizing and integrating Delta science by accelerating knowledge discovery through shared priorities, data and models. It embraces alternative hypotheses, genuine differences in scientific opinion, new technologies and a range of modeling approaches through a structured and transparent manner. The Delta Science Plan creates the institutional capacity to support, enhance and network science programs that contribute to Delta science. It Delta Science Plan builds the infrastructure for making the highest caliber science available for Delta water and environmental decision-making, such as adaptive management decision-making required by the Delta Reform Act and the Delta Plan (Box 1-2). The Delta Science Plan covers the geographic extent of the Sacramento-San Joaquin Delta (as defined in Section 12220 of the California Water Code) and Suisun Marsh (as defined in Section 29101 of the Public Resources Code) and may also address larger-scale processes, functions, and stressors outside its primary geographic focus area that influence conditions within the Delta.

BOX 1-1 VISION

The Delta Science Plan aims to achieve the vision of 'One Delta, One Science' – an open Delta science community that works collaboratively to build a shared state of scientific knowledge with the capacity to adapt and inform future water and environmental decisions.

Implementation of the Delta Science Plan will provide independent, peer-reviewed, objective science products to inform Delta decisions aimed at achieving the coequal goals, but expressly will not pass value judgment on the trade-offs among different decisions. It also recognizes the needs for agencies to meet their missions and regulatory responsibilities.

Science Action Agenda and *The State of Bay-Delta Science*

The Delta Science Plan is developed as one of three elements of an overall Delta Science Strategy for achieving the vision of One Delta, One Science. The other two elements of the Delta Science Strategy include the Science Action Agenda (Action 2.2) and The State of Bay-Delta Science (Action 2.6).

The Science Action Agenda (Action Agenda) establishes the prioritized science actions to achieve the objectives of the Delta Science Plan. The Action Agenda identifies priorities for science activities (i.e., research, monitoring, data management, modeling, synthesis and communication) to address decision-makers' "grand challenges"[4] over a four-year period. The Action Agenda will be a shared agenda for science programs in the Delta that are housed in multiple federal, State and local agencies, universities

[3] The Sacramento-San Joaquin Delta and Suisun Marsh are referred to throughout this document collectively as "the Delta."

[4] "Grand challenges" are large-scale, persistent and difficult policy and management issues

and non-governmental organizations. It will serve as the common agenda from which agencies and programs can develop their science work plans (e.g., the Interagency Ecological Program Work Plan).

The State of Bay-Delta Science (SBDS) is a summary synthesis of the current scientific knowledge for the Delta. Specifically, SBDS communicates the state of knowledge to address the "grand challenges," including progress made on key research questions and remaining knowledge gaps, which are used to guide updates to the Action Agenda.

BOX 1-2 DELTA SCIENCE PLAN SUPPORT FOR DELTA PLAN

"[The Delta Science Plan] is essential to support the adaptive management of ecosystem restoration and water management decisions in the Delta." - Delta Plan

The following highlights the relationship of the Delta Science Plan to implementation of the 2009 Delta Reform Act and the Delta Stewardship Council's Delta Plan. The Delta Reform Act requires the Delta Plan to be based on and implemented using best available science. Furthermore, the legislation requires the use of science-based, transparent and formal adaptive management strategies for ongoing ecosystem restoration and water-management decisions. The Delta Plan also identifies the need for a comprehensive science plan for the Delta and recommends that the Delta Science Program, working with others, develop a Delta Science Plan that creates an overarching road map for organizing and integrating ongoing scientific research, monitoring, analysis and data management among entities by December 31, 2013. To ensure that best science is used to develop the Delta Science Plan, the Delta Plan recommends that the Delta Independent Science Board review the draft Delta Science Plan.

The Delta Science Plan supports implementation of the Delta Reform Act and the Delta Plan through:

1. Carrying out the Delta Science Program's responsibilities to, "develop, coordinate and provide the best possible and transparent scientific information to inform water and environmental decision making in the Delta." (Delta Reform Act 85280 (b)(4))
2. Promoting and providing best available science and adaptive management support for implementing the Delta Plan (Delta Reform Act 85308 (a) and (f); Delta Plan GP 1)
3. Monitoring and evaluating progress toward achieving the coequal goals (Delta Plan Ch. 2; Delta Reform Section 85308 (c))
4. Addressing science and information needs in the Delta Plan (Delta Plan Ch. 2, 3, 4, and 6; Delta Reform Act 85308 (e))
5. Supporting communication of science to inform Delta Plan implementation (Delta Plan Ch. 2)
6. Providing a strategy for leveraging reliable funding to sustain needed science advancements and infrastructure

What are the Objectives of the Delta Science Plan?

Manage Scientific Conflict - Agencies charged with regulating and managing natural resources are often faced with a confusing flood of information, scientific and otherwise. When the stakes are high, the "science" provided by different agencies and interest groups can draw conflicting conclusions about the causes and solutions for resource management problems even when based on the same data. While scientific disagreement is healthy and even desirable, open and unresolved conflicting scientific findings do not help agencies make difficult resource management decisions and are often used as grounds for legal proceedings. The Delta Science Plan seeks to manage scientific conflict through an independent and transparent process that will provide the highest caliber science to support Delta water and environmental management decisions.

The processes described in this plan will help to manage scientific conflict at every step between identification of "grand challenges" in a Policy-Science Forum (Action 2.1) through effective

communication of the results of high-priority research. The Action Agenda will direct resources to the highest priority issues and the web-based tracking system (Action 2.3) will make information about research and other science activities available to all. The adaptive management actions in Chapter 3 clarify how science can help resource managers make better decisions in the face of uncertainty. Peer review (Section 4.6) helps to ensure the quality of the science that underlies Delta decisions. Synthesis tools (Action 4.5.1) build higher-level understanding of key issues and can help to provide an independent and authoritative assessment of the available scientific information. Expert panel workshops are a particularly useful tool for timely synthesis of scientific information and managing conflict.

Coordinate and Integrate Delta Science in a Transparent Manner - Current fragmentation of science institutions hinders efficient development and use of a common and trusted body of science for Delta decision-making. These fragmented science institutions do not have the capacity to efficiently address "grand challenges" that will need rigorous science support to address the coequal goals. This plan addresses "grand challenges" through a shared approach for organizing and integrating ongoing scientific research, monitoring, data management, analysis, synthesis and communication. This is accomplished through both the Action Agenda (Action 2.2) and building and sustaining a web-based tracking system that inventories and tracks Delta Science activities (Action 2.3).

Enable and Promote Science Synthesis - The lack of a collaborative mechanism for synthesis hinders the timely translation of information into usable knowledge. This plan will establish a Science Steering Committee (facilitated by the Delta Science Program) tasked with guiding science synthesis efforts to address decision-makers' "grand challenges" (Action 2.4). It also takes action to enable and identify resources for focused science synthesis efforts through directed action or self-forming groups in response to requests for proposals (Action 2.5).

Build Effective Policy-Science Interactions - Opportunities for effective interactions between decision-makers and the broad science community are limited. Furthermore, the roles of science (to inform decision-making) and the roles of policy and managers (to prioritize and make decisions) are not always clearly understood. Challenges to communicate and develop a shared understanding of needs, opportunities and roles at these interfaces have led to considerable frustration. This plan provides a new path forward for building effective interactions at these interfaces through establishing a Policy-Science Forum, which includes directors of federal and State agencies, Delta science leaders and select members of the Science Steering Committee (Action 2.4). This forum will facilitate shared understanding of policy priorities and scientific information and the direct communication of new understanding into actionable alternatives for management and policy changes.

Strategic and Topical Support for Effective Adaptive Management - Past attempts to adaptively manage Delta water operations and ecosystem restoration have rarely covered the full adaptive management cycle (Plan, Do, Evaluate and Respond). There is a risk of not being able to attain or quantify system-level progress toward achieving the coequal goals if multiple adaptive management efforts are incomplete, nonintegrated, respond too slowly or fail to consider system-wide and local effects. Under the Delta Science Plan, adaptive management implementation will be integrated through

a Restoration Framework, a Water Management Framework and Delta Science Program Adaptive Management Liaisons (Chapter 3).

Identify, Maintain and Advance the "State of Delta Knowledge" - The state of knowledge of the Delta system is advancing rapidly and distributed across many institutions, which makes it difficult to assimilate in a timely manner. This plan will facilitate the maintenance and growth of Delta-wide knowledge through the activities of the Policy-Science Forum, Science Steering Committee and the Delta Science Program. The Science Steering Committee and Policy-Science Forum will play key roles in providing guidance for prioritizing research (Section 4.1), integrating monitoring and associated research (Section 4.2) and conducting targeted and ongoing synthesis activities (Section 4.5). The Delta Science Program with others will facilitate Delta-wide approaches for data management and accessibility (Section 4.3), shared models (Section 4.4) and independent peer review (Section 4.6). To more effectively inform policy and management decisions and the public, this plan initiates a science communication strategy for the Delta (Section 4.7).

What will the Delta Science Plan Achieve?

The Delta Science Plan aims to achieve One Delta, One Science – an open Delta science community that works collaboratively to build a shared state of scientific knowledge with the capacity to adapt and inform future water and environmental decisions. To achieve this vision, the Delta Science Plan will serve as the coordinated and targeted science plan for ongoing and future Delta science. As a living plan, the Delta Science Plan retains the flexibility for innovation and responsiveness to emerging issues such as natural disasters.

The Delta Science Plan lays out 28 actions that initiate the organization and communication of science for timely and relevant decision support for policy and management actions. Implementation of this plan will result in a suite of options available for developing and packaging responses to decision-makers' science needs (e.g., summaries of the state of knowledge and science-expert advice conveyed by the Delta Lead Scientist or Science Steering Committee). It establishes resources and time for scientists working for agencies to participate in synthesis activities that address priorities. Ultimately, implementation of this plan will result in a community of scientists working in the Delta in an integrated manner contributing to the increased reliability of the State's water supply and an improved Delta ecosystem that is more resilient and favors native species.

To ensure that these outcomes and the objectives of the Delta Science Plan are achieved, performance measures and metrics will be developed (Action 2.8). Outcomes of the Delta Science Plan and progress toward achieving its objectives will be evaluated based on these performance measures. This will allow the Delta Science Plan to be refined and updated to foster innovation and maximize the generation of new knowledge to inform the "grand challenges" confronting Delta policymakers and managers. The first assessment will be conducted on the first year of Delta Science Plan implementation. Following this initial assessment and associated adjustments, the Delta Science Plan will be updated at least once every five years or more often as needed, in parallel with major revisions to the Delta Plan as appropriate.

Organization of the Delta Science Plan

The Delta Science Plan is organized around central elements for achieving the vision of One Delta, One Science. The following chapters describe in detail the problems, objectives, actions and expected outcomes for:

- Chapter 2, Organizing Science to Inform Policy and Management
- Chapter 3, Adaptive Management for a Complex System
- Chapter 4, Building the Infrastructure for Science
    - Section 4.1, Funding Research
    - Section 4.2, Monitoring and Associated Research
    - Section 4.3, Data Management and Accessibility
    - Section 4.4, Shared Modeling
    - Section 4.5, Synthesis for System-wide Perspectives
    - Section 4.6, Independent Scientific Peer Review and Advice
    - Section 4.7, Communication
- Chapter 5, The Future of Delta Science

Background information and a box highlighting "Efforts to Build On" are also found within each chapter and major section. Actions are described in short within the Delta Science Plan. Several actions refer to appendices for details, including processes and roles and responsibilities of action participants. For each action or suite of actions the primary responsibility (i.e., facilitating or leading) is assigned and action participants (i.e., joint development or implementation responsibilities) are identified.

2. ORGANIZING SCIENCE TO INFORM POLICY AND MANAGEMENT

"A collaborative effort is needed, where scientists and governance professionals work together as a single team, rather than two separate entities."[5]

Transformation of how policy, science and management communities engage is essential for identifying and addressing complex questions and issues surrounding natural resources management in the Delta. Transformation means adjusting the way we work as policymakers, scientists and resource managers, learning each other's "language," and embracing a team approach. This means working together to articulate problems, set goals and priorities, increase understanding and share in progress toward achieving the coequal goals. This plan establishes and strengthens forums for decision-makers and scientists to work together to evaluate alternative Delta futures through early engagement, continuous dialogue and opportunities to develop innovative approaches for using best available science. It improves connections among policymakers, scientists and managers and provides new mechanisms, structures and tools for regular and effective interactions to improve shared understanding and stewardship of the Delta (Figure 2-1).

Efforts to Build On:

- Town Hall Meeting with policymakers and the science community at the 2012 Bay-Delta Science Conference
- 2012 DSP-coordinated invited Science Expert Panels to synthesize the state of knowledge for State Water Resources Control Board members for the Bay-Delta Plan Phase 2 Update.
- National trends of science networks: (i.e., Network for Earthquake Engineering Simulation (NEES)

Improve Policy-Science Interactions

Problem Statement

Effective interactions between decision-makers and scientists beyond the bounds of individual organizations are not clearly established for communicating "grand challenges", exploring issues, and building understanding about the science needed to support decisions and how it can be best used. A regular forum for building trust between scientists that inform decision making and the policymakers that prioritize and make decisions does not exist. Without this forum, cross-program and agency identification and communication of key scientific uncertainties that are likely to limit restoration and water-management effectiveness and return on investment will be limited.

Objectives

- Establish a shared approach for identifying and communicating decision-makers' "grand challenges" and the associated priorities for research, monitoring, and evaluation to address these challenges
- Institute forums for identifying and communicating the key scientific uncertainties and understandings to decision-makers

[5] National Research Council on Sustainability of Water and Environmental Management in the California Bay-Delta Report (2012), Page 175

- Define mechanisms for early engagement of decision-makers in setting research and monitoring priorities, continuous dialogue and effective use of best available science to inform decision making

Actions

2.1 Establish a Policy-Science Forum

Establish a Policy-Science Forum where directors of federal and state agencies and science leaders gather around key issues (e.g., drought, introduction of native species) to: a) communicate "grand challenges"; b) explore issues directly with leaders of the scientific community for scientists to fully understand the science needed to support decisions and how that science can be best used; c) direct committees as needed to collaboratively analyze policy alternatives and advise adaptive management of policies and programs [Appendix B].

Primary Responsibility: Delta Science Program

Action Participants: Directors of federal and State agencies, Delta Plan Interagency Implementation Committee, Lead/Chief Scientists with responsibilities in the Delta, relevant science leaders identified by the Lead Scientist (i.e., the IEP Lead Scientist, BDCP Science Manager, leading academic researchers, and agency research program directors); Science Steering Committee

Expected Outcomes

- Improved interactions at the policy-science-management interfaces
- Shared understanding of best available science and critical uncertainties among scientists and decision-makers

Integrate and Track Science Activities

Problem Statement

Currently, science efforts related to the Delta are performed by multiple entities with multiple agendas and without an overarching plan for coordinating data management and information sharing among entities (Delta Stewardship Council 2013). Despite current science coordination through the Interagency Ecological Program and other efforts, science work plans and implementation programs remain fragmented without a common agenda.

Objectives

- Establish a shared science agenda to guide science actions performed by multiple programs and agencies in the Delta
- Inventory and track science activities in the Delta

Actions

2.2 Develop, implement and update a Science Action Agenda

Develop, implement and update a Science Action Agenda (Ch. 1) through an inclusive process that organizes, integrates and prioritizes science activities across programs to address decision-makers' "grand challenges" in an efficient manner [Appendix C].

Primary Responsibility: Delta Science Program

Action Participants: IEP, BDCP, Ecosystem Restoration Program (ERP), California Water Quality Monitoring Council (CWQMC), State and Federal Contractors Water Agency (SFCWA) and other science programs of federal, State and local agencies

2.3 Sustain a web-based tracking system of science activities

Building on existing efforts, develop and sustain a web-based tracking system of science activities that inventories and tracks inputs and outputs of research projects, monitoring, modeling, data management, synthesis, peer review and other science activities to improve the transparency of science activities in the Delta.

Primary Responsibility: Delta Science Program

Action Participants: DSC, IEP, BDCP, ERP, CWQMC, SFCWA and other science programs of federal, state, and local agencies

Expected Outcomes

- Ongoing and collaborative prioritization of science actions
- Integrated science efforts and work plans among agencies and programs
- Science coordination, tracking and leadership provided by the Delta Science Program

Guide and Support Synthesis

Problem Statement

Current science institutions do not have the capacity to conduct the synthesis activities needed to inform actions for achieving the coequal goals. The lack of a collaborative mechanism for synthesis hinders the timely translation of information into usable knowledge.

Objective

- Build capacity and sustain collaborative processes for ongoing science synthesis to develop shared scientific understanding

Actions

2.4 Establish a Science Steering Committee

Establish a Science Steering Committee to guide the distillation of diverse scientific information and accelerate knowledge discovery for informing decision making through:

1) Translating the "grand challenges" articulated at the Policy-Science Forum into specific research priorities and actionable questions,
2) Providing high-level guidance for topics to be addressed in the Action Agenda (e.g., research topics),
3) Recommending topics for focused science synthesis efforts (including requests for proposals),
4) Providing guidance to science experts writing SBDS
5) Conducting science synthesis in sub-groups, and
6) Representing the One Delta, One Science-Community at Policy-Science Forums [Appendix D]

Primary Responsibility: Delta Science Program

Action Participants: Delta Lead Scientist, Policy-Science Forum participants, individual scientists with relevant expertise (Delta scientists)

2.5 Enable and identify resources for Focused Science Synthesis

Enable and identify resources for Focused Science Synthesis teams that distill the state of knowledge on specific topics (e.g., what is the role of ammonia/ammonium within the Delta ecosystem?). Focused Science Synthesis teams will address directed action and self-form in response to requests for proposals (RFPs).

Primary Responsibility: Delta Science Program

Action Participants: Science Steering Committee, Delta Lead Scientist, scientists, science programs of federal, State, and local agencies

Expected Outcomes

- Science synthesis is performed regularly
- Science synthesis efforts can be undertaken at short notice to address critical issues identified by decision-makers
- Synthesized science is provided to decision-makers to inform policy and management decisions through joint exploration of "what if" questions and evaluation of alternative futures

Update and Communicate the State of Science and Delta Science Plan Performance

Problem Statement

Currently, there is no routine publication or update of the state of scientific knowledge about the Delta system. Failure to update and communicate the state of scientific knowledge about the Delta system leads to outdated information for making important decisions toward achieving the coequal goals. Also, performance measures and metrics are needed to evaluate and report Delta Science Plan performance and inform future refinements to the plan.

Objective

- Regularly update and communicate the state of scientific knowledge about the Delta system
- Develop performance measures for evaluating and reporting on Delta Science Plan performance

Action

2.6 Publish and Update The State of Bay-Delta Science

Publish and update The State of Bay-Delta Science at least once every four years, aligned with the Biennial Bay-Delta Science Conference (offset from development of the Action Agenda) to regularly update and communicate the state of knowledge about the Delta system [Appendix E].

2.7 Deliver Annual State-of-Delta Science Address

The Delta Lead Scientist, in consultation with the science community, will deliver an annual review of Delta science. Depending on the point in the four-year cycle of science, the presentation will highlight the Science Action Agenda, The State of Bay-Delta Science and key questions, findings and innovations. This address will occur at a suitable venue and will be webcast and archived on the Delta Stewardship Council webpage.

2.8 Develop and Report Performance Measures

Measures and metrics will be developed to evaluate Delta Science Plan performance [for Draft Performance Measures see Appendix A]. Parameters will be tracked that capture the development and impacts of the proposed science infrastructure, the role of science in guiding adaptive management and the effectiveness of the organization of science to guide future refinements of the Delta Science Plan.

Performance monitoring will include surveys and selected interviews with representatives of all the contributors, users and beneficiaries of the Delta Science Plan conducted by an independent third party.

Primary Responsibility: Delta Science Program, Delta Lead Scientist

Action Participants: Relevant experts, the Science Steering Committee

Expected Outcome

- Ongoing assessments of the state of knowledge that reflects the dynamic nature of the Delta-system, advances in technologies and the rapidly growing knowledge base
- Transparent reporting of Delta Science Plan performance based on performance evaluations

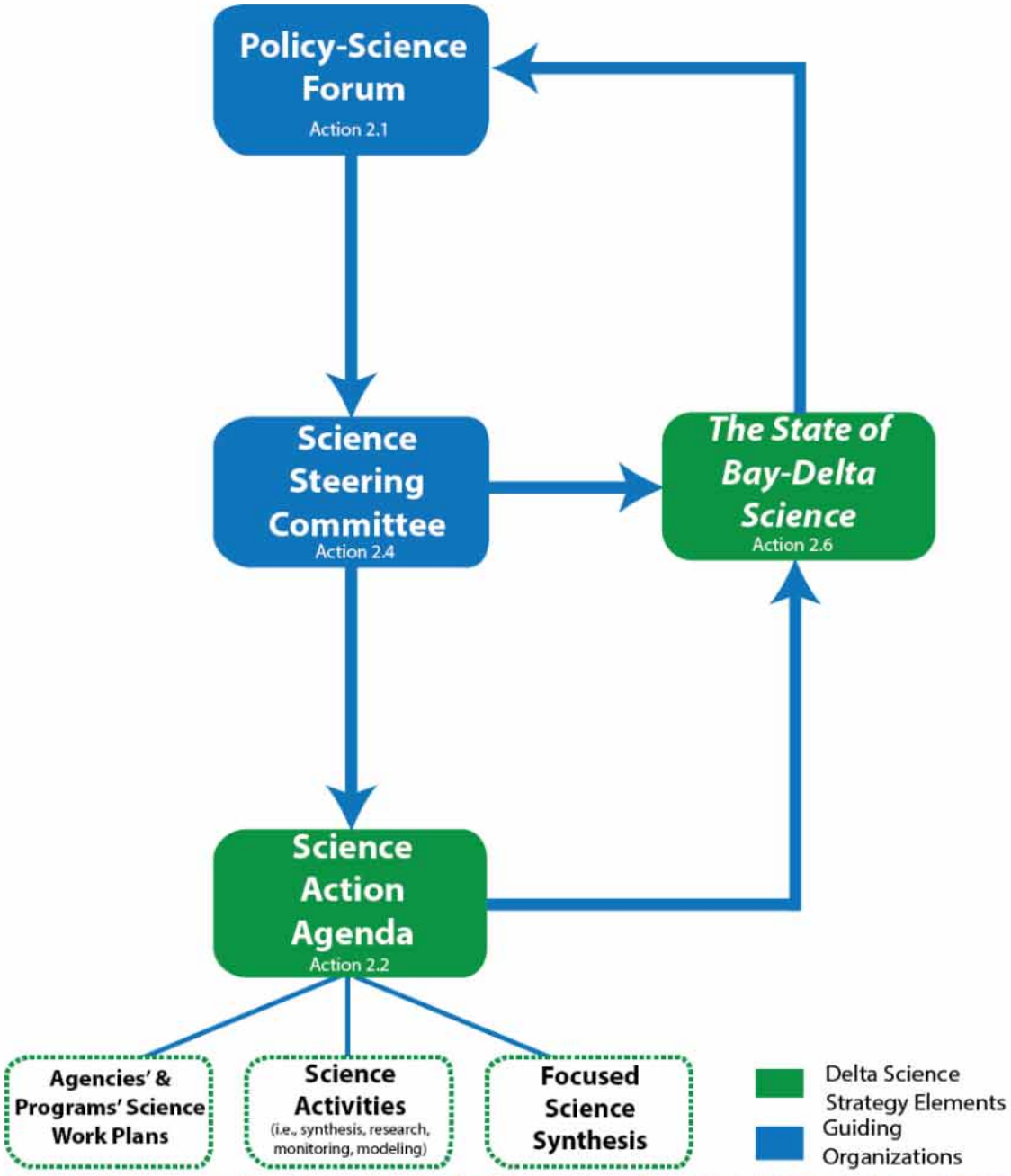

Figure 2-1. A summary of how science is organized to inform policy and management. Arrows represent the connection and flow of guidance and information among organizational elements (the Policy Science Forum and the Science Steering Committee) and Delta Science Strategy elements (the Science Action Agenda and The State of Bay-Delta Science). Implementation of the Science Action Agenda is carried out through agencies' and programs' science work plans, a number of science activities and focused science synthesis.

3. ADAPTIVE MANAGEMENT FOR A COMPLEX SYSTEM

"'Adaptive Management' means 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."[6]

Several Delta planning and policy efforts have now adopted adaptive management as the path forward for managing complex natural resources programs and projects (Box 3-1). Adaptive management is a strategy for making management decisions under uncertain conditions rather than delaying action until more information is available or adopting a rigid, prescriptive approach.[7] Adaptive management has been successfully applied at the individual project level, but rarely at the programmatic and landscape scales. To successfully implement adaptive management at the large scale of the Delta, new strategies are needed to better define and describe the roles and responsibilities of policy, science and management. These new strategies need to allow for decisions that involve different time periods, different portions of the Delta and different water management and ecological issues. Adaptive management is a continuous and iterative process, in which new insights and solutions are used to improve understanding of the problem, which in turn leads to the next generation of actions based on lessons learned from previous actions.

Actions in this chapter are based on the three-phase, nine-step adaptive management process outlined in the Delta Plan (Figure 3.1). This chapter explains how the structures and processes identified in other Delta Science Plan chapters are applied to adaptive management. It focuses on how to best move toward continual knowledge application in water management and ecosystem restoration, combined with continual knowledge acquisition as actions are implemented.

Box 3-1 Example Delta Plans Proposing to Use Adaptive Management

- ☐ Delta Plan
- ☐ Draft Bay Delta Conservation Plan
- ☐ Bay-Delta Water Quality Control Plan
- ☐ Water Quality Control Plans for the Bay Area and Central Valley Regional Boards
- ☐ Central Valley Project/State Water Project (CVP/SWP) Biological Opinions
  - Real-time Water Operations
  - Collaborative Science and Adaptive Management Program (CSAMP)
  - Fish Restoration Program Agreement (FRPA)
  - Yolo Bypass Salmonid Restoration and Fish Passage Implementation Plan
- ☐ Ecosystem Restoration Program Conservation Strategy
- ☐ Suisun Marsh Plan
- ☐ California Water Plan
- ☐ Integrated Regional Water Management Plans

[6] Delta Reform Act § 85052

[7] Note that adaptive management is appropriate when management actions can be taken to influence the system to achieve a desired outcome and when uncertainty about the impact of management actions is high (Williams, et al. 2007)

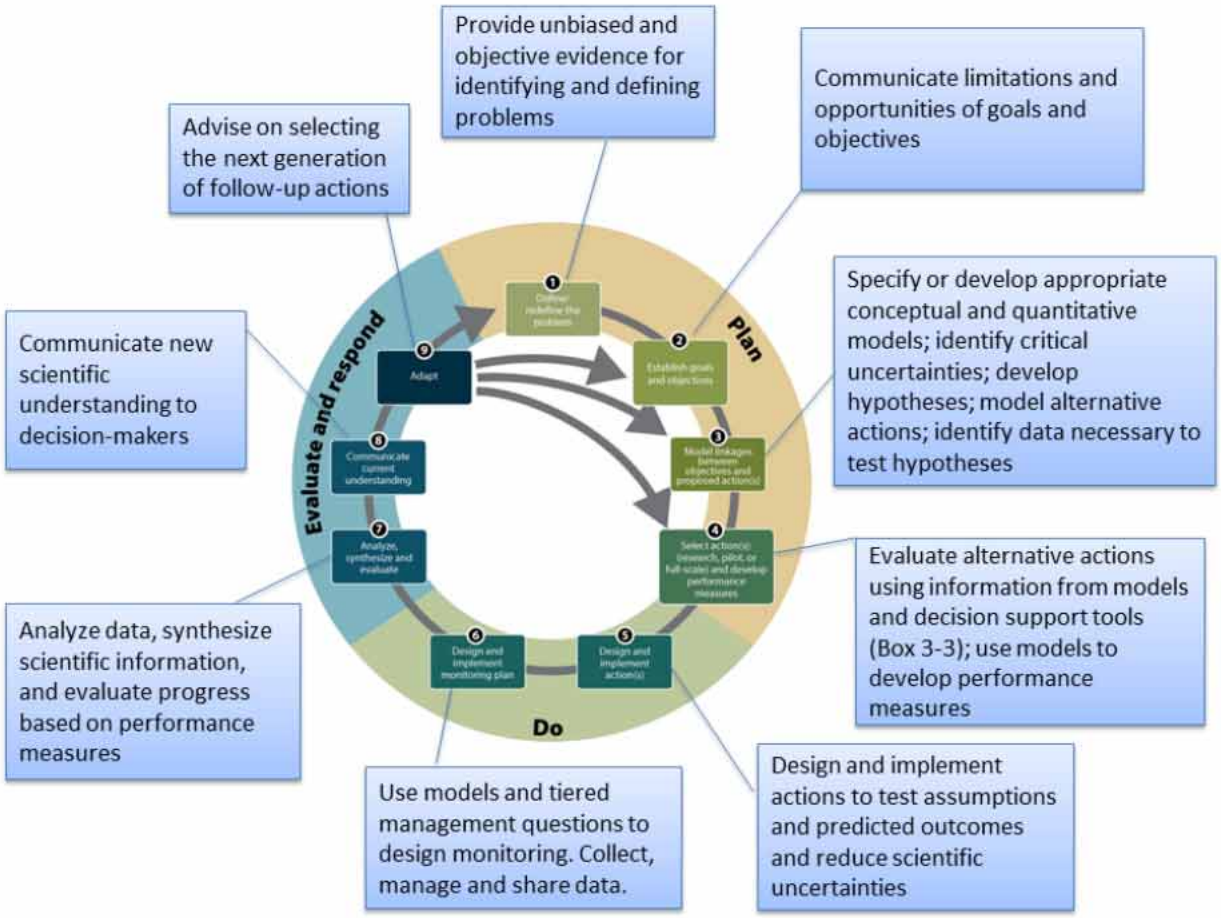

Figure 3-1. Delta Plan Adaptive Management Framework with the role of science identified in call-out boxes for each step. Guidelines for each step are found in Appendix F.

Problem Statement

Past attempts to adaptively manage Delta water operations and habitat restoration have rarely covered the full adaptive management cycle, and have not considered the appropriate time frame and spatial scale required for changes to occur as a result of management actions. System-level progress toward achieving the coequal goals will not be possible if multiple adaptive management efforts are incomplete, nonintegrated, or fail to consider system-wide and local effects, or are unable to respond within the time frame of management actions.

Objective

- Efficiently improve system-wide understanding in the face of uncertainty through water management and ecosystem restoration consistent with the Delta Plan adaptive management approach and user guidance [Appendix F] to efficiently improve system-wide understanding in the face of uncertainty.

Actions

3.1 Hold an Annual Adaptive Management Forum

Hold an annual Adaptive Management Forum with national and international experts and local proponents to provide adaptive management training to build capacity for planning and implementing adaptive management, establish and refine adaptive management frameworks (Action 3.2), share lessons learned from the Delta and elsewhere, and integrate across ecosystem restoration and water management adaptive management activities.

Primary Responsibility: Delta Science Program

Action Participants: National and international experts on adaptive management; local proponents of adaptive management from federal, State and local agencies, non-governmental organizations, private organizations and academia

3.2 Develop and Use Adaptive Management Frameworks

Develop and utilize frameworks to guide science-based adaptive management consistent with the Delta Plan's adaptive management framework and provide for consistent and integrated regional and system-wide approaches [Box 3-2 and Appendix G]:

1) A Restoration Framework to provide principles and guidelines for adaptive management of Delta ecosystem restoration actions in each priority habitat restoration area[8] such as the Delta Conservancy's Delta Restoration Network, and
2) A Water Management Framework to provide principles and guidelines for adaptive management of Delta water management actions through shared approaches, such as

Box 3-2 Elements of Integrated Regional and System-wide Adaptive Management

Habitat Restoration

- Shared landscape-scale conceptual models that incorporate documented landscape functions and processes from historical ecology research (Action 4.4.2)
- Qualitative and quantitative modeling and expert opinion assessment ("DRERIP evaluation") of possible restoration design outcomes (Box 3-3)
- Integrated monitoring to systematically inform adaptive management and report on Delta environmental changes to policymakers and the public (Action 4.2.2)
- Means to compare restoration outcomes to quantifiable goals and performance measures to adjust future management steps if needed

Water Management

- Coordinate real-time water operations of the Central Valley Project/State Water Project with real-time physical and biological data and modeling
- Use an interdisciplinary approach to evaluate "what if" scenarios for optimizing water supply, species protection and other beneficial uses (e.g., hydropower, agricultural and municipal uses, recreation and harvest fisheries).

[8] The Delta Plan identifies six priority habitat restoration areas: Yolo Bypass, Cache Slough Complex, Cosumnes River – Mokelumne River Confluence, Lower San Joaquin River Floodplain, Suisun Marsh, Western Delta/Eastern Contra Costa County.

the Long-term Operations Biological Opinions RPA Implementation and the Collaborative Science and Adaptive Management Program and its Collaborative Adaptive Management Team (CSAMP/CAMT).

Primary Responsibility: Delta Science Program and Delta Stewardship Council Planning along with (1) Delta Conservancy and its Restoration Network participants; (2) NMFS, USFWS, CDFW, DWR, USBR and other CSAMP/CAMT participants

Action Participants: Delta Plan Interagency Implementation Committee, proponents of adaptive management from federal, State and local agencies, non-governmental organizations, private organizations and academia

Box 3-3 Decision Support Tools for Adaptive Management

Clearly articulated conceptual models that specify key state variables (e.g., temperature, water volume, population size), describe their dynamic interrelationships, and project consequences of alternative management actions are a key component of adaptive management (Williams et al. 2007, Walters 1986). Models are extremely valuable because they require the author(s) to specify the predicted link between management objectives and proposed actions to clarify how and why each action is expected to contribute to those objectives. They also provide a venue to identify areas of uncertainty, assess the likelihood of success, identify potential restoration or water management actions, develop expectations and performance measures and define monitoring needs.

The Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) conceptual models were developed for the purpose of showing the characteristics and dynamics of the Delta ecosystem, qualitatively predicting ecosystem and species response to specific changes in ecosystem attributes, and providing the science-based information needed to determine whether a restoration action would result in (or contribute to) a desired management outcome. These models are valuable tools themselves, but were designed to provide information for use in structured assessments of proposed restoration actions through the DRERIP Action Evaluation Procedure and Decision Support Tool (DiGennaro et al. 2012). The Delta Science Program, in collaboration with others, will build upon this tool to water management decisions and make it an integral component of the Water Management Framework.

3.3 Adaptive Management Liaisons

Establish a team of Delta Science Program staff members with expertise in the science supporting adaptive management 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 Adaptive Management Liaisons to their counterparts in agencies and organizations that are planning and implementing effective adaptive management programs and projects including Delta Plan covered actions [Appendix H].

Primary Responsibility: Delta Science Program

Action Participants: Agencies and organizations that are planning and implementing adaptive management

3.4 Modeling Future Scenarios

Facilitate interdisciplinary teams to model alternative future scenarios and predict system-wide responses. Alternative scenarios will be developed and explored for each of the six priority restoration areas and across the entire Delta and address the basic science, Delta change management, operations and restoration as described in Box 3-4. This will allow the finite resources such as water, the tidal energy that drives the processes essential for the success of tidal wetland restoration, sites suitable for certain ecological functions and the landscape scale mosaic of habitats to be envisioned by the people of the Delta, scientists and the decision-makers that will ultimately decide the fate of the ecosystem.

Primary Responsibility: Delta Science Program

Action Participants: Agencies and organizations that are planning and implementing adaptive management, CWEMF

BOX 3-4 – Categories of Science to Support Achievement of the Coequal Goals

- **Basic science** to understand the dynamic state of the estuary and how the major stressors (altered hydrology, alterations to the physical landscape, invasive species introductions, and pollutants) affect ecosystem restoration outcomes and water supply reliability.
- **Delta change management** that anticipates step-changes in the shape or state of the contemporary Delta from floods, seismic events, toxic spills, or new introductions of invasive species. This category requires skilled and rapid decision-support for prioritizing and executing responses.
- **Operation of the Delta – from Sierra to the sea** for water supply reliability, flood management, and power benefits. This includes modeling alternative management scenarios for operating the Delta of the future – the one that evolves through both unanticipated events and by design.
- **Restoration** to purposefully change the Delta ecosystem to support conservation of native species at the system-scale. Restoration at the Delta-scale will take decades and continually confound and surprise us. Restoration actions (past, present and future) will affect one another, and staging restorations to be ecologically relevant is a must.

Expected Outcomes

- Management and policy decision-making processes take advantage of current research, modeling and monitoring with results that are packaged and communicated effectively. New scientific findings and understanding are incorporated into new and ongoing management actions
- Resources are used efficiently to achieve faster and more effective implementation of water management and ecosystem restoration
- Individual adaptive management programs and plans have greater consistency, facilitating learning, integration of results and evaluation of cumulative and system-wide benefits

- Critical uncertainties among management alternatives are addressed in an organized and efficient manner that accelerates shared learning for application to future management actions
- Problem formulation, reflection and continuous learning become institutionalized across agencies and interest groups

4. BUILDING THE INFRASTRUCTURE FOR SCIENCE

"In carrying out this section, the council shall make use of the best available science."[9]

The Delta Reform Act and the Delta Plan require the use of "best available science" in decision making that affects the achievement of the coequal goals (Box 1-2). The dynamic nature of the scientific enterprise should be recognized and mechanisms for including new knowledge or the latest data should be built into the process where appropriate. The Delta Science Plan pursues science that enables discovery and continuously improves and adds to the body of scientific knowledge. If applied correctly, adaptive management will take advantage of the improving body of scientific knowledge.

This chapter describes the infrastructure necessary to develop the science needed to inform complex decisions surrounding the management of the Delta. Science that informs policy and management decisions is built on a foundation of research, models, monitoring, analysis, synthesis, peer review and communication (Figure 4-1). At its most basic level, science is built on hypotheses that express ideas about how the world works. In a complex system like the Delta, hypotheses often take the form of conceptual models which can then be applied and tested through analyses and computer models. Models need data that come from research and monitoring. Synthesized research tells modelers how to improve algorithms that capture our understanding of processes and our ability to predict future conditions. Scientists use data analysis, modeling results and research findings to synthesize higher level understanding about how a system works.

All of these elements are essential to building defensible and transparent science to support current and future decisions about the Delta. The Delta Science Program will work with other programs to further develop and integrate these components (Box 4-1). The Delta Independent Science Board is charged with providing oversight of all Delta scientific research, monitoring, and assessment programs.

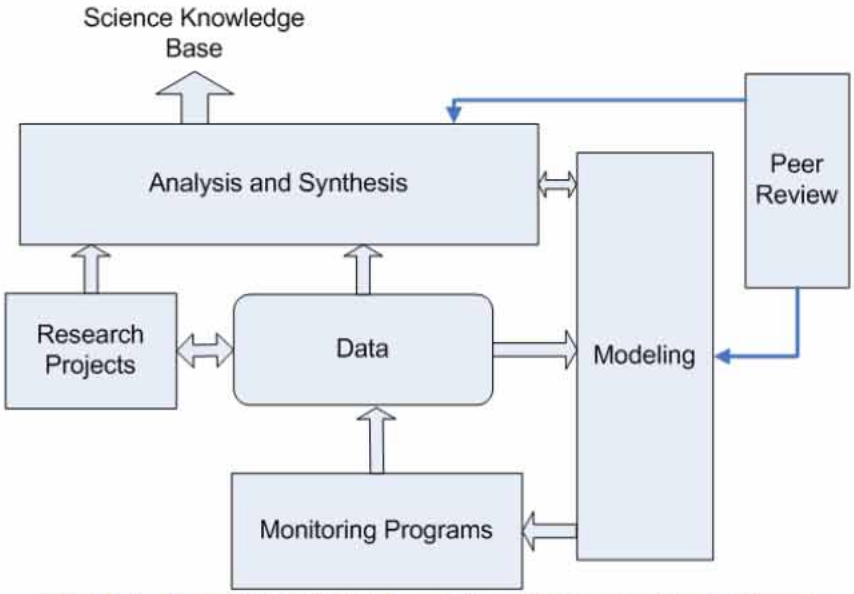

Figure 4-1. Conceptual relationships of the major elements of science

[9] Water Code §85302(g)

Box 4-1 Building Capacity

As detailed in Chapter 5, formidable systemic hurdles exist in building the infrastructure for science. Without the essential tools and resources necessary to conduct the science, it is far from assured that the investments placed in achieving the outcomes envisioned in the Delta Plan and other major planning efforts to achieve the coequal goals will come to fruition. The Delta Science Program will work with others to assess possible mechanisms for enhancing:

- The ability to recruit and retain the next generation of scientists
- Career-tracks for scientists in government
- Access to continuing professional development opportunities, national professional conferences and forums for idea exchanges
- Access to basic scientific tools such as scientific journals, up-to-date hardware and software, the role of universities in supporting science, modeling and professional development of scientists throughout the Delta Science Community (agencies, stakeholders, local government and consultants)

4.1 Funding Research

Research in the Delta is done by universities, federal, state and local agencies, and private and nonprofit organizations. It ranges in scale from foundational (e.g., analyzing the diet of California clapper rails) to broad (e.g., developing linked models that provide information on discharge, flow paths, and other ecosystem attributes). Research in the Delta should address short-term management needs (e.g., what kinds of flow patterns are needed?) and develop long-term comprehensive understanding (e.g., what is the role of known stressors and emerging contaminants on the productivity of tidal marshes?). Research will include projects that may be risky to implement, but could have a big impact on the current state of scientific knowledge. Providing for these differing needs requires a range of Delta research funding processes.

Efforts to Build On:

- Multi-agency sponsorship of Delta Science Fellows solicitations
- Research needs identified by BDCP
- Delta Science Program Proposal Solicitation Package (PSP) process for identifying research priorities

Problem

There is a continuous need for scientific research to inform Delta decision making. In addition to research that addresses specific management questions, research that helps to answer basic questions about how the Bay-Delta system works and research that helps train the next generation of scientists is also needed. However, a shared and balanced portfolio of research funding programs and mechanisms that provide sustainable short-term and long-term science needs does not exist.

Objective

- Establish a balanced portfolio of research funding programs and mechanisms that provide for short-term and long-term science needs

Actions

4.1 Support Research

Competitive Research Grants - The Delta Science Program will manage the solicitation process for selecting research projects. To increase efficiency of peer review, all funding agencies are invited to participate in this biennial process. Competitive proposals will be assessed on intellectual merit (provided by anonymous peer review and science review panels) and broader impacts (assessed by the Science Steering Committee and the responsible funding agency/ies).

Delta Science Fellows - The Delta Science Program and California Sea Grant will jointly manage an annual Delta Science Fellows solicitation with potential research topics and funding invited from other organizations. The selection will be based on intellectual merit (provided by anonymous peer review and science review panels) and broader impacts (assessed by the Science Steering Committee and the responsible funding agency/ies).

Rapid-response Research Grants - To maintain flexibility and responsiveness of Delta science, some research funds are set aside for opportunistic research or to address unexpected events such as a major flood, earthquake, levee failure, or salt-water intrusion into the Delta. These time-sensitive, innovative or exploratory research ideas will be managed similar to the National Science Foundation's "RAPID" or "EAGER" grants. They will be funded through: a) focused solicitations where the scope of a project is generally known but it is open for proposals, or b) directed actions where the scope of the project is well defined and the appropriate project team has been identified for example, due to ongoing activities.

Primary Responsibility: Delta Science Program

Action Participants: IEP, BDCP, ERP, SFWCA and other science programs of federal, state, and local agencies

Expected Outcomes

- Research is prioritized and funded efficiently
- The capacity to conduct high priority research is expanded

See also

- Chapter 2 objectives
- Section 4.5 objectives

4.2 Monitoring and Associated Research

Environmental monitoring provides important scientific information that helps policymakers, managers and the public address challenging environmental issues. The term "monitoring" covers a wide variety of sampling, analysis, measurement and survey activities. A comprehensive Delta monitoring program would follow environmental change as policy decisions are implemented and provide information to

support adaptive management. It should include information about water supply, the ecosystem, and the Delta as place.

In the Delta, environmental monitoring has long played an important role and many long-term monitoring programs exist. For example, the Interagency Ecological Program (IEP) has been monitoring various kinds of fishes and ecological parameters (e.g., water flow, water quality, phytoplankton, zooplankton, benthic invertebrates) for decades. Additional programs soon will be added as part of the new BDCP, if approved, and the Delta Regional Monitoring Program; both programs are currently under development. None of the existing and planned programs capture or coordinate Delta monitoring in the comprehensive manner needed to support the Delta Plan, BDCP, other plans, programs, and regulatory requirements. No shared strategy exists for Delta monitoring. We propose the development of a comprehensive monitoring strategy that will allow for better design, coordination, and integration of Delta monitoring. This plan would be based on a common monitoring framework and would build on recent efforts sponsored by the Delta Science Program, the California Water Quality Monitoring Council, and others. Inherent to this monitoring framework is the appropriate and timely assessment, reporting and publication of monitoring results.

Efforts to Build On:

- Current and emerging regional monitoring programs
  - Delta Regional Monitoring Program
  - Regional Monitoring Program for San Francisco Bay (includes Suisun)
  - Interagency Ecological Program
- Delta Independent Science Board periodic reviews of monitoring programs that support adaptive management of the Delta
- Monitoring strategies
  - UMARP framework (Luoma at al. 2010)
  - Comprehensive Monitoring Program Strategy for California (CA WQMC 2010)

Problem

A shared strategy for integrated monitoring to address Delta ecosystem and water management needs does not exist. Monitoring needs span a wide range of data types from flow, land use, and vegetation to fish abundance and distribution and a geographic range that goes from the headwaters of Sierra Nevada streams to the Pacific Ocean.

Objectives

- Develop a comprehensive inventory of monitoring in the Delta compiled from existing inventories but extended across a broader geographic range and range of disciplines
- Develop a framework that will provide a common focus for existing monitoring programs and monitoring plans
- Integrate and improve monitoring programs and fill-in high priority monitoring gaps to provide the information needed for Delta water management and ecosystem restoration decisions

Actions

4.2.1 Support and sustain a web-based information system for monitoring activities

Support and sustain a web-based information system describing monitoring activities in the Delta, their products, and their nexus with regulatory requirements and management actions to make monitoring information more accessible.

Primary Responsibility: California Water Quality Monitoring Council

Action Participants: Delta Science Program; statewide, regional and local monitoring programs

4.2.2 Build a complete Delta monitoring program

Build a Delta monitoring program with a shared purpose and strategy for integrated monitoring to systematically inform adaptive management and report on Delta environmental changes to policymakers and the public.

Primary Responsibility: Delta Science Program

Action Participants: IEP; BDCP; and federal, State and local agencies; NGOs

Expected Outcomes

- Development of a collaborative and comprehensive monitoring framework based on clear conceptual models
- Regular monitoring information feedback for adaptive management
- Improved availability of data for assessing outcomes of water management and habitat restoration actions
- Improved availability of data for use in regulations

See Also

- Section 4.3, Data Management and Accessibility, for information about data interoperability
- Section 4.7, Communication, for information about making monitoring information available online

4.3 Data Management and Accessibility

"One of the greatest challenges for 21st-century science is how we respond to this new era of data-intensive science. This is recognized as a new paradigm beyond experimental and theoretical research and computer simulations of natural phenomena—one that requires new tools, techniques, and ways of working."[10]

[10] Douglas Kell, University of Manchester, on The Fourth Paradigm: Data-Intensive Scientific Discovery (http://research.microsoft.com/en-us/collaboration/fourthparadigm/)

During the last decade, collection of environmental data has increased exponentially for many purposes, including regulatory compliance, effectiveness monitoring of mitigation, research to understand fundamental processes and landscape-scale status and trends monitoring. Deploying new sensor technologies, improving the accessibility of data, use of community-data-driven models and coordinated research networks will accelerate knowledge discovery. Adaptive management for water supply reliability and resilient Delta ecosystems and economies will depend on the availability of reliable and usable data.

Science programs, agencies and researchers collect data that are designed to meet their respective requirements, mandates or specific questions. It is difficult to know what data is being collected, the quality of the data and how the data can be accessed and queried. This makes it difficult to conduct synthesis activities that are comprehensive and reproducible without a major investment of time and resources. Globally, the emerging era of 'Big Data' is transforming how science is conducted (Science, February 11, 2011), but data is only useful when it can be accessed, analyzed and transformed into knowledge.

Efforts to Build On:

- California Technology Agency (http://www.cio.ca.gov/)
- Water Quality Monitoring Council, My Water Quality (http://www.waterboards.ca.gov/mywaterquality/)
- National initiatives, for example: DataONE http://www.dataone.org/

Problem Statement

Collaborative science and data synthesis will face challenges unless there is a commitment to build an open community of science with data sharing agreements, interoperability standards and the documentation to correctly interpret the data. This requires resources to build and sustain the infrastructure for existing databases to communicate with each other as well as the adoption of the philosophy of data sharing.

Objective

- Build on existing and emerging data management systems to enable the Bay-Delta region's environmental and project-implementation data to be easily accessed, visualized and processed from diverse data management systems by agencies, scientists, interested public, academia and 'citizen scientists' (including K-12 schools) resulting in enhanced accumulation of knowledge

Actions

4.3.1 Host a Data Summit

Host a summit on environmental and project-implementation data to explore the needs for cyber-infrastructure improving data management, data sharing and data mining. Information generated in the Summit will inform the Science Action Agenda for innovations in data management as well as ideas for enhancing and sustaining current initiatives.

4.3.2 Develop Guidelines for Data Sharing

Based on outcomes from the Summit, guidelines for data sharing will be developed including descriptions of existing or needed web services for enabling community data access, integration, visualization and display.

Primary Responsibility: Delta Science Program, California Water Quality Monitoring Council, California Technology Agency and other key partners

Action Participants: Delta Conservancy, USGS, NMFS, BDCP, IEP, CAMT and other agencies and programs responsible for managing environmental data related to the Delta, as well as representatives from universities, consultants, NGOs and invited experts in the field of data management

Expected Outcomes

- Timely data sharing that cross agency and discipline boundaries
- Web services enabling community data access, integration, visualization and display
- Data access for researchers, agencies, scientists, stakeholders, academia and 'citizen scientists' (including K-12 schools), with clear metadata that includes descriptions of accuracy estimates and the level of quality control applied to the data set
- Timely integration of emerging technologies for accessing real-time data, and data assimilation to drive models

4.4 Shared Modeling

"Models can be used to develop insights, often in a transparent, visual and defensible manner. Models are needed for adaptive management and planning. They summarize and integrate our understanding of systems and processes with greater precision and transparency."[11]

A new era is emerging of open computer codes, cloud computing, data accessibility, data visualization and virtual networks of scientists supporting and advancing models. The Delta modeling community embraces these changes and seeks to be at the forefront of developments for addressing

> Modeling is an essential and inseparable part of all scientific, and indeed all intellectual, activity…the professional modeler brings special skills and techniques to bear in order to produce results that are insightful, reliable, and useful... such as sophisticated statistical methods, computer simulation, systems identification, and sensitivity analysis. These are valuable tools, but they are not as important as the ability to understand the underlying dynamics of a complex system well enough to assess whether the assumptions of a model are correct and complete. Above all, the successful modeler must be able to recognize whether a model reflects reality, and to identify and deal with divergences between theory and data. (Silvert. 2001)

[11] Delta Science Program Invited Panel, 2012.

environmental issues. Models will continue to be a central part of our understanding of how the Delta functions as a system and be a key component in the design, management, and performance assessment of projects and actions.

The Bay-Delta system is a complex and dynamic system and the potential massive scale of forced changes due to restoration projects, changes in water operations, new invasive species, climate change or natural disasters will mean that we can no longer rely on the past to predict future conditions. Modeling is critical to explore anticipated outcomes of management alternatives in the Delta and the models must be transparent with a clear understanding of the expected uncertainty in predictions

Problem

Modeling takes place at many agencies, academic institutions and private entities that are often pursuing different questions. Even when using the same model, different scenarios, different assumptions and different data, conflicting conclusions sometimes can be drawn. Further, it is difficult to exchange data used in modeling between discipline-specific models which is often necessary to address many contemporary questions. Modeling needs to be done in a more interdisciplinary and collaborative way to accelerate knowledge discovery, avoid duplication of efforts and support diverse modeling approaches.

Objectives

- Accelerate discovery of knowledge about how the Delta system functions through development of a mechanism that supports models used for today's management actions, while researching and testing models for the future
- Provide managers with predictions of likely outcomes resulting from management actions
- Established community models that are accessible, transparent, sustained by multiple sources and encapsulate the current knowledge of the Delta system
- Use these models to articulate different futures for the Delta depending on the management decisions made

Efforts to Build On:

California Water and Environmental Modeling Forum – The CWEMF mission is to increase the usefulness of models for analyzing California's water-related problems. CWEMF carries out this mission by:

- Facilitating an open exchange of information on California water issues;
- Resolving technical disagreements in a non-adversarial setting; and
- Ensuring that technical work continues to take into account the needs of stakeholders and decision-makers.

Since 1994, CWEMF has initiated and managed a number of impartial peer reviews. These peer reviews:

- Document model strengths and weaknesses
- Suggest improvements
- Assess the suitability for intended applications

CWEMF has helped build the modeling community by bringing modelers together from California and across the country at its annual meetings.

Actions

4.4.1 Develop a collaborative community modeling framework

Develop a framework for collaborative community modeling to enhance interdisciplinary modeling, accelerate knowledge discovery and avoid duplication of efforts and support diverse modeling approaches. This framework will be based around the four science needs shown in Box 1-3 and will be developed through a Modeling Summit co-hosted by CWEMF and the Delta Science Program.

4.4.2 Develop, update and maintain conceptual models

Develop, update and maintain conceptual models to identify the current state of knowledge, identify gaps in understanding, contribute to the identification of research priorities and support adaptive management planning and implementation. The Delta Science Program will track and help promote these conceptual models in guiding Delta management, including landscape-scale conceptual models for the six priority ecosystem restoration areas identified in the Delta Plan

4.4.3 Support high-priority model development

Support high-priority model development and refinement through research grants, fellowships, workshops, seminars and conferences.

4.4.4 Embrace alternative modeling approaches

Embrace alternative modeling approaches and support inter-model comparisons to help quantify uncertainty and sensitivity arising from different assumptions, quality and quantity of available data, different algorithms or alternative scenarios.

Primary Responsibility: Coordination by Delta Science Program, with key roles for CWEMF (4.4.1 and 4.4.4) and ERP (4.4.2)

Action Participants: DWR, BDCP, CAMT, IEP, SWRCB, agencies, academics, consultants

Expected Outcomes

- Enhanced collaborative activities between modelers, shared input data, shared scenarios and results, data streaming between different models and a modeling community that is at the forefront of predicting the outcomes of alternative water and environmental management scenarios
- Accelerate the transfer of best available science to inform management actions in support of water supply reliability and Delta ecology
- Reduce the resources required for initial model set-up and application, thereby increasing the time and resources modelers have available to conduct synthesis, interpretation, uncertainty analyses, information transfer, improvement of model algorithms and development of the next generation of models to address Delta issues

4.5 Synthesis for System-wide Perspectives

The central challenge in understanding a system as large and complex as the Delta is integrating information about the components into a coherent whole. Decades of research and monitoring have yielded tremendous volumes of data, but too often, appropriate methods to integrate across multiple data sources are lacking. The financial resources required to meet this mandate have yet to be agreed upon and allocated (See Appendix 2: Funding Delta Science). Leadership and mechanisms for bringing together researchers from agency, stakeholder and academic communities are needed to foster scientific synthesis to accelerate knowledge discovery and its application in policy development and adaptive management in the Delta.

Efforts to Build On:

- The State of Bay-Delta Science 2008
- Synthesis products in San Francisco Estuary Watershed Science
- National Center for Ecological Analysis and Synthesis model
- IEP Pelagic Organism Decline
- Delta Science Program Workshops
- IEP Management Analysis and Synthesis Team
- Estuary and Wetlands Monitoring Portal and Integrative Health of the Estuary Webtools

Problem

Synthesis is the single most important need for developing Delta science (NRC 2012). Without mechanisms, protocols and resources for conducting ongoing synthesis, new insights and better understanding of the Delta system and science-based decision making will be delayed.

Objectives

- Provide timely support for policy and management decisions
- Promote and support the practice of data analysis and synthesis in the Delta science community

Actions

4.5.1 Establish mechanisms and protocols for ongoing synthesis

Establish mechanisms and protocols for conducting ongoing syntheses to accelerate knowledge discovery about the Delta, to manage scientific conflict through shared processes and to support policy and management decisions. Four mechanisms are:

1) Invited white papers/journal articles by small groups of authors
2) Expert workshop panels similar to the CALFED Science Program Ammonia/Ammonium Workshop [Appendix I]
3) Delta Collaborative Analysis and Synthesis (DCAS) – Focused teams with regional and national interdisciplinary experts that conduct in-depth analyses over a period of one year resulting in peer-reviewed journal articles or white-papers that summarize current knowledge or bring fresh perspectives to a major issue
4) The State of Bay-Delta Science updates.

Primary Responsibility: Delta Science Program

Action Participants: IEP; BDCP; SWRCB; and other federal, State, and local agencies

Expected Outcomes

- Accelerated knowledge discovery about the state of the Delta ecosystem
- Diverse synthesis publications including SBDS, scientific journals articles (e.g., articles in San Francisco Estuary and Watershed Science) and Delta Science Program White Papers.
- A culture of interdisciplinary and collaborative scientific exploration that enhances the understanding of a dynamic system
- A better understanding about how the Delta responds to change induced by management actions, climate change, natural disasters and chronic stressors

4.6 Independent Scientific Peer Review and Advice

> Making well-informed decisions regarding the use and protection of natural resources requires that we fully consider and employ the most reliable and accurate scientific information and judgment available. Calls for inclusion of "the best available science" and independent analyses or review of environmental policy and decision making repeatedly are heard from Congress, the Executive Branch, and other interests. We agree that such participation by the nation's scientific community in the form of independent scientific review can contribute to better-informed environmental policy and decision making.'[12]

The peer review process uses independent scientific experts and plays a key role in determining what is "best available science." Peer review increases the credibility of scientific information and helps scientists improve the quality of their work. Peer review should be an integral and expected part of the science conducted in the Delta. A culture of constructive ideas and innovation to improve the quality and applicability of science should be fostered. The Delta Science Program's policy and procedures for independent peer review of processes, programs, plans and products are included in Appendix J. Peer review is also a key part of research grant funding programs. In addition to providing feedback on scientific integrity, well-designed peer review processes provide independent perspectives and judgments from experts in the subject area. High-quality peer reviews are conducted in a manner so that they are objective, rigorous and transparent.

Efforts to Build On:

- Draft Delta Science Program Policy and Procedures for Independent Scientific Review (February 2013)
- Delta Science Program Proposal Solicitation Package review process
- National Academies' review approach and role
- Delta Independent Science Board reviews

A companion to peer review is independent scientific advice. Projects and programs might often benefit from the active participation of an independent scientist or scientists when they are faced with challenging technical or scientific issues. In these cases, an independent entity can help by identifying experts with experience in the appropriate disciplines who can provide advice at key points in planning,

[12] Gary K. Meffe, P. Dee Boersma, Dennis D. Murphy, Barry R. Noon, H. Ronald Pulliam, Michaele E. Soule and Donald M. Waller. Independent Scientific Review in Natural Resource Management. Conservation Biology Volume 12, No. 2, April 1998

implementation, or evaluation. Similarly, the advice of the Delta Independent Science Board may be requested during the planning stages of a project, synthesis activity or program.

Scientific peer review or advice can be set up in several ways. The entity conducting the review, number of reviewers, the type of process (e.g. panel meeting, independent written reviews), and the length of time for the review can all be adjusted to fit the complexity, level of scientific uncertainty, importance of the subject, and available funding. In its broadest sense, peer review includes the review functions of the Delta Science Program, the Delta Independent Science Board and the National Research Council. Figure 4.6-1 shows how these review functions are related.

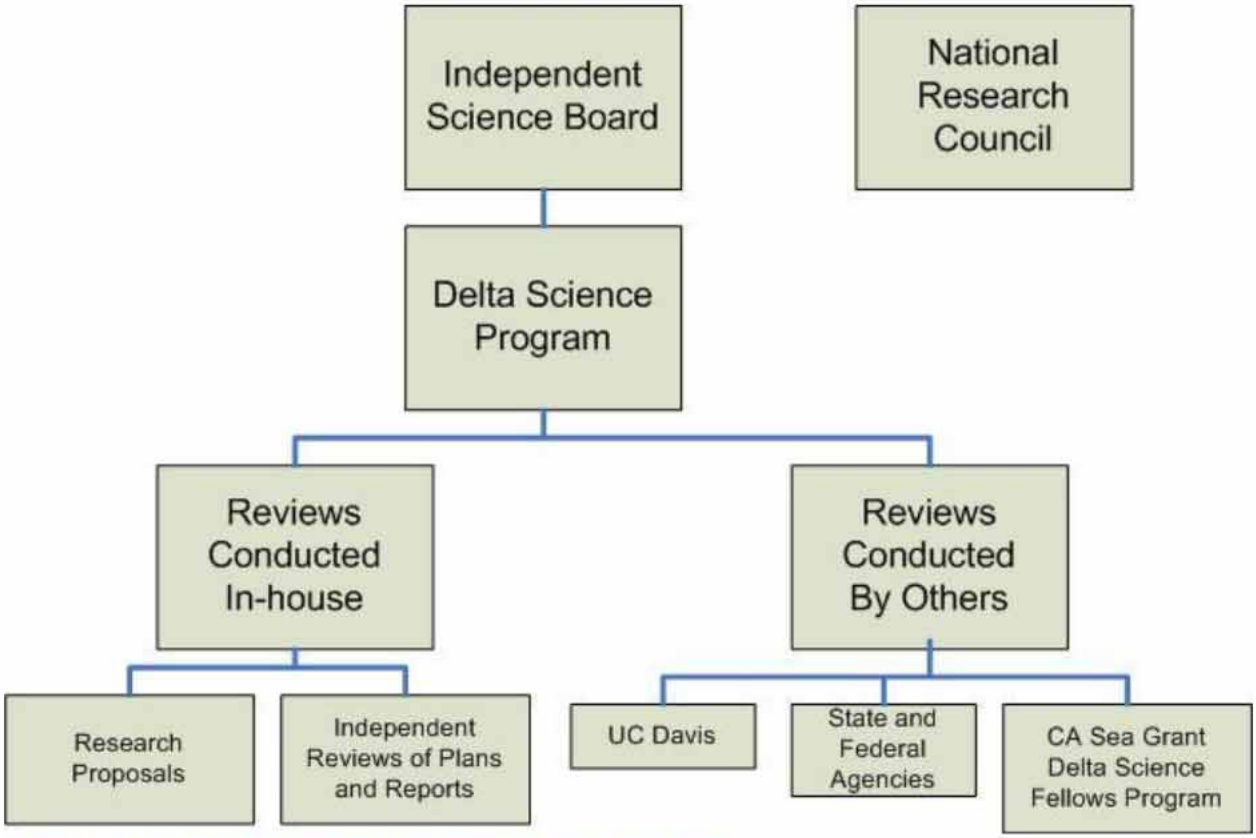

Figure 4.6-1 Structure of reviews conducted under the Delta Science Plan.

The Delta Science Program will take a leadership role in the review of proposals, processes, programs, plans, and products. Reviews may be conducted in-house organized by Delta Science Program staff or by other agencies or institutions with Delta Science Program tracking and guidance. The Delta Independent Science Board's review responsibilities are defined in statute and include periodic reviews of the "scientific research, monitoring, and assessment programs that support adaptive management of the Delta" (Water Code §85280 (a)(3)). Upon request, the National Research Council may be asked to review issues with broad implications for federal agencies or of importance to restoration or water management efforts nationally.

Problem

Research reports and science-based planning and management documents are often used that do not undergo an effective process of scientific peer review. Such reports and documents may include information that is misleading or inaccurate. Decision-makers and environmental managers require peer-reviewed, defensible, robust science for managing the Delta resources; however, a standard level of peer review is not yet consistently applied in the Delta.

Objectives

- Clearly documented independent scientific peer review and advice processes that are consistently applied
- Thorough and thoughtful changes to reports and documents in response to peer review comments

Actions

4.6.1 Adopt a process for conducting scientific peer review

Adopt a well-defined, transparent and widely accepted process for conducting scientific peer review that is consistent across programs and can be applied to research, planning and management documents in the Delta.

4.6.2 Develop a response mechanism to peer review

Develop a response mechanism to peer review of programs, reports or actions that address each major point in the review, how the concern is being addressed, and the reasons for not being able to address any issue.

Primary Responsibility: Delta Science Program

Action Participants: federal, State and local agencies; NGOs, stakeholders

Expected Outcomes

- Transparent collaborative peer review and advice processes that produces the best science, clearly outlining assumptions and limitations
- High quality scientific information that builds trust in decision-making processes

4.7 Communication

Communication is essential to building the Delta science community, building understanding of the issues, and delivering important science messages to the public, managers, policymakers and stakeholders. In fact, it is the keystone for transforming information into knowledge, and knowledge into action. Communication takes many forms from the various digital media, publications, news articles, seminars, workshops, and conferences to water cooler conversations. The concept of "best available science" is predicated on the way that scientific information is reviewed and communicated. No matter how important, scientific information that is not communicated is not "available". This section addresses how scientists communicate with each other, and to managers, policymakers and the public.

A broad range of avenues exists for science communication including seminars, the biennial Bay-Delta Science and State of the Estuary conferences, the Delta Science Program's Science News newsletter and the San Francisco Estuary and Watershed Science online journal. However, the world of communication is dynamic and continually offering new opportunities for improving the way scientists speak to each other and the world.

Efforts to Build On:

- Delta Science Program's Science News
- San Francisco Estuary and Watershed Science
- IEP's online calendar (http://www.water.ca.gov/iep/activities/calendar.cfm)
- Pulse of the Delta
- Pulse of the Estuary
- My Water Quality
- IAHR – Rivers-list (http://riverslist.iahr.org/)
- The State of Bay-Delta Science
- Bay-Delta Science Conference
- State of the Estuary Conference
- Estuary Newsletter

Problem Statement

Important scientific information is often underutilized because it is not effectively communicated. Better science communication is needed to effectively inform policy and management decisions and to build the Delta science community.

Objectives

- Improved communication of science to the public, managers, and policymakers and within the science community through current communication mechanisms and the development and application of innovative communication tools
- Exchange of new scientific information and its implications with scientists, policymakers and managers on a regular basis
- Develop and implement programs that are targeted at the broader public and K-12 to enhance their understanding of complex scientific issues in the Delta

Action

4.7 Develop and implement a communication strategy

The Delta Science Program will develop and implement a broad-based communication strategy that will make use of a range of media and communications tools [Appendix K].

Primary Responsibility: Delta Science Program

Action Participants: Communication experts, IEP, BDCP, Ecosystem Restoration Program, CWQMC, SFCWA and other science programs of federal, state, and local agencies, state legislature

Expected Outcomes

- Enhanced Delta science communication among scientists, decision- and policy-makers and the public so that policy and management decisions are informed by the most up-to-date scientific information

- Improved access to scientific information so that scientists working in the Delta are better informed
- Increased availability of scientific information in formats readily accessible to the non-scientist

See Also

- Chapter 2, Organizing Science to Inform Policy and Management
- Section 4.5, Synthesis for System-wide Perspectives

5. RESOURCES FOR DELTA SCIENCE

Substantial resources have been dedicated for decades to conduct monitoring and research focused on specific agency mandates and responsibilities. This has resulted in considerable knowledge, such as the status of endangered species, the flow characteristics throughout the Delta, and the potential effects of climate change (NRC 2012). However, despite this knowledge base, insufficient resources are pooled to focus on overarching and often controversial questions common to multiple agencies, but outside the jurisdictional boundaries of any single one. In addition, as identified in a recent report by the Public Policy Institute of California (Gray et al. 2013), science coordination efforts among agencies with different cultures have proven inefficient, especially for funding science.

Sufficient resources for science are a prerequisite for adaptive management and informed decision-making. The Delta Science Program has the responsibility for bringing together the key players who can evaluate science-based solutions to address interactive effects of multiple stressors on the ecosystem and water supply and for generating scientifically based projections on the consequences of actions taken finding science-based solutions to meet often conflicting goals. It will take a joint effort by the scientific community to find partnerships and support to build the resource capacity to implement strategic directions outlined in the Delta Science Plan and earlier science planning documents (e.g., Vance 2005; CalEPA Steering Committee for Science 2007; Ocean Science Trust 2008). Champions are needed in the legislature, Governor's Office, and control agencies to advance the capacity of scientists working in agencies to fulfill their duties. Adequate resources are required to build the infrastructure for science (Chapter 4) for the entire scientific community to meaningfully contribute to one or more of the "grand challenges" facing the Delta.

Formidable systemic hurdles exist in developing the infrastructure for science described in Chapter 4. The science and management communities together will need to dedicate considerable effort to communicate to funding decision-makers about how relatively small, yet sustainable investments in science can generate disproportionately larger paybacks in terms of operational efficiencies, less litigation, and better environmental and social outcomes. Improvements in the science infrastructure are required to gain access to even the most basic tools required by scientists to inform the multibillion dollar effort to achieve the coequal goals. Without the essential tools and resources necessary to conduct the science, it is far from assured that the investments placed in achieving the outcomes envisioned in the Delta Plan and other major planning efforts to achieve the coequal goals will come to fruition. The science planning documents referenced above are consistent in their recommendations and apply to this day:

- Increase the ability to recruit, retain, and equitably remunerate scientists
- Provide scientists with access to continuing professional development opportunities, such as to scientific journals, up-to-date hardware and software, and national professional conferences and forums for idea exchanges

- Improve linkages and opportunities for interactions between academia and science serving specific ecosystem and water management needs (e.g., research partnerships, professional networks)

Implementing the Delta Science Plan will require strong leadership from the Delta Science Program. To fulfill this leadership role, the Delta Science Program will need to expand its capacity to facilitate and coordinate Delta Science Plan actions. This will include the ability to supplement core career staff with 'rotators' modeled on the National Science Foundation, whereby scientists from other organizations (including federal agencies, State agencies, local government, universities, stakeholders and non-governmental organizations) may spend a fixed term within the Delta Science Program to help implement the Action Agenda, coordinate updates to SBDS, coordinate workshops and peer review activities, or participate in other responsibilities of the Delta Science Program. The salaries of rotators may be covered by the Delta Science Program during the period of appointment. The rotators ensure a continuous infusion of new ideas, ensures the staff that facilitate 'One Delta, One Science' are representative of the community that the Delta Science Program serves and builds trust that the processes used are open and transparent.

Problem Statement

Insufficient resources are pooled to focus on overarching and often controversial questions common to multiple agencies, but outside the jurisdictional boundaries of any single one. Without the essential tools and resources necessary to conduct the science, particularly synthesis activities (NRC 2012), it is far from assured that the investments placed in achieving the outcomes envisioned in the Delta Plan and other major planning efforts to achieve the coequal goals will come to fruition.

Objectives

- Generate an appropriate funding base for fulfilling the vision of an open Delta science community that builds a shared state of knowledge with the capacity to adapt and inform future water and environmental decisions. This funding should include flexibility for innovation and responsiveness to issues such as natural disasters or new invasive species.
- Improve the organizational structure for science and create funding efficiencies via pooled resources to address questions beyond the limited mandates of individual agencies
- Reform the underlying capacity challenges to conduct science for ecosystem and water management, such as the ability to recruit and retain scientists into state service, as well as providing them with the essential tools required to fulfill their duties
- Apply a mix of sustainable funding mechanisms for science that supports the science at a scale commensurate with the challenges and the level of activities being conducted for water supply reliability, ecosystem restoration, and flood risk reduction. This is particularly critical for implementation of adaptive management.

Actions

5.1 Adequately staff the Delta Science Program

Staff the Delta Science Program adequately for its mission with new core staff.

Primary Responsibility: Delta Science Program

5.2 Supplement the Delta Science Program with rotators

Supplement the Delta Science Program core staff with rotators from other entities and develop funding and contracting mechanisms to cover the salary and benefits of the rotator.

Primary Responsibility: Delta Science Program

Action Participants: 'Rotators' – scientists from other federal, State, and local government, universities, stakeholders and NGOs

5.3 Implement and sustain the science infrastructure

Implement and sustain the science infrastructure described in Chapter 4, through multiple funding sources.

Primary Responsibility: Delta Science Program

Action Participants: All employers of scientists and engineers contributing to California achieving the co-equal goals

Summary of Actions

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS
CHAPTER 2: ORGANIZING SCIENCE TO INFORM POLICY AND MANAGEMENT				
2.1	Establish a Policy-Science Forum	Establish a Policy-Science Forum where directors of federal and state agencies and science leaders gather around key issues (e.g., drought, introduction of native species) to: a) communicate "grand challenges"; b) explore issues directly with leaders of the scientific community for scientists to fully understand the science needed to support decisions and how that science can be best used; c) direct committees as needed to collaboratively analyze policy alternatives and advise adaptive management of policies and programs [Appendix B].	Delta Science Program	Directors of federal and State agencies, Delta Plan Interagency Implementation Committee, Lead/Chief Scientists with responsibilities in the Delta, relevant science leaders identified by the Lead Scientist (i.e., the IEP Lead Scientist, BDCP Science Manager, leading academic researchers, and agency research program directors); Science Steering Committee
2.2	Develop, implement and update a Science Action Agenda	Develop, implement and update a Science Action Agenda (Ch. 1) through an inclusive process that organizes, integrates and prioritizes science activities across programs to address decision-makers' "grand challenges" in an efficient manner [Appendix C].	Delta Science Program	IEP, BDCP, Ecosystem Restoration Program (ERP), California Water Quality Monitoring Council (CWQMC), State and Federal Contractors Water Agency (SFCWA) and other science programs of federal, State and local agencies
2.3	Sustain a web-	Building on existing efforts, develop and sustain a	Delta Science	DSC, IEP, BDCP,

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS
	based tracking system of science activities	web-based tracking system of science activities that inventories and tracks inputs and outputs of research projects, monitoring, modeling, data management, synthesis, peer review and other science activities to improve the transparency of science activities in the Delta.	Program	ERP, CWQMC, SFCWA and other science programs of federal, state, and local agencies
2.4	Establish a Science Steering Committee	Establish a Science Steering Committee to guide the distillation of diverse scientific information and accelerate knowledge discovery for informing decision making through: 1) Translating the "grand challenges" articulated at the Policy-Science Forum into specific research priorities and actionable questions, 2) Providing high-level guidance for topics to be addressed in the Action Agenda (e.g., research topics), 3) Recommending topics for focused science synthesis efforts (including requests for proposals), 4) Providing guidance to science experts writing SBDS 5) Conducting science synthesis in sub-groups, and 6) Representing the One Delta, One Science-Community at Policy-Science Forums [Appendix D]	Delta Science Program	Delta Lead Scientist, Policy-Science Forum participants, individual scientists with relevant expertise (Delta scientists)
2.5	Enable and identify resources for Focused Science Synthesis	Enable and identify resources for Focused Science Synthesis teams that distill the state of knowledge on specific topics (e.g., what is the role of ammonia/ammonium within the Delta ecosystem?). Focused Science Synthesis teams will address directed action and self-form in response to requests for proposals (RFPs).	Delta Science Program	Science Steering Committee, Delta Lead Scientist, scientists, science programs of federal, State, and local agencies
2.6	Publish and Update The State of Bay-Delta Science	Publish and update The State of Bay-Delta Science at least once every four years, aligned with the Biennial Bay-Delta Science Conference (offset from development of the Action Agenda) to regularly update and communicate the state of knowledge about the Delta system [Appendix E].	Delta Science Program	Relevant experts, the Science Steering Committee
2.7	Deliver Annual State-of-Delta Science Address	The Delta Lead Scientist, in consultation with the science community, will deliver an annual review of Delta science. Depending on the point in the four-year cycle of science, the presentation will highlight the Science Action Agenda, The State of Bay-Delta	Delta Science Program	Relevant experts, the Science Steering Committee

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS
		Science and key questions, findings and innovations. This address will occur at a suitable venue and will be webcast and archived on the Delta Stewardship Council webpage.		
2.8	Develop and Report Performance Measures	Measures and metrics will be developed to evaluate Delta Science Plan performance [for Draft Performance Measures see Appendix A]. Parameters will be tracked that capture the development and impacts of the proposed science infrastructure, the role of science in guiding adaptive management and the effectiveness of the organization of science to guide future refinements of the Delta Science Plan. Performance monitoring will include surveys and selected interviews with representatives of all the contributors, users and beneficiaries of the Delta Science Plan conducted by an independent third party.	Delta Science Program	Relevant experts, the Science Steering Committee
CHAPTER 3: ADAPTIVE MANAGEMENT FOR A COMPLEX SYSTEM				
3.1	Hold an Annual Adaptive Management Forum	Hold an annual Adaptive Management Forum with national and international experts and local proponents to provide adaptive management training to build capacity for planning and implementing adaptive management, establish and refine adaptive management frameworks (Action 3.2), share lessons learned from the Delta and elsewhere, and integrate across ecosystem restoration and water management adaptive management activities.	Delta Science Program	National and international experts on adaptive management; local proponents of adaptive management from federal, State and local agencies, non-governmental organizations, private organizations and academia
3.2	Develop and Use Adaptive Management Frameworks	Develop and utilize frameworks to guide science-based adaptive management consistent with the Delta Plan's adaptive management framework and provide for consistent and integrated regional and system-wide approaches [Box 3-2 and Appendix G]: 1) A Restoration Framework to provide principles and guidelines for adaptive management of Delta ecosystem restoration	Delta Science Program and Delta Stewardship Council Planning along with (1) Delta Conservancy and its Restoration Network	Delta Plan Interagency Implementation Committee, proponents of adaptive management from federal,

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS
		actions in each priority habitat restoration area[13] such as the Delta Conservancy's Delta Restoration Network, and 2) A Water Management Framework to provide principles and guidelines for adaptive management of Delta water management actions through shared approaches, such as the Long-term Operations Biological Opinions RPA Implementation and the Collaborative Science and Adaptive Management Program and its Collaborative Adaptive Management Team (CSAMP/CAMT).	participants; (2) NMFS, USFWS, CDFW, DWR, USBR and other CSAMP/CAMT participants	State and local agencies, non-governmental organizations, private organizations and academia
3.3	Adaptive Management Liaisons	Establish a team of Delta Science Program staff members with expertise in the science supporting adaptive management 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 Adaptive Management Liaisons to their counterparts in agencies and organizations that are planning and implementing effective adaptive management programs and projects including Delta Plan covered actions [Appendix H].	Delta Science Program	Agencies and organizations that are planning and implementing adaptive management
3.4	Modeling Future Scenarios	Facilitate interdisciplinary teams to model alternative future scenarios and predict system-wide responses. Alternative scenarios will be developed and explored for each of the six priority restoration areas and across the entire Delta and address the basic science, Delta change management, operations and restoration as described in Box 3-4. This will allow the finite resources such as water, the tidal energy that drives the processes essential for the success of tidal wetland restoration, sites suitable for certain ecological functions and the landscape scale mosaic of habitats to be envisioned by the people of the Delta, scientists and the decision-makers that will ultimately decide the fate of the ecosystem.	Delta Science Program	Agencies and organizations that are planning and implementing adaptive management, CWEMF
CHAPTER 4: BUILDING THE INFRASTRUCTURE FOR SCIENCE				
4.1	Support Research	Support research through competitive research grants, Delta Science Fellows, and rapid-response	Delta Science Program	IEP, BDCP, ERP, SFWCA and other

[13] The Delta Plan identifies six priority habitat restoration areas: Yolo Bypass, Cache Slough Complex, Cosumnes River – Mokelumne River Confluence, Lower San Joaquin River Floodplain, Suisun Marsh, Western Delta/Eastern Contra Costa County.

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS
		research grants to address grand challenges and priority policy and management needs. **Competitive Research Grants -** The Delta Science Program will manage the solicitation process for selecting research projects. To increase efficiency of peer review, all funding agencies are invited to participate in this biennial process. Competitive proposals will be assessed on intellectual merit (provided by anonymous peer review and science review panels) and broader impacts (assessed by the Science Steering Committee and the responsible funding agency/ies). **Delta Science Fellows** - The Delta Science Program and California Sea Grant will jointly manage an annual Delta Science Fellows solicitation with potential research topics and funding invited from other organizations. The selection will be based on intellectual merit (provided by anonymous peer review and science review panels) and broader impacts (assessed by the Science Steering Committee and the responsible funding agency/ies). **Rapid-response Research Grants** - To maintain flexibility and responsiveness of Delta science, some research funds are set aside for opportunistic research or to address unexpected events such as a major flood, earthquake, levee failure, or salt-water intrusion into the Delta. These time-sensitive, innovative or exploratory research ideas will be managed similar to the National Science Foundation's "RAPID" or "EAGER" grants. They will be funded through: a) focused solicitations where the scope of a project is generally known but it is open for proposals, or b) directed actions where the scope of the project is well defined and the appropriate project team has been identified for example, due to ongoing activities.		science programs of federal, state, and local agencies
4.2.1	Support and sustain a web-based information system for monitoring activities	Support and sustain a web-based information system describing monitoring activities in the Delta, their products, and their nexus with regulatory requirements and management actions to make monitoring information more accessible.	California Water Quality Monitoring Council	Delta Science Program; statewide, regional and local monitoring programs

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS
4.2.2	Build a complete Delta monitoring program	Build a Delta monitoring program with a shared purpose and strategy for integrated monitoring to systematically inform adaptive management and report on Delta environmental changes to policymakers and the public.	Delta Science Program	IEP; BDCP; and federal, State and local agencies; NGOs
4.3.1	Host a Data Summit	Host a summit on environmental and project-implementation data to explore the needs for cyber-infrastructure improving data management, data sharing and data mining. Information generated in the Summit will inform the Science Action Agenda for innovations in data management as well as ideas for enhancing and sustaining current initiatives.	Delta Science Program, California Technology Agency and other key partners	National and international experts and leaders from federal, State, and local agencies, stakeholders, NGOs and academia
4.3.2	Develop Guidelines for Data Sharing	Based on outcomes from the Summit, guidelines for data sharing will be developed including descriptions of existing or needed web services for enabling community data access, integration, visualization and display.	Delta Science Program, California Water Quality Monitoring Council, California Technology Agency and other key partners	Delta Conservancy, USGS, NMFS, BDCP, IEP, CAMT and other agencies and programs responsible for managing environmental data related to the Delta, as well as representatives from universities, consultants, NGOs and invited experts in the field of data management
4.4.1	Develop a collaborative community modeling framework	Develop a framework for collaborative community modeling to enhance interdisciplinary modeling, accelerate knowledge discovery and avoid duplication of efforts and support diverse modeling approaches. This framework will be based around the four science needs shown in Box 1-3 and will be developed through a Modeling Summit co-hosted by CWEMF and the Delta Science Program.	Coordination by Delta Science Program, with key roles for CWEMF	DWR, BDCP, CAMT, IEP, SWRCB, agencies, academics, consultants
4.4.2	Develop, update and	Develop, update and maintain conceptual models to identify the current state of knowledge, identify gaps	Coordination by Delta Science	DWR, BDCP, CAMT, IEP,

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS
	maintain conceptual models	in understanding, contribute to the identification of research priorities and support adaptive management planning and implementation. The Delta Science Program will track and help promote these conceptual models in guiding Delta management, including landscape-scale conceptual models for the six priority ecosystem restoration areas identified in the Delta Plan	Program, with key roles for ERP	SWRCB, agencies, academics, consultants
4.4.3	Support high-priority model development	Support high-priority model development and refinement through research grants, fellowships, workshops, seminars and conferences.	Coordination by Delta Science Program, with key roles for CWEMF (4.4.1 and 4.4.4) and ERP (4.4.2)	DWR, BDCP, CAMT, IEP, SWRCB, agencies, academics, consultants
4.4.4	Embrace alternative modeling approaches	Embrace alternative modeling approaches and support inter-model comparisons to help quantify uncertainty and sensitivity arising from different assumptions, quality and quantity of available data, different algorithms or alternative scenarios.	Coordination by Delta Science Program, with key roles for CWEMF	DWR, BDCP, CAMT, IEP, SWRCB, agencies, academics, consultants
4.5.1	Establish mechanisms and protocols for ongoing synthesis	Establish mechanisms and protocols for conducting ongoing syntheses to accelerate knowledge discovery about the Delta, to manage scientific conflict through shared processes and to support policy and management decisions. Four mechanisms are: 1) Invited white papers/journal articles by small groups of authors 2) Expert workshop panels similar to the CALFED Science Program Ammonia/Ammonium Workshop [Appendix I] 3) Delta Collaborative Analysis and Synthesis (DCAS) – Focused teams with regional and national interdisciplinary experts that conduct in-depth analyses over a period of one year resulting in peer-reviewed journal articles or white-papers that summarize current knowledge or bring fresh perspectives to a major issue 4) The State of Bay-Delta Science updates.	Delta Science Program	IEP; BDCP; SWRCB; and other federal, State, and local agencies
4.6.1	Adopt a process for conducting scientific peer review	Adopt a well-defined, transparent and widely accepted process for conducting scientific peer review that is consistent across programs and can be applied to research, planning and management documents in the Delta.	Delta Science Program	federal, State and local agencies; NGOs, stakeholders
4.6.2	Develop a response mechanism to	Develop a response mechanism to peer review of programs, reports or actions that address each major point in the review, how the concern is being	Delta Science Program	federal, State and local agencies; NGOs,

ACTION NUMBER	SHORT TITLE	ACTION LANGUAGE	PRIMARY RESPONSIBILITY	ACTION PARTICIPANTS
	peer review	addressed, and the reasons for not being able to address any issue.		stakeholders
4.7.1	Develop and implement a communicatio n strategy	The Delta Science Program will develop and implement a broad-based communication strategy that will make use of a range of media and communications tools [Appendix K].	Delta Science Program	Communication experts, IEP, BDCP, Ecosystem Restoration Program, CWQMC, SFCWA and other science programs of federal, state, and local agencies, state legislature
CHAPTER 5: RESOURCES FOR DELTA SCIENCE				
5.1	Adequately staff the Delta Science Program	Expand the capacity of the Delta Science Program to facilitate and coordinate Delta Science Plan actions.	Delta Science Program	---
5.2	Supplement the Delta Science Program with rotators	Supplement the Delta Science Program core staff with rotators from other entities and develop funding and contracting mechanisms to cover the salary and benefits of the rotator.	Delta Science Program	'Rotators' – scientists from other federal, State, and local government, universities, stakeholders and NGOs
5.3	Implement and sustain the science infrastructure	Implement and sustain the science infrastructure described in Chapter 4, through multiple funding sources.	Delta Science Program	All employers of scientists and engineers contributing to California achieving the co-equal goals

1

Glossary

[Under construction]

Includes all relevant terms in Delta Plan but also addresses contentious issues as definitions of science and scientists.

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APPENDIX A: Draft Outcome Performance Measures

Overarching/ Ultimate Performance Outcome

The community of scientists working in the Delta in an integrated manner contributed to the increased reliability of the State's water supply and an improved Delta ecosystem that is more resilient and favors native species.

Performance Outcomes <5 Years

Science Action Agenda (Short-term (<5 years) outcome)

Federal, state and local agency work plans and efforts reflect the issues and priorities established in the Science Action Agenda.

Adaptive Management

Agreed upon adaptive management frameworks are incorporated into all water management actions and ecosystem restoration efforts.

Performance Outcomes >5 Years

Shared Modeling

Duplicative efforts are reduced because the Delta science community worked together to develop models that are widely used.

Quality

Documentation is provided for all data and end products are routinely subjected to peer review.

Scientific Communications

Current scientific information presented in The State of Bay Delta Science is widely cited in the development of research questions and decision-making.

Conflict

Scientific conflict within the Delta is reduced as demonstrated by the number of issues addressed through adaptive management (Chapter 3), synthesis activities (Chapter 4.5) or Peer Review and Advice (Chapter 4.6), frequency of the use of synthesis products in hearings, policy documents and lawsuits; and a decreasing trend in the number of lawsuits filed on disagreements about science.

Effectiveness

Routine surveys of the Delta community (including federal and State agencies and stakeholders) uniformly indicate that implementation of the Delta Science Plan is having a positive effect on the development and use of science to support actions for improving water supply reliability and restoring and enhancing the Delta ecosystem.

APPENDIX B: Policy-Science Forum

Objective

Facilitate two-way interactions between policy and science communities for:

a) Communicating "grand challenges";

b) Exploring policy issues directly with leaders of the scientific community for scientists to fully understand the science needed to support decisions and for policy-makers to understand how that science can be best used;

c) Directing committees as needed to collaboratively analyze policy alternatives and advise adaptive management of policies and programs.

Participants

- Leaders from federal and state government institutions (e.g., directors of agencies)
- Delta Plan Interagency Implementation Committee,
- Leading scientists working on Delta issues,
- Relevant science leaders identified by the Delta Lead Scientist (i.e., the IEP Lead Scientist, BDCP Science Manager, Leading Academic Researchers, and Agency Research Program Directors)
- Subset of Science Steering Committee Members
- Interested public, through public comment at open meetings

Leadership

- Co-chaired by a Rotating Policy Agency Director and the Delta Lead Scientist
- Executive Committee – A small rotating executive committee will be identified from the larger Policy-Science Forum and include no more than six members. Membership on this team will be rotating. Roles and responsibilities include:
  - Setting the agenda for Policy-Science Forum meetings
  - Documenting the shared "grand challenges" identified by the policy community and the communication of high-level science to address the "grand challenges."
  - Ensuring other expected outcomes of the Forum are documented.
- Facilitated by the Delta Science Program

Meetings

- Forum meetings will occur at least once every year in a public setting, potentially at biennial science conferences
- Meetings of the larger group will be held in public

Potential Products

A summary document (i.e., memo) of shared "grand challenges" identified by the policy community and the communication of high-level scientific understanding that addresses past or ongoing "grand challenges."

APPENDIX C: Process for Developing and Updating the Science Action Agenda

Science Action Agenda Content

The Action Agenda will contain the priority science activities for addressing decision-makers' "grand challenges" on a four-year cycle. The Action Agenda will include multiple directed science activities and open competitive solicitations. It will include activities to predict potential outcomes of various management and intervention options, often referred to as "alternative futures." The Action Agenda will support coordinated and transparent adaptive management. It will retain flexibility to conduct science around unanticipated specific events such as a flood, earthquake, levee failure, salt-water intrusion into the Delta, or major releases of hazardous materials.

Identifying Priority Science Activities

The Action Agenda will be developed and updated through an open process by the Delta science community (including federal and State agencies, local agencies, academics, and interested public) and the Science Steering Committee (Action 2.4) under the leadership of the Delta Science Program. The Policy-Science Forum (Action 2.1) will provide high-level guidance for the Action Agenda through the identification of decision-makers' "grand challenges" including statements about major problems, goals and objectives. The Science Steering Committee will translate the "grand challenges" into science questions to be addressed through priority science activities. These science questions will be used to guide the development and updates to the Action Agenda. Priorities for science actions identified at summits (i.e., the adaptive management forum (Action 3.1) and through collaborative efforts for developing community tools (i.e., data management (Action 4.3.1.) and shared models (Action 4.4.1.)) will also be incorporated into the Action Agenda. Input from agencies, the science community and interested public on priority science activities will be gathered through forums such as, the Annual IEP Workshop, State of the Estuary Conference, Delta Stewardship Council meetings and the Biennial Bay-Delta Science Conference, as well as through written public comments. The Delta Lead Scientist has final authority for selecting and articulating the rationale for the science priorities in the Action Agenda.

Review Process

The Action Agenda will be reviewed by the 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.

Use

The Action Agenda will be the shared science priority actions for the Delta. It will provide the overarching agenda and direction for developing and updating individual science programs' work plans. The Delta Science Program will coordinate the implementation of the Action Agenda through an open process that connects agencies and interested parties to collectively fund priority actions. Collective implementation of the Action Agenda will build the knowledge base and science tools necessary to address decision-makers' needs.

Updating the Action Agenda

The four-year cycle of the Action Agenda will be aligned with the Biennial Bay-Delta Science Conference to maximize opportunities for openly engaging the science community, policymakers, managers and interested public. Discussions on and releases of Action Agenda updates will be timed to gather input through the Annual IEP Workshop, State of the Estuary Conference, Delta Stewardship Council meetings and the Biennial Bay-Delta Science Conference.

APPENDIX D: Science Steering Committee

Objective

Build capacity and sustain collaborative processes for ongoing science research and synthesis to develop shared scientific understanding.

Charge to the Science Steering Committee

Guide the distillation of diverse scientific information to accelerate knowledge discovery for informing decision-making through:

1) Translating the "grand challenges" articulated at the Policy-Science Forum into specific research priorities and actionable questions,
2) Recommending topics for focused science synthesis efforts (including requests for proposals),
3) Providing high-level guidance for topics to be addressed in the Action Agenda (e.g., research topics),
4) Providing guidance to science experts writing SBDS
5) Conducting science synthesis in sub-groups, and
6) Representing the One Delta, One Science Community at Policy-Science Forums

Committee Composition

The Science Steering Committee will comprise no more than 12 interdisciplinary science experts. Committee members will be selected by the Delta Lead Scientist based on their scientific merit and balance of expertise, similar to the requirements of the National Academies of Science for composing balanced committees without significant conflict of interest[14]. This means that members of this committee will be selected by the Delta Lead Scientist for their scientific expertise and merits rather than as representatives of agencies, institutions or interest groups. Criteria for participation on the committee may include:

- Relevant scientific expertise
- Outstanding scientific credentials
- The ability to think synthetically about the Delta system and translate "grand challenges" into science questions and priority science activities

The Delta Lead Scientist will evaluate the committee composition on an annual basis to ensure its balance of expertise can adequately guide science to address current and anticipated "grand challenges".

Leadership

The Science Steering Committee will be facilitated by the Delta Science Program under the leadership of the Delta Lead Scientist.

[14] http://www.nationalacademies.org/xpedio/groups/nasite/documents/webpage/na_069688.pdf

A subset of the Science Steering Committee will represent the community of Delta scientists at Policy-Science Forum meetings.

Potential Products

- Science questions and preliminary priority topics for the Science Action Agenda
- Recommended topics for focused science synthesis directed actions and RFPs
- Science synthesis products produced by sub-groups of the Science Steering Committee
- Guidance and direction for revising and updating SBDS

APPENDIX E: *The State of Bay-Delta Science*

Objective

Regularly summarize and communicate current scientific knowledge to be used to inform policy and management decision and associated "grand challenges." This includes progress made on key research questions and the identification of knowledge gaps.

Content and Use

The State of Bay-Delta Science (SBDS) is a synthesis and summary of the latest scientific understanding of the Delta. It includes science information that is distilled and presented in a manner that can be used to support policy and management decisions. SBDS will be used to inform the Policy-Science Forum and to guide updates to the Action Agenda. It will also be a foundational component of the Delta Lead Scientist's delivery of the Annual State-of-Delta Science Address.

Production Timeline

The State of Bay-Delta Science, 2008 will be updated by the end of 2014. Thereafter, it will be published at least once every four years with periodic online updates as new knowledge becomes available. The four-year production cycle of SBDS 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 (i.e., the Biennial Bay-Delta Science Conference, Annual IEP Workshop and State of the Estuary Conference) will be used to gather additional broad input on the topics addressed in SBDS.

Authors and Publishers

The State of Bay-Delta Science will be written by relevant science experts with guidance from the Science Steering Committee. The Delta Science Program will be responsible for publishing SBDS.

Review Process

The State of Bay-Delta Science will be reviewed by the Delta Independent Science Board.

APPENDIX F: Adaptive Management Guidelines

The following are suggested guidelines for each of the nine steps of the Delta Plan adaptive management framework to help proponents incorporate adaptive management into their programs, plans or projects.

1) Define/Redefine the Problem

- Proponents and stakeholders articulate the problem statement as a group.
- Link management problem with relevant scientific knowledge and conceptual models.
- Covered action project proponents identify funding source(s) for carrying out the adaptive management process as part of the certification of consistency with Policy GP 1 of the Delta Plan.

2) Establish Goals and Objectives

- Articulate specific objectives.
- Place objectives into larger landscape/watershed context.
- Through early engagement with the Delta Science Program Adaptive Management liaison(s), develop shared understanding of the limitations and opportunities of goals and objectives based on conceptual models.

3) Model Linkages between Objectives and Proposed Action(s)

- Use conceptual and quantitative models (including landscape-scale and community models developed under the Delta Science Plan Action 4.4.2) to develop hypotheses, determine the range of potential outcomes (benefits and risks) of alternative actions, and determine what information is needed to test hypotheses, analyze results, and reduce critical uncertainties.

4) Select Action(s) and Identify Performance Measures

- Use the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) Action Evaluation Procedure and accompanying worksheets as an organizing tool for evaluating project objectives and initial range of actions.
- Articulate expected benefits and risks of actions designed to meet project objectives.
- Select adequate and realistic performance measures based on desired outcomes, project conceptual model and simulation models.
- Ensure consistency and integration with system-wide performance measures.

5) Design and Implement Actions

- Use the conceptual models and Action Evaluation Procedure to evaluate various designs.
- Consider the range of outcomes under various alternative actions ("alternative futures") through modeling and expert evaluation.
- Consider effects on other current actions and determine future actions that could be precluded by this action.
- Design action(s) and appropriate monitoring approach to reduce uncertainty, test model predictions, and integrate into related research programs.

6) Design and Implement Monitoring Plan

- Based on the models and tiered management questions associated with the project, determine the most appropriate statistical design of the proposed monitoring program, including linkage to: companion research effort, modeling, performance measures and system-wide monitoring, including the collaborative and comprehensive Delta monitoring program (Action 4.2.2).

- Document other data sources to be used in assessment.
- Develop funding source and identify responsible entities for monitoring.
- Develop data management plan for project.
- Collect and share data via an open Delta cyber-infrastructure (Action 4.3.2).

7) Analyze, synthesize and evaluate

- Analyze data and use shared mechanisms and protocols for synthesis (Actions 4.5.1) to learn the effects of the action taken.
- Evaluate progress based on performance measures and utilize independent scientific peer review protocols to check the integrity of the science (Actions 4.6.1 - 4.6.2).

8) Communicate Findings

- Communicate current understanding through science-management team discussions and communication tools (Actions 4.7.1)
- Provide adequate opportunities for all interested parties to engage in process.

9) Adapt

- Redefine the problem being addressed.
- Adjust the goals and objectives.
- Recalibrate models with new data, as appropriate.
- Adjust management actions if necessary, based on outcomes and responses to implementation in Step 5.
- Evaluate robustness of management, regulatory, and policy structures to implement change and adaptation on this or future related projects.

APPENDIX G: Attributes of Adaptive Management Frameworks (Action 3.2)

[UNDER DEVELOPMENT]

i. Integration of adaptive management activities to improve nesting of adaptive management projects into landscape-scale efforts, shared learning and efficient use of resources.
ii. Institutional arrangements to sustain scientific assessment and support rapid, nimble, and authoritative management decisions at appropriate time intervals (water operations decisions generally occur at more frequent intervals than habitat restoration decisions).
iii. Use of conceptual models including landscape-scale conceptual models for priority restoration areas based on historical ecology and latest science
iv. Emphasis on hypothesis-testing and linkage to companion science programs
v. Use of broadly accepted and transparent quantitative models to analyze alternative futures (short- and long-term) and address "what if" questions
vi. Expert evaluation and peer review of project design (see Box G-1),
vii. Monitoring, data management and evaluation consistent with system-wide efforts and Delta Science Plan recommendations
viii. Focused synthesis and communication of the state of knowledge needed to inform adaptive management decisions
ix. Scientific oversight by the Delta Independent Science Board

Box G-1 Ecosystem Restoration at Prospect Island and Yolo Ranch - DRERIP Evaluation

Prospect Island and Yolo Ranch are individual restoration initiatives in the Delta identified to satisfy biological opinion requirements for delta smelt and salmon habitat. Historically, the process of planning and implementing habitat restoration in the Delta and Suisun Marsh has been long and unsatisfactory. Obtaining clarity on project objectives, understanding landscape potential, managing property, acquiring permits, and making scientific observations are among the challenges the agencies and other involved parties face.

In developing the Delta Regional Ecosystem Restoration Plan (DRERIP), the Ecosystem Restoration Program commissioned a suite of conceptual models about Delta ecosystem processes, habitats, stressors and life history of key fish species, and created a scientific evaluation process for restoration projects. The purpose of the DRERIP scientific evaluation process was to evaluate restoration project designs based on the best available scientific understanding on a variety of issues, utilizing the DRERIP conceptual models. The evaluation process engages the conceptual model authors and other recognized experts to consider the effects of restoration design alternatives on such issues as mercury methylation potential, aquatic vegetation recruitment and establishment, primary productivity, creation of salmonid and delta smelt habitat, predation, and changes in regional hydrodynamics and generate an emerging consensus on the range of management actions that might achieve desired outcomes, while keeping in mind both risks to investments and those associated with unintended consequences. The up-to-date scientific information is then vetted with managers who consider it in formulating their implementation designs. This scientific evaluation process was conducted recently for the Prospect Island restoration project as part of the Fish Restoration Program Agreement process.

Given the scale of planned ecosystem restoration, the process for evaluating projects must be much more adept and swift than it has been in the past. The Prospect Island and Yolo Ranch evaluations have been instructive both because design improvements emerged from the discussion, and the dynamics of the group deliberations illustrate how complex restoration actions can be effectively carried out. While the design evaluations were somewhat different, several important lessons were learned. First, the evaluations demonstrated the value of historical ecological assessment. The landscape position of the projects and broader regional physical and biological context provide essential clues about landscape ecological potential. Second, significant hydrodynamics and transport modeling was completed prior to the evaluation about such metrics as current structure, water exposure time, and regional tidal range effects. Modelers were in the room and were able to demonstrate concepts in real time that elevated the group understanding of key processes. Third, landscape changes will initiate a complex and non-linear cascade of processes and outcome trajectories that are difficult to predict with certainty. There was a deep recognition that the projects will affect, and be affected by, the regional ecosystem, especially as it changes in the future from climate change and additional restoration. Finally, many participants agreed that the evaluation process would be improved if a regional landscape conceptual model had been incorporated from the beginning with advance insights about the sensitivity of tidal energy, currents, turbidity, and fish-habitat behavior (to name a few) to landscape changes. The designs of both projects were changed based on this scientific evaluation.

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APPENDIX H: Delta Science Program Adaptive Management Liaisons (Action 3.3)

[UNDER DEVELOPMENT]

Delta Science Program Adaptive Management Liaisons (Action 3.3)

The Delta Reform Act and Delta Plan require the use of an adaptive management framework to improve the planning, implementation and evaluation of projects. The Delta Science Program will make available adaptive management liaisons for early consultation on adaptive management for Delta Plan proposed covered actions. Early consultation for covered actions will assist project proponents to obtain consistency determinations and increase the likelihood that the best alternative for implementation is chosen to advance program, plan, and system-wide goals and objectives.

Proponents of actions that do not require consistency determinations under the Delta Plan may also benefit from the advice of Delta Science Program staff prior to the implementation phase of a project or plan, especially those that have the potential to: (1) substantially advance the coequal goals; (2) are likely to add to the knowledge base and reduce uncertainties related to achieving performance measures in the Delta Plan; and (3) are likely to reduce other significant barriers to large-scale restoration or water management improvements, such as regulatory constraints.

There are several advantages of early involvement by Delta Science Program staff in non-covered actions and those that are outside of the Council's geographic jurisdiction but could have significant direct or indirect benefits to Delta ecosystem functions or decrease reliance on water exports from the Delta. They may include:

- increased competitiveness in future grant applications for Integrated Regional Water Management projects, the Carbon Cap-and-Trade Auction Investment fund, and other sources
- savings in staff time for project proponents resulting from information on regional monitoring and other activities, advice on conceptual models and assistance in networking with other programs
- a greater degree of accountability and transparency via broadly applicable performance measures via a standardized approach to the use of science across agencies and programs

APPENDIX I: Delta Science Program Draft Policies and Procedures for Independent Science Workshops (August 2013)

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 provides independent synthesis of the state of scientific knowledge on topics of importance to decision-makers. The typical purpose of a 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 any agency or other interested party. The workshop will focus 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 (competing) commitments of the Delta Science Program and the relevance of the workshop with respect to the goals and objectives of it and the Delta Stewardship Council. Furthermore, the Delta Science Program will only agree to provide conduct a workshop if there is sufficient funding available, if there is sufficient time available to complete the workshop and deliver a report, and if there is sufficient scientific information to justify a workshop. The ultimate decision to provide 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 prior to initiation of the workshop. Participants in a Workshop Planning Group composed of those parties may communicate their expectations for the pending workshop, will provide input on the Charge to the Panel, may consider the workshop agenda and panel-member composition, and may 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 for the Charge to the

Panel), questions and tasks for the panel, a description of the role of the panel and rules for its deliberations and the form and scope of the workshop product, and a timeline of deliverables.

Independent Science Workshop Panel

Panels will include no fewer than five 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 and with 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 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 to be 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 practicable. Unless there are compelling reasons to do otherwise, each independent scientific workshop will have a public meeting. While the workshop panel will deliberate on camera to develop their recommendations, the 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 for panel 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 to the Delta Stewardship Council's list serve.

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 J: Delta Science Program Draft Policy and Procedures for Independent Scientific Review (February 2013)

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 promotes and provides independent scientific review of processes, programs, plans, and products. The policies and procedures below describe how independent scientific review provided by the Delta Science Program will be conducted.

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 (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. Furthermore, the Delta Science Program will only agree to provide a review if there is sufficient funding available for the review, if there is sufficient time available to complete the review and deliver a report, if the apposite document is complete and ready for review[15]. The ultimate decision to provide a review rests with the Lead Scientist for the Delta Science Program.

Planning Meetings

Meetings to plan for a review may be held with members of the requesting party, authors of the document(s) subject to review, and interested agency/stakeholder representatives prior to initiation of the review. Participants in a Review Planning Group composed of those parties may communicate their expectations for the pending review, will provide input on the Charge to the Panel, may consider the review schedule and panel-member composition, and may provide pertinent background documents or other instructional materials for the review through the Delta Science Program.

Charge to the Panel

Charge questions are developed with input from the Review 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 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.

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 for the Charge to the

[15] Review of draft documents, like final documents, is appropriate provided they are complete and ready for review. In contradistinction, review of partial documents, whether final or draft, is generally inappropriate.

Panel), questions and tasks for the panel, a description of the role of the panel and rules for its deliberations and the form and scope of the review product, and a schedule of deliverables.

Independent Science Review Panel

Panels will include no fewer than five members. The Lead Scientist has the final authority for the selection of Independent Scientific Review Panel members and will consider input from the Review Planning Group. 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 review, 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 review.

Materials for Review

Materials to be reviewed by the Independent Scientific Review Panel include the review document or documents, and pertinent background materials. 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 review questions and tasks, and consider the management implications of materials provided to the review panel and 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, with panel members on issues pertinent to the review during the review period 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 review process will be open and transparent to the extent practicable. Unless there are compelling reasons to do otherwise, each independent scientific review will have a public meeting. While the review panel will deliberate on camera 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 list serve.

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 K: Communication

This is an initial outline of existing and new communication tools to be included in a comprehensive Delta science communication strategy.

1. Enhance existing communication tools

   - ☐ Continue support for the open access journal, San Francisco Estuary and Watershed Science, and expand its visibility within the community

   - ☐ Continue publication of the Delta Science Program's Science News and explore opportunities for joint publication with the San Francisco Estuary Partnership's Estuary News

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

   - ☐ Continue support for existing scientific conferences including the biennial Bay-Delta Science Conference and the State of the Estuary Conference to discuss new research findings and explore new initiatives; invite the Policy-Science Forum to meet during the conferences and convene media events around these gatherings

   - ☐ Expand the number of workshops and seminars currently being conducted including brown bag luncheon seminars and seminars hosted jointly with the UC Davis Center for Aquatic Biology and Aquaculture (CABA) which are open to the public and free of charge

   - ☐ Improve the existing Delta Science Program website including expansion of its scientific content to include peer-reviewed and white papers on Delta issues; conference, workshop, and seminar summaries, and establishment of pages specifically oriented to the non-scientist, general public and those in grades K-12

2. Develop new communication tools

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

   - ☐ Include preparation of outreach materials summarizing recent scientific research results and findings specifically directed to policy- and decision-maker

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

APPENDIX L: Funding Delta Science

[This may be prepared under separate cover]

[This chapter needs an in-depth discussion about funding Delta science as a whole – not merely the Science Program housed at the DSC. It takes time and effort to develop shared work plans with partner agencies, align common approaches, and develop sustainable funding for specific mandated activities and those going beyond individual jurisdictional boundaries. An example would be the stewardship of the California Aquatic Resources Inventory.