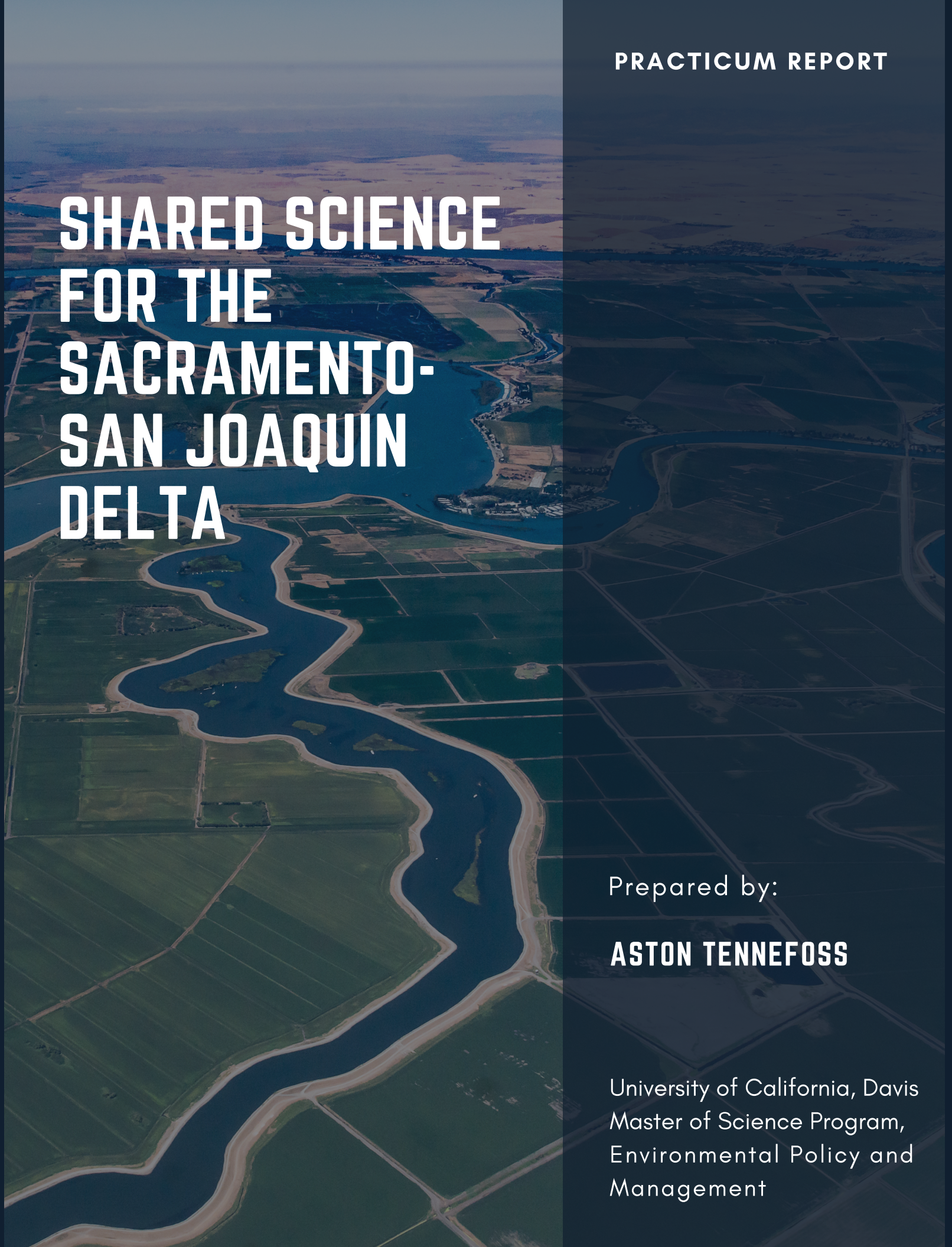

PRACTICUM REPORT

SHARED SCIENCE FOR THE SACRAMENTO-SAN JOAQUIN DELTA

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I alone am responsible for the recommendations in this report and any errors herein.

TABLE OF CONTENTS

SUMMARY 4

IMPORTANCE OF THE SACRAMENTO-SAN JOAQUIN DELTA 5

OBJECTIVES AND SCOPE OF THIS STUDY 5

CURRENT SYSTEM OF SCIENCE 7

- Stakeholder Network 7
- Collaborative Venues 8
- Funding 11

GAPS BETWEEN CURRENT AND DESIRED SYSTEM OF SCIENCE 13

- Priorities 13
- Science Governance 13
- Project Implementation 14
- Resources 15
- Communication 15

BARRIERS TO OVERCOMING GAPS 16

RECOMMENDATIONS TO OVERCOME BARRIERS 18

CONCLUDING THOUGHTS 27

GLOSSARY OF TERMS 28

REFERENCES 31

APPENDICES 34

- Appendix A: List of agencies with personnel interviewed for this report 34
- Appendix B: Federal Crosscut Budget Summary 35
- Appendix C: Relevant Meetings Attended 36

SUMMARY

Increased water supply reliability and a healthy Delta ecosystem each relies on effective Sacramento-San Joaquin Delta (Delta) management decisions, which are statutorily required to be informed by the best available science (Water Code §85308(a)). Agencies currently employ science broadly based on regulatory obligations, management responsibilities, and the availability of funding; however, interagency collaboration and funding for consistent long-term efforts to foster decision-support science are insufficient, often limited by procedures, regulations or statutory authorities. State funding usually must be spent and/or contracted for within three years of a budget allocation. This period is insufficient for the long-term scientific and technical efforts needed for the Delta. Reliable science, like a reliable water supply, requires forethought, sustained collaboration across agencies, and consistent funding. This paper examines whether a path to shared funding to promote shared decision-support science exists for the Delta. The resulting recommendations stem from consideration of political and structural dynamics that have created barriers for shared science and its funding.

An extensive literature review, attendance at meetings relevant to Delta science, and information from a series of 23 interviews have led to the following recommendations:

1. **Implement stronger institutional coordination of science across agencies.** Existing fragmentation of mandates and efforts among agencies hampers collaboration and efficiency. Finding and exploiting opportunities for improved collaboration requires development of a governance structure including both decisionmakers and scientists. Any future arrangement should promote trust, provide actionable authority, and maintain agency sovereignty. Several options are available to strengthen science coordination and integration across agencies.

2. **Establish a competitive and targeted incentive grant program, funded through the state budget act, to provide matching resources for research and technical partnerships across agencies, and between agencies and other qualified entities.** Such grants, administered by the Delta Science Program, would match State agency funds for collaborative studies aligning with the Science Action Agenda and/or Delta Science Plan. By requiring data management and reporting consistent with the Open and Transparent Water Data Act, these grants also would advance the open data legislative mandate while promoting One Delta, One Science – an efficient use of general funds to leverage consistent funding from both State and non-State sources.

3. **Provide ongoing, consistent long-term funding for adaptive science to inform Delta restoration projects as part of adaptive management programs, Eco-Restore, and other mitigation and restoration programs.** Adaptive management programs are a proving ground for science and management; funds for capital projects should include a percentage for ongoing synthesis, analysis and evaluation of project actions. These projects directly align with the co-equal goals of enhancing the Delta ecosystem and water supply reliability. Monitoring and learning from these projects would constitute a tangible general fund commitment to those long-term priorities.

4. **Develop funding for critical synthesis from existing data, with priority of projects and agency co-lead responsibility.** Regulatory requirements drive agencies to focus on data collection and reporting, allowing only rather little analysis of how the data can aid decision-making. Agency scientists, when given synthesis priorities and a regular management audience, are better positioned to identify trends in existing data and opportunities for actions that will be evaluated against measurable objectives and outcomes.

5. **Allocate science priorities based on agency and stakeholder areas of expertise, capacity, and jurisdiction.** Science priorities span a diverse range of topics and action areas. For each priority to be addressed, actions should be allotted among agencies and stakeholders to achieve full breadth of coverage, take advantage of existing efforts, harness experienced leaders, and respect jurisdictional boundaries. No one agency or stakeholder can achieve all science priorities independently or integrate findings effectively to inform decision-making across agencies.

6. **Establish a regular system of workgroups and discussions to bring science and policymakers together.** Examples of science gatherings and policy gathering abound but, separation of science and policy discussions is the norm. The value of science for policy cannot be realized if its relevance is not communicated regularly and succinctly to managers. Science and policy interactions promote new ideas for both science and policy.

7. **Seek federal funding for science priorities across the Bay-Delta.** Trillions of dollars in economic output are tied to Bay-Delta water, which directly affects the national and global economy. The federal government has an economic interest in the continued viability of the Bay-Delta water supply and ecosystem. Federal funding for Bay-Delta science and projects throughout the entire Delta watershed should be comparable to that for other major national estuaries.

IMPORTANCE OF THE SACRAMENTO-SAN JOAQUIN DELTA

The Sacramento-San Joaquin River Delta, also known as the California Bay Delta, covers more than 1,100 square miles, and is central to California's water supply system. The network of islands, channels, and wetlands also is home to an expansive but highly disrupted ecosystem.

OBJECTIVES AND SCOPE OF THIS STUDY

Policymakers make more effective decisions about water delivery and ecosystem health when supported by science. The current structure for science in the Delta watershed relies on agency funding, which largely focuses on regulatory compliance. Data collection and studies are planned through several collaborative venues; however, funding for science to support decisionmakers is scarce, fragmented, and often short-term. Annual budgeting, particularly because of California's revenue volatility, is inherently unstable, and, therefore, inconsistent and unreliable.

Stakeholders express enthusiasm for collaboration and science, but often differ on steps needed for interagency Delta science. Considering these opinions and the existing structures and

regulatory requirements within the Delta, there is a need for a system to prioritize and incentivize shared science to achieve management objectives in support of the state's co-equal goals.

Science governance is the organization, management, and implementation of science actions within the Delta. The analysis of science funding focuses on entities that provide funds as opposed to those which solely receive funds for science.

This report focuses on policy analysis of Delta environmental science, science governance, overlap of agency research, monitoring and regulation, budgeting, funding and fiscal issues.

This study:

- Evaluates the current system of collaborative Delta science and its funding.
- Examines gaps between the current organization of science and underachieved policy aspirations for science.
- Identifies barriers to funding and collaboration for scientific research in the Delta.
- Recommends opportunities to overcome existing barriers and to move to more reliably funded and efficiently organized interagency science.

Background research included a literature review of current funding methods and scientific collaborations. The focus of this literature was constrained to only include studies (a) centered on the Delta, or (b) addressing issues related to science, water, water use, water delivery, groundwater, or aquatic ecosystems. Search terms used were: (1) Sacramento-San Joaquin Delta (2) Delta science, (3) science governance, (4) science funding, (5) collaborative science, and (6) shared science.

Interviews with relevant Delta stakeholders included individuals whose organizations' missions have been to affect water management in the Delta through the funding or use of science. This list includes both federal and state water, agricultural, and environmental agencies as well as a suite of non-governmental organizations and interests that sometimes influence agency decision-making. Questions to guide these interviews included:

- What are some of the political dynamics you face in your role?
- What is the purpose or goal of science within your organization?
- Are your organization's activities motivated/influenced by the Science Action Agenda?
- Do you have a structure in place for reporting out or otherwise governing or managing science?
- What are current funding mechanisms for science at [*agency/organization*]?
- Does funding factor into your decision-making process for what science is performed?

A complete list of individuals interviewed, and their corresponding agencies, is included in the Appendix A.

This report begins with an overview of the current structure for science in the Delta and then identifies gaps between the current and desired systems of science. After identifying barriers to overcoming these gaps, recommendations are provided to address those barriers.

CURRENT SYSTEM OF SCIENCE

The science enterprise in the Delta includes a myriad of state, federal, and local government, non-government, academic, and private agencies, programs, and institutions. The variety of organizations leads to multiple approaches and reasons for conducting science, and variable funding for its execution.

Stakeholder Network

As the hub of water delivery in California, actions and changes within the Delta affect residents within its legal boundaries and those in the greater watershed and service area. The result is a large, diverse stakeholder group, including local, state, and federal agencies, elected officials, and water users in most of the State (see Table 1). Each of these individuals or groups uses science; however, their priorities vary with their goals and/or regulations. For example, consideration of environmental effects as part of Water Right Decision 1641 established monitoring and reporting requirements for DWR, USBR, and SWRCB according to Public Resources Code section 21081.6(a) (State Water Resources Control Board, p. 137).

Given legislative mandates, agencies frequently pursue in-house science priorities based on their individual missions, limiting in the conduct, use, and integration of science (National Research Council 2012, p. 191) A lack of integration frequently leads to uncertainty and disparate science management, especially because there is no single entity responsible for Delta science (Gray, Thompson, Hanak, Lund, & Mount, 2013, p. 55).

The 2009 Delta Reform Act mandated creation of the Delta Science Program (DSP) with a mission "… to provide the best possible unbiased scientific information to inform water and environmental decisionmaking in the Delta ... through funding research, synthesizing and communicating scientific information to policymakers and decisionmakers, promoting independent scientific peer review, and coordinating with Delta agencies to promote science-based adaptive management" (Water Code §85280(b)(4)), but the DSP "lacks sufficient statutory authority to organize all of the science in the Delta" (Gray et al. 2013, p. 56). The DSP has successfully led collaborative efforts to develop and refine the Delta Science Strategy, which includes the Delta Science Plan, the Science Action Agenda, and the State of Bay-Delta Science (Delta Science Plan 2016).

*Table 1: Doers and Funders of Delta Science**

State Government	***NGOs***
CA Department of Fish and Wildlife, Delta Stewardship Council, CA Department of Water Resources, State Water Resources Control Board, Delta Conservancy, CA Environmental Protection Agency, CA Natural Resources Agency, CA Department of Food and Agriculture	California Trout, The Nature Conservancy, Natural Resources Defense Council, The Bay Institute, Environmental Defense Fund, Ducks Unlimited, Coalition for a Sustainable Delta, Water Foundation
Federal Government	***Academic***
Bureau of Reclamation, National Oceanic and Atmospheric Administration, US Environmental Protection Agency, US Geological Survey, US Fish and Wildlife Service, US Army Corps of Engineers	National Science Foundation, National Academy of Sciences, UC (Davis, Merced, Berkeley, Santa Cruz, Santa Barbara, Riverside, Los Angeles, Irvine, San Diego), CSU (Sacramento, Northridge, San Francisco, etc.), University of San Francisco, Stanford University, University of the Pacific, University of Washington, other universities
Local & Water Agencies & Regional Government	***Private***
San Luis & Delta Mendota Water Authority, State Water Contractors, Central Valley water contractors, Westlands Water District, Metropolitan Water District, East Bay Municipal Utility District, Oakdale Irrigation District, South San Joaquin Irrigation District, Contra Costa Water District, Delta Regional Monitoring Program, Sacramento Regional Sanitation District, Port of Stockton	Landowners Institutes Public Policy Institute of California Pacific Institute Funding Foundations Hewlett, S.D. Bechtel, Jr. Firms Engineering and biology consulting firms

*A representative, but not exhaustive, list

Collaborative Venues

The Delta Science Plan lays out a vision of *One Delta, One Science* along with specific objectives and actions to achieve that vision. The document serves as a "framework for science cooperation across authorities vested in multiple agencies" (DSP, 2016). Several programs have been developed where this framework guides collaboration. A representative, but not comprehensive, summary of collaborative venues is outlined below.

Interagency Ecological Program (IEP)
https://water.ca.gov/Programs/Environmental-Services/Interagency-Ecological-Program

IEP is "boots on the ground", as one interviewee put it. IEP was formed through a memorandum of understanding in 1970 and includes six federal agencies (NMFS, USACE, USBR, USEPA, USFWS, USGS) and three state agencies (DWR, CDFW, SWRCB). The program coordinates monitoring activities throughout the Bay-Delta and has amassed a continuous history of data from

decades of the Bay Study, which entails monthly sampling of water quality and various species from the interior Delta to the south Bay. Other efforts include the fall midwater trawl and enhanced Delta smelt monitoring (Culberson, 2018). As "special studies", IEP has sponsored several integrated science projects over time. IEP participating agencies provide funding for projects outlined in the yearly Annual Work Plan, with nearly half of the budget coming from DWR.

Collaborative Science and Adaptive Management Program (CSAMP)
https://water.ca.gov/-/media/DWR-Website/Web-Pages/What-We-Do/Science/Files/Collaborative-Science-and-Adaptive-Management-Program-Purpose-Document-2-13-17.pdf

Formed in April 2013, CSAMP resulted from a U.S. District Court decision to extend the court-ordered schedule of revisions to the 2008 and 2009 BiOps. USBR, USFWS, NMFS, and DWR worked for two years in collaboration with public water agencies and NGOs to develop a science and adaptive management program, until the original BiOps decision was reversed by the Ninth Circuit. A court order no longer compelled CSAMP to convene; however, the parties involved agreed to voluntarily continue their efforts. CSAMP focuses on promoting the collaborative development of scientific information to inform sound decision-making, especially regarding species of concern in the Delta and the water operations affecting them (DSC, July 2018). The program is comprised of a policy group of agency and organization leads and a Collaborative Adaptive Management Team (CAMT) including designated managers and scientists functioning under the governance and direction of the policy group. CSAMP relies on in-kind service from participating organizations but does not have a budget.

Aquatic Science Center (ASC)
https://www.sfei.org/about/about-aquatic-science-center

The ASC is a Joint Powers Authority (JPA) formed in 2007 which serves as a fiduciary agent administered by the San Francisco Estuary Institute (SFEI). Created by the Bay Area Clean Water Agencies (BACWA), itself a JPA, and the State Water Resources Control Board, ASC promotes and delivers "science support functions and information management for governmental and non-governmental organizations with roles in water quality protection, policy development, and assessment" (SFEI | ASC, 2018). This support includes integration of monitoring efforts and data management and reporting, as well as serving as a forum to connecting science and decision-making. Base funding for SFEI activities come from USEPA through the San Francisco Estuary Partnership, established through the Clean Water Act's National Estuary Program.

Southern California Coastal Water Research Project (SCCWRP)
http://www.sccwrp.org/

A major non-Delta California aquatic science interagency collaborative is SCCWRP, which began in 1969 when five local agencies (Cities of San Diego and Los Angeles, the County Sanitation Districts of Los Angeles and Orange Counties, and Ventura County) signed a Joint Powers Agreement (JPA) to pursue and sponsor scientific research in the coastal waters of southern California. The agreement has been amended 14 times and, today, the JPA governing board consists of representatives from its fourteen members (Mearns, Allen, & Moore, 2001, p. 3, 7). These members include four wastewater dischargers, four stormwater management agencies, and six regulatory agencies (SCCWRP, 2018). SCCWRP activities have expanded to include wastewater and storm discharge monitoring, development of new standards, identification and

testing of new technology, and development of new approaches to water and ecosystem management (Hanak et al. 2013, p. 22). A mixture of fees on participating dischargers and contributions from outside grants and interests fund SCCWRP.

Surface Water Ambient Monitoring Program (SWAMP)
https://www.waterboards.ca.gov/water_issues/programs/swamp/

SWAMP began in 2000 as a coordinating program for water quality monitoring among each of the State and Regional Water Boards. Program activities are guided by State legislative mandate and outside reviews. In 2006, SWAMP expanded its efforts to include partnerships with stormwater agencies, municipal wastewater dischargers, and irrigated lands regulatory programs. When the California Water Quality Monitoring Council (CWQMC) was formed by legislative mandate, the two programs met to align their statewide strategies. (SWAMP 2018). A portion of the SWAMP program, administered by the Office of Information Management and Analysis (OIMA), is funded by the Federal Clean Water Act Section 106 Grant from USEPA. OIMA also receives a portion of fees collected in the Waste Discharge Permit Fund to support regional ambient monitoring needs. (State Water Resources Control Board, May 2017, p. 12)

California Water Quality Monitoring Council (CWQMC)
https://mywaterquality.ca.gov/monitoring_council/

A Memorandum of Understanding between the California Environmental Protection Agency (CalEPA) and the California Natural Resources Agency (CNRA) established the CWQMC in 2007. The legislatively mandated MOU tasks CWQMC with "improving the efficiency and effectiveness of water quality and related ecosystem monitoring, assessment, and reporting efforts throughout California through enhanced coordination. The Council's goal is to improve the delivery of water quality and related ecosystem health information to decision makers and the public" (SWAMP, 2018). The CalEPA and CNRA Secretaries select Council members with the intent to represent a range of water quality interests. Membership includes regulators, the public, the scientific community, and agency staff, among others (CWQMC, 2018). Resources for monitoring, assessment, and reporting come from each collaborating agency's budget.

Delta Regional Monitoring Program (Delta RMP)
https://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_regional_monitoring/

The Delta RMP began in 2015 as a collaboration between the Central Valley Regional Water Quality Control Board, the Aquatic Science Center, and other scientists and interested parties. Participation is encouraged for entities whose projects will affect the Delta and the Delta RMP actively recruits members. Members include publicly owned treatment works (POTWs), municipal storm water agencies, irrigated agriculture coalitions, Interagency Ecological Program, water suppliers (including exporters), resource agencies, and regulatory agencies. A contribution of financial resources confers voting rights for budget and financial decisions. The program structure creates opportunities to pool resources which would otherwise be spent on individual monitoring water quality monitoring requirements (State Water Resources Control Board, 2017).

In addition to specific structures for collaboration, many agencies engage non-governmental organizations, universities, and private contractors for science activities.

Funding

Scientific research in the Delta is funded by numerous local, state, and federal agencies, non-governmental organizations, academic, and private interests. Table 1 lists a large, but not exhaustive, sample of these entities. The diversity of funding sources and different accounting methods make quantification of sources challenging, especially since scientific research is rarely separated into individual budget line items. A summary of Delta science funding mechanisms and examples of their implementation is included in Table 2. The Science Funding Initiative Workgroup is a preliminary effort by the Delta Stewardship Council to coordinate with stakeholders to categorize and better understand the Delta science funding landscape; the effort is ongoing as of this writing.

The Delta Science Program (DSP) budget is a subset of the Delta Stewardship Council (DSC) overall budget and DSP budget development occurs with input from the DSP Lead Scientist and the DSC Executive Officer. Budget amounts are based on historical staffing needs and funding for outside science. In the 2016-17 and 2017-18 DSP budgets, $5 million was dedicated to science at the Lead Scientist's discretion; much of this amount was used for student and post-doctoral fellowships.

Table 2: Delta Science Funding Overview

Funding Mechanism	Funding Source
Legislative Appropriations (State & Federal)	Agency budgets • General Fund • Special funds (i.e. Environmental License Plate Fund)
State Bond Funding	Proposition 1 • Watershed Grant Restoration Program Proposition 68 Other bond propositions as proposed and approved by voters
Agency Revenues	Water use & permit fees
Non-governmental organizations	Donations Membership fees
Private	Product & service sale revenues Donations

The 2018-19 State Budget includes $28.6 million for the Council. Nearly two thirds of this amount comes from the State's General Fund. Approval of the DSC 2018-19 Critical Delta Science Investigation Enhancement Budget Change Proposal provided ongoing General Fund support for three permanent adaptive management liaison positions and one permanent senior legal counsel position with an additional $2 million in one-time funds from the Environmental License Plate

Fund (California Department of Finance, 2018). The one-time allocation will be awarded as part of the recent Delta Science Proposal Solicitation process (CDFW & DSP, August 2018, p. 1).

Accounting for science funding in other systems is similarly challenging. Direct comparisons between estuaries are limited to broad views of annual budgets and total budgeted expenditures which are not updated to reflect actual spending (DSC, 2016, p. 75). Appendix B provides a table of estimated annual funding for restoration and projects based on Federal Crosscut budget numbers to highlight state and federal funding trends.

GAPS BETWEEN CURRENT AND DESIRED SYSTEM OF SCIENCE

The current system of Delta science is evolving, but still lacks consistency and systematic direction. Whether through advances in modeling and data gathering, updates to science strategies, or pursuit of new areas of study to meet the challenges of an evolving Delta, the science community has embraced change. Several aspirations for Delta science have been identified and documented by stakeholders. Although desires for the direction of science are outlined in guiding documents across agencies and entities, gaps remain.

Priorities

The various collaborative venues within the Delta science enterprise demonstrate the prevalent belief in the value of collaboration and a common set of goals. With many parties involved, divergent priorities are inevitable. To better align priorities for future science actions, the Delta Science Program (DSP) solicited input from stakeholders to develop the 2017-2021 Science Action Agenda (SAA). The document is intended to address existing science gaps and serve "as the glue for synergistic and multi-benefit science to support important management needs" (Delta Stewardship Council, 2017, p. 6). As indicated by the title, the SAA aspires to guide science actions for four years before another update. Execution of the 13 priority actions is meant to advance the Delta Science Plan while building science capacity for future needs; however, the document implies that completion of each action is sufficient for success and that collaboration is inevitable. While many entities may have agreed collaboratively on the priority actions, there is no mention of how budgets, studies, or developed tools might be shared or discussed among stakeholders.

The SAA references long-term benefits, long-term studies, long-term databases, long-term costs, and long-term infrastructure without specifying a meaning for "long-term". The phrase is reminiscent of the "longer, 50-year viewpoint" suggested by Healey, Dettinger, and Norgaard (2016, p. 15) or of the horizon scanning referenced in the Draft Delta Science Plan Update (DSP, 2018). This view to the future is a promising start but requires further development and a structure for executing the agenda, including secure, consistent, long-term funding.

Science Governance

The governance model for Delta science is complex and in flux. The Delta Science Plan is broadly accepted as a guide; however, specific organizational roles need clarity. At the highest level, policymakers recognize a need to achieve the vision of One Delta, One Science and conversations about how to move forward influence regular public meetings. At its April 2018 meeting, the Delta Plan Interagency Implementation Committee (DPIIC) convened a panel on the topic, "One Delta, One Science – How Do We Get There?". The discussion revealed a lack of clarity on "what is meant by governing science?" (DPIIC). The Science Funding Initiative Workgroup is currently developing a "white paper" on the subject for presentation to the DPIIC meeting scheduled for April, 2019.

The DSP and practitioners of Delta science need to maintain some independence; however, science cannot support decisionmakers without clarity on management priorities that might be affected by opportunities generated by scientific studies. One interviewee emphasized this point by

recognizing the importance of Delta science but stressing that shared management objectives do not start with scientists.

Management initiatives and legislation already generate opportunities for decision-support science. For example, the upcoming Delta Stewardship Council Delta Plan 5-Year review is a chance for agencies to contribute to creating a roadmap for planning with decision-support science needs in mind (DSC, May 2018). Implementation of new collaborative processes for shared science and ongoing funding could be incorporated into the DSC recommendations report. Additionally, recent amendments to Water Code §§ 10609.4, 10609.6, 10609.8, 10609.9, and 10609.10 mandate studies and investigations to establish indoor and outdoor water use standards. The water management planning legislation, which supports the co-equal goal of water supply reliability, will require science collaboration to achieve prudent implementation of efficiency standards.

Project Implementation

Even when legislative priorities yield synergies for science, data collection is often prioritized over evaluation. With limited funding, restoration projects like those funded by Proposition 1 through the Watershed Restoration Grants Branch of CDFW only include monitoring activities during project implementation, not throughout its expected life (or, at least, through assurance of passive sustainability). CDFW is currently looking into options for monitoring beyond the implementation phase of projects.

Ongoing project evaluation complements the Delta Science Plan goal of supporting adaptive management, which incorporates an iterative experimentation process. At the May 2018 Delta Independent Science Board meeting, Dr. John Wiens highlighted the lack of adaptive management experimentation in the Delta to date (Delta Independent Science Board, May 2018). The 2016 State of Bay-Delta Science previously mentioned this need, calling for "[t]argeted science within an adaptive management framework" (Healey, Dettinger, & Norgaard, 2016, p. 17). Several interviewees suggested adaptive management would be a driver for implementation of the pending Phase I update for the Bay-Delta Water Quality Control Plan. However, with neither clear objectives nor a consistent monitoring program (supported by identified sources of funding) in place, there is little confidence that adaptive management will actually guide implementation.

Eco-Restore is another program that offers future opportunities for experimentation (Moyle, Durand, & Jeffres, 2018, p. 20, 27). Mike Roberts, Special Assistant for Delta Restoration, presented at a recent DPIIC meeting and highlighted the benefits of the Eco-Restore projects, which also expose barriers by focusing on the streamlining of permitting, land management, and budgeting (DPIIC, April 2018). Identification of sites for focused experimentation has been successful in other watersheds, like Chesapeake Bay, where partner activities focus on healthy watersheds with interrelated outcomes (DSC, 2016, p. 45). The North Delta Habitat Arc and Central Delta Corridor have been proposed as promising areas for future restoration (Moyle, Durand, & Jeffres, 2018, p. 21, 41) and adaptive management to guide future and broader restoration actions as envisioned in SFEI's *A Delta Renewed* (Robinson et al. 2016).

As with Proposition 1 projects, resources are needed for analysis, synthesis, and dissemination. If effectiveness monitoring is not funded after project implementation, value is lost.

Resources

The Public Policy Institute of California has called for "an effective, well-funded system of adaptive management" to be incorporated into Delta organizational culture (Hanak et al. 2013, p. 10). Interviews with stakeholders across the science enterprise demonstrated a broad endorsement of an adaptive management culture, but funding limitations stymie this and other science ambitions.

The desired system of science expands the suite of science actions and opportunities, which in turn may be expected to expand the required science budget. This is not to say funds are not available; they are often already allocated or restricted. For example, when available, resources are often assigned to a pre-defined action. Statute frequently specifies where fees, like those for hunting or fish harvest, should be spent.

> ***"You can be flush, but the money is limited in its application."***

The Delta Independent Science Board Water Quality Science review pointed out a symptom of water quality science that applies broadly to the science enterprise. Resources for research and monitoring tend to support specific compliance needs, but not studies (Delta Independent Science Board, 2018, p. 5).

Communication

For decision-support science to be effective, it must be accessible and communicated effectively to managers and the Delta science community. For scientists collecting data, its application may seem obvious; however, without accessibility or a system to communicate and discuss science for application, questions of duplication and management relevance arise. Further, decisionmakers need to frame and communicate the questions they need answered to support their actions and direction.

Recent passage of the Open and Transparent Water Data Act attempts to partially address the issue of accessibility by integrating water and environmental data systems (Cantor et al. 2018, p. 7). Development of this data system is underway with the potential for the science enterprise to help guide its maturation.

Scientists have demonstrated consensus on several potential impact areas and top priorities in the Delta (Hanak et al. 2013, p. 14, 16), but regular, wide distribution of management relevant studies like these is still needed. Consensus without improved communication is ineffective.

BARRIERS TO OVERCOMING GAPS

Several hurdles hinder achieving the desired science system for the Delta. These barriers are summarized below and are followed by detailed recommendations to address them.

I. **Stakeholder definitions of science**
The collection of Delta science activities and science programs encompass monitoring, real-time operations, science investigations, planning, compliance, EIRs, etc. This diversity means science is defined and used differently depending on organizational mission, priorities, or requirements. The expertise, capacity, and jurisdiction required to achieve the actions outlined in the Delta Science Plan or Science Action Agenda are not common to every stakeholder, making sharing of science knowledge a challenge.

II. **Financing**
Multi-year experiments to understand trends depend upon multi-year resource commitment; integration of scientific inquiry, synthesis of scientific findings, and two-way communication between scientists and decisionmakers need to be sustained over the long term; however one-time funding is more common than ongoing or shared funding and works against sustainability. For monitoring already underway, there is a constant risk of data holes if budgets are cut. It would be irresponsible to allow continuous data sets to lapse, so programs must balance ongoing studies with new science actions. State funding for water management has historically relied on user fees and bond funding, which include a portion for science; however, additional methods for raising revenue have been controversial.

III. **Science governance definition**
The overlap of Delta operations with science activities has muddied the distinction between management governance and science governance. Ideally, management decisions in areas like operations will be supported by science, but environmental regulations are the frequent drivers and "side boards". Often, science is assumed to dictate these decisions as well. With the "messy" science network in the Delta, Dr. Mark Lubell noted two main options for moving the governance structure forward – (1) reduce complexity or (2) embrace complexity (DPIIC, April 2018).

IV. **Compliance driven agency science**
A primary objective of the Delta Science Plan is to enable and promote science synthesis (DSP, 2016, p. 10). Though agencies recognize the value of synthesis, it is often ignored due to limited resources which are often dedicated to making certain that regulatory requirements are met. By some estimates, this compliance element is as much as 80% of science funding (DPIIC). IEP creates an Annual Work Plan which ties each planned activity to the relevant regulation or code (Interagency Ecological Program, 2018). Healey, Dettinger, and Norgaard emphasized the narrow focus of government agencies on immediate policy and management issues (2016, p. 16). While a natural consequence of mandates and judicial restrictions, this constrained approach limits broad, forward-looking science that might prove more useful to support management decisions.

V. **Cumbersome permitting for science and restoration**

A "take" of protected fish may occur incidentally as part of scientific studies and project implementations. Permits allowing studies to proceed come in several forms: incidental take permits, Habitat Conservation Plans (HCPs), Water Quality certifications, Streambed Alternation permits, environmental mitigation requirements and Natural Communities Conservation Plans (NCCPs). Jurisdiction for processing these permit applications resides with USFWS, NMFS, USACE, Regional water quality control boards and DFW. Where agency responsibilities overlap, separate permitting processes are required. The Clean Water Act also has requirements for dredging and discharge that are administered by USACE (Gray et al. 2013, p. 49-50). Each additional required process introduces project timeline uncertainty and related cost, making projects and the science that inform their development, implementation and adaptive management increasingly difficult to complete.

VI. **Development of science performance measures**

Without a measure for the effectiveness of various components of the science enterprise, gauging the progress of science becomes nearly impossible. Absent a method for evaluation of scientific results, accountability and efficiency suffer. While science discovery progresses at a rate and scale outside of our ability to forecast, the Delta Science Plan includes an objective to develop and report performance measures (DSP, 2016, p. 21). These measures and metrics, intended to assess progress on the plan, have not yet been developed.

VII. **Lack of empowerment**

Collaborative groups like IEP and CSAMP lack centralized authority to act based on internal discussions – they coordinate actions (Interview; DSC, July 2018). Although dialogue occurs regarding funding for coordinated actions, budget priorities depend on individual agency budget considerations and historical funding allocations and actions. Without authority or funds, participants increasingly become messengers and conveners; "meeting burnout" was a recurrent theme in interviews.

VIII. **Lack of trust**

This barrier builds off of the governance overlap discussed above. Varying political opinions on the future of California water operations pull perceptions of science ethics into their orbit. The challenge for Delta science will be to remain impartial and independent while providing a medium for transboundary discussions among stakeholders.

RECOMMENDATIONS TO OVERCOME BARRIERS

In analyzing whether a path to shared funding to promote shared science exists for advancing water supply and ecosystem sustainability in the Sacramento-San Joaquin Delta, two main themes emerged – political considerations and structural implications. Recommendations are addressed within these two themes to recognize the political dynamics that have created barriers for shared science in addition to the funding and structural barriers that have limited shared science.

An extensive literature review, attendance at meetings relevant to Delta science, and information received through a series of 23 interviews have led to the following recommendations:

1. Implement stronger institutional coordination of science across agencies.

Several collaborative venues have been identified which allow participants to coordinate their science actions. These forums, combined with the Delta Science Program, are advancing science in the Delta, but gaps and barriers remain. Without a comprehensive process for communicating and organizing science, stakeholders will continue to pursue disparate goals and science governance will be perceived as politically motivated to generate "combat science". Introducing an institutional mechanism will reinforce scientific independence and empower the Delta Science Program, and the science enterprise as a whole, "to provide the best possible unbiased scientific information" to support critical operational and regulatory decisions affecting the Delta (Water Code §85280(b)(4)).

Two primary options exist to structure coordinated science – (1) voluntary participation or (2) formalized agreement. Either option can include varying degrees of involvement.

Voluntary collaborative venues have been effective at trust building. The recent DPIIC discussion highlighted the opportunity for CSAMP participants to make an impact as an incentive to voluntary participation. A similar argument was used by Kris Tjernell who contended that ownership of content in the Delta Plan has led to its success (DPIIC, April 2018). Structures based on voluntary participation have the potential to overcome a lack of trust. During a Delta Stewardship Council panel discussion, Jason Peltier stated that "trust and understanding is the best path forward" (DSC, July 2018).

Criticism of CSAMP includes its restricted participation. There is no structure for joining. With no clear mandate, this selective participation may be a motivator to encourage involvement from this more focused group of stakeholders. By contrast, the Delta RMP, also a voluntary organization, incentivizes participation and financial contributions in return for voting rights. CSAMP is not part of decision-making, operations, or other collaborative venues and so is limited in its ability to get things done or take scientific initiative.

The next incremental step beyond a purely voluntary collaboration arrangement is a memorandum of understanding (MOU). MOUs allow participations from governmental and non-governmental entities, including regulators, permitting agencies, environmental groups, contractors, and user associations. An MOU established the IEP in 1970 and that MOU has been revised eight times in its history as the IEP evolved (Culberson, 2018). While it has been successful at coordinating

scientific actions among represented agencies, IEP is not empowered to make budget decisions or take action independently. Similarly, the Puget Sound Federal Task Force, formed by MOU in 2016, is meant to promote collaboration with federally recognized tribes. Section VIII. (f) of the agreement specifies agencies will "utilize their own resources" (Puget Sound Federal Task Force, 2016, p. 8).

Basing his/her response on career experience, one interviewee observed:

> *"Unless there is money, an MOU won't go anywhere."*

MOU activities are accomplished with budget funds from parties in the agreement or through in-kind service, with parties allocating individuals' time to promote the shared objectives described in the MOU. An MOU offers a chance to share resources and knowledge to achieve a common goal where collaboration may have previously been lacking. These collaborative efforts may prove sufficient to the shared purpose or can function as a first step toward something more formal or structured.

A more formal mechanism for organizing collaboration in funding and for carrying out shared scientific activities is the joint powers agreement to form a joint powers authority (JPA). JPA authority is limited to the common powers of its signatories, meaning agencies whose authority do not overlap may be ineffective members of the same JPA. The SWRCB is a signatory in the ASC and SCCWRP. Each of these JPAs focuses on regional discharges and water quality. It is not uncommon for JPAs to form separately from State agencies rather than having them as members. In the Bay Area, BACWA existed as a JPA ahead of the 2007 agreement forming the ASC.

Like JPA membership, JPA funding can take many forms. SCCWRP has had consistent funding through its history. From 1970 to 1999, the annual budget averaged approximately $1.13 million. At inception, the JPA incorporated a system of self-imposed tithing based on quantities of water discharged by each of the five original member agencies. Over time the composition of funding has changed as grants and outside interests have contributed. This has allowed a system for phasing out member contributions over time. (Mearns, Allen & Moore, 2001, p. 15-16).

SCCWRP has the advantage of being flexible and adaptable. The participants have changed and evolved over time as the agreement has been amended, allowing members to revisit the goals of the authority (Mearns, Allen & Moore, 2001, p. 14). In its nearly fifty-year history, only one federal agency, USEPA, has participated (SCCWRP, 2018). Because JPAs are state-sponsored organizations, federal agencies cannot be signatories (Gray et al. 2013, footnote 42). USEPA has a non-voting, technical advisory capacity at SCCWRP (2018); this is also true for the ASC (Aquatic Science Center, 2017, p. 5).

Without federal signatories, a JPA's authority to integrate science only extends as far as public agencies within the state. The nature of a JPA under California law also means private and non-governmental organizations cannot participate – potentially reducing effectiveness and trust. As with SCCWRP, federal agencies may serve as advisors; however, there is no example of a JPA

with six federal advisory members (IEP participants: NMFS, USACE, USBR, USEPA, USFWS, USGS). In fact, the example of CALFED is a cautionary tale. The formalization of the California Bay-Delta Authority (CBDA) led to competition, not cooperation (Lurie, 2011, p. 260). When a federal regulatory body did not materialize, the CALFED enterprise became lopsided and limited in its authority (Lurie, 2011, p. 257).

Any structure chosen has potential advantages and disadvantages. A common goal for any mechanism implemented should be vertical integration of the decision-making process, with science participating at every level from technical implementation to policy discussions (Marcinkevage, DSC, July 2018). Each of the mechanisms outlined embraces complexity, even a JPA. While each may improve integration, none of them will remove stakeholders or entities from the system. Short of combining existing collaborative venues, reduction of complexity is not a likely outcome of institutional coordination.

2. Establish a competitive and targeted incentive grant program, funded through the state budget act, to provide matching resources for research and technical partnerships across agencies, and between agencies and other qualified entities.

The California 2018-19 State Budget calls for "Basing Actions in Science" (California State Budget, 2018-19, p. 101-102). By including this language, the Governor's office and the legislature highlight their willingness and intent to make future decisions informed by science. This acknowledgement is a positive step toward collaborative decision-support science. Carefully executed, it has the potential to inform management decisions with science and reinforce the administration's commitment to the public good, while magnifying the impact of allocated funds.

To most efficiently use tax revenue and expand the scientific basis for management actions affecting the Delta watershed, a grant program funded through the General Fund and administered by the Delta Science Program under the direction of the Delta Lead Scientist is recommended.

Interagency partnerships and alignment with the Science Action Agenda could be screening criteria for the competitive grant. These grant applicant partnerships would not be limited to state agencies; they could extend to associations, environmental groups, and local agencies. Further, grants would only be awarded to partnerships providing matching funds between a suggested 25-50%. Priority would be given to proposals with a data management plan aligning with the Open and Transparent Water Data Act. This requirement aligns with Action 3.5 in the August 22, 2018 Draft Delta Science Plan Update (DSP, 2018, p. 25). The recently released Draft Delta Science Proposal Solicitation Notice also includes a Data Management Plan (DMP) provision in the scoring criteria, although an increase in the weight of this requirement is suggested (CDFW & DSP, August 2018, p. 12, 16).

There have been four prior Proposal Solicitation Packages in 2004, 2006, 2007 and 2010 totaling over $27 million for 48 research grants. Based on several interview responses, success of the proposed grant program will depend on ongoing funding. The matching requirement would demonstrate Delta stakeholders' commitment to proposed studies while efficiently prioritizing actions and amplifying the effect of funds. Long-term funding availability would encourage building these opportunities into agency budgets. Independent oversight by the Delta Science

Board combined with increased agency collaboration would increase transparency and build trust in Delta science.

3. Provide ongoing, consistent long-term funding for adaptive science to inform Delta restoration projects as part of adaptive management programs, Eco-Restore, and other mitigation and restoration programs.

Delta restoration projects address many goals of the Delta Plan and have potential to achieve multiple objectives of the Science Action Agenda and Delta Science Plan as well. Funding of adaptive science for mitigation and restoration programs will advance the state mandated co-equal goals and the efforts already underway at the Delta Conservancy and other organizations. These projects also provide opportunities to learn which processes and procedures work, and which need improvement in future implementations. To enable experimental start-up and ongoing effectiveness monitoring, a phased approach is recommended for ongoing funding of adaptive science.

In the initial phase, the legislature would provide $5 million in one-time funds in the nature of a seed grant for an Adaptive Science Fund. The one-time amount will initiate the fund for long-term operations, maintenance and monitoring, and allow for scientific studies to begin planning concurrently with project planners.

Once studies are up and running, a surcharge of 1-5% would be applied to restoration projects and this would be placed in the Adaptive Science Fund, thus continuing to support the adaptive science enterprise. This percentage is intended to support ongoing evaluation for projects. Every project will serve as a proof-of-concept, with the goal of streamlining permitting, land management, and budgeting, which can then scale to other processes. Rather than compliance monitoring, this ongoing evaluation should be thought of as effectiveness monitoring, a term used by Dr. Denise Reed of Louisiana at the Science Enterprise Workshop (DSC, 2016, p. 117).

At some point, the number of current restoration activities, if properly monitored and used as learning labs, will inform our long-term adaptation of the dynamic estuary. This will trigger the third long-term phase of funding, tentatively in 2023. During this phase, a fixed charge of $1-2/acre-foot will be applied to watershed diversions, including upstream and Delta exports, for continuing science to be administered under an Adaptive Science Fund. In a California WaterBlog post, for example, Dr. Jeffrey Mount considered fees on the use of water originating in the watershed and indicated “a $1/acre-foot fee on water use would generate more than $20 million annually” (Mount & PPIC, 2018). Alternatively, existing contractor science programs could provide the funding. The charge would be matched at the same rate by the General Fund. With water users committed to adaptive science, General Fund dollars would leverage their investment to further promote ecosystem health, thereby increasing the broad societal benefit. This funding phase would enable ongoing adaptive science while offsetting the impact of water use. The matching structure also puts a check on other entities wishing to capitalize on the ability of the state or exporters to absorb costs for public benefit.

During the time of CALFED, former Senator Mike Machado expressed concern over any funding scheme that assigned the public “a greater share of the costs than would otherwise be warranted”

(Pitzer & Sudman, 2005, p. 3). Progress toward the goal of reduced reliance on the Delta for water supply would mean the annual matched funding would effectively be capped. Using Dr. Mount's fee rate, for example, annual General Fund matching would not exceed $20 million at a rate of $1/acre-foot exported from the watershed. The fee rate and General Fund match could be adjusted to achieve balance between the beneficial use of exports and the State commitment to base actions in science. The match would engender a sense of fairness and demonstrate an ongoing willingness to invest in the public good.

The Adaptive Science Fund would be managed by the Delta Stewardship Council. Administrative processes and tools, like the DeltaView reporting tool, are already in place at the Council and administrative supervision will be needed to ensure funds are used as intended. Past examples of fund diversion, like the "restoration funds" imposed under CVPIA in 1992 (Rosen et al. 2009, p. ES-1, 48), have reinforced the need for reliable oversight and accountability.

For adaptive science to contribute meaningfully in the Delta, managers will need to adopt a management strategy for the future. This plan can be improved and adapted as experimentation progresses along proposed restoration areas like the North Delta Habitat Arc and Central Delta Corridor.

4. Develop funding for critical synthesis from existing data, with priority of projects and agency co-lead responsibility.

Research and monitoring efforts are an important part of the Delta science enterprise; many data sets span decades. As monitoring and sampling continues, a large backlog of data and information continues to accrue. In spite of a Delta Science Plan call to prioritize synthesis activities (2016, p. 38), resources and a culture of support for synthesis are lacking. Consistent with the Draft Delta Science Plan Update, renewed efforts to develop critical synthesis resources are recommended.

Synthesis activities will achieve three primary goals: (1) Collaboration among experts will increase interagency communication and improve access to data. (2) Additional knowledge gained from synthesis can be incorporated into adaptive management decisions to iteratively improve operations. (3) Expert synthesis will be guided by an established set of expectations, thus providing rigor, consistency, and agency accountability.

Resistance to synthesis stems, in part, from the perceived use of synthesis studies. If resources are devoted to synthesis activities and the resulting study is immediately shelved, the entire exercise loses value. For policymakers with limited time, reading and absorbing the content from multiple synthesis studies may not be feasible. A culture shift must occur within agencies, at all levels, to place value on synthesis activities, and to make syntheses valuable. Additionally, syntheses must have an audience. To understand the kind of syntheses that are important to policymakers, policymakers must be engaged from the outset.

Funding for science synthesis can be achieved in one of two recommended ways. First, by reassigning existing duties, likely through streamlining of internal functions, staff will have additional time for synthesis. The implementation of AB 1755 may organically reduce some

resource time pressures through improved data management and allow time for evaluation and application of the resulting insights.

Second, in addition to opportunities for staff efficiencies, allocation of tax revenues through the General Fund is probably needed. Recently, the Delta Stewardship Council successfully submitted the Critical Delta Science Investigation Enhancement Budget Change Proposal for the 2018/19 budget to add adaptive management resources and legal counsel (California Department of Finance, 2018).

To ensure agency accountability for synthesis resources, programmatic performance measures are needed to give rigor and utility to funded studies. Consistent processes will aid management synthesis across the science enterprise. These process criteria should be developed and clearly articulated or reviewed by a neutral party, such as the Delta Independent Science Board. Regular trainings in protocols would provide consistency. Similar to USEPA practices described by Dr. Mary E. Kentula, protocols would be a requirement of funding for synthesis (Delta Independent Science Board Meeting, July 2018).

The Science Tracker currently in development by the Delta Science Plan will identify research, like synthesis, which is already occurring. This tool could be adapted to include programmatic performance measures in addition to science studies in progress.

Working in coalitions of multiple agencies and independent researchers, agency scientists, when given synthesis priorities and a regular management audience, could be well-positioned to identify trends in existing data and opportunities for measuring outcomes to inform ongoing management activities. Synthesis increases system knowledge and establishes a baseline to guide future actions. With set protocols for conducting critical synthesis, stakeholders system-wide will benefit from a common understanding and confidence in published results.

5. Allocate science priorities based on agency and stakeholder areas of expertise, capacity, and jurisdiction.

The actions and objectives detailed in the Delta Science Plan and Science Action Agenda span a diverse range of topics and action areas. For each documented priority to be addressed, a “divide and conquer” approach is recommended to take advantage of existing efforts, leverage existing institutional expertise, and respect jurisdictional boundaries.

A single agency or stakeholder cannot achieve all science priorities independently, so thoughtful allocation of priorities has the dual benefit of achieving a greater number of actions and empowering stakeholders within their areas of expertise. These divisions of labor can be categorized into short-term or long-term actions with timelines attached. Timelines should incorporate checkpoints to include participation and guidance from other agencies and outsiders, so the resulting science is more broadly useful, and more broadly credible.

Several examples of prioritization efforts were presented in the Science Enterprise Workshop. Dr. Bill Labiosa highlighted a short-term effort in the Puget Sound to list high-priority activities in need of increased collaboration or funding (DSC, 2016, p. 30). In Chesapeake Bay Watershed,

Scott Phillips pointed to the challenge, common across the science enterprise, of having more needs than resources, which necessitates a prioritization process (DSC, 2016, p. 44).

DPIIC and the Delta Stewardship Council have each undertaken individual prioritization initiatives, which could be expanded to implement this recommendation. DPIIC identified several actions for acceleration as part of its EcoRestore Project Tracking Matrix Review (DPIIC, 2017, p. 2). The Delta Plan Administrative Performance Measures Dashboard contains status data for each tracked agency to highlight progress toward Delta Plan recommendations. These recommendations have been split according to specific agency capacity and jurisdiction (admin-measures-dashboard.deltacouncil.ca.gov/).

One interviewee suggested a need for an agile approach where someone asks the important management questions, someone works on the monitoring, and an agile environment exists to make the two work well together. This suggestion ties back to the institutional coordination recommendation. Process development and prioritization would benefit from increased coordination through a common collaborative mechanism.

6. Establish a regular system of workgroups and discussions to bring science and policymakers together.

The value of science for decision-making depends on the ability of policymakers to access its insights and to communicate management priorities to scientists. The Delta Science Program currently displays two conferences on its website, the Biennial Bay Delta Science Conference and the State of the San Francisco Estuary. The Program also convenes regular brown bag seminars around critical topics of interest and hosts workshops to solicit input and advice from Delta science stakeholders.

Discussions with interviewees suggest these endeavors are valuable for accelerating scientific collaboration, but that policymakers can only be relied on to attend the conferences for short periods as panel members. The staggered calendar for these conferences means policy-science interactions occur reliably once a year. This conference frequency is consistent with other systems. In the Northwest, the Puget Sound Salish Sea Ecosystem Conference is held every two years (DSC, 2016, p. 30). Infrequent conferences carry the burden of communicating the entire one or two-year history of the system – spanning diverse topic areas and attempting to look to future needs – all within a few days.

> *"Scientists cannot decide the management objectives."*

Creation of a more regular system of communication would enrich interactions and improve targeted efforts around specific topics or with specific managers. The State Water Resources Control Board has pioneered a version of this recommendation by establishing a quarterly report to the Board by the DSC's Lead Scientist. Interviews with scientists throughout the system suggest an eagerness to improve communication, in part to avoid the frequent assertion that science is "not

management relevant". More frequent interaction would better define roles and expectations for each party in a policy-science interaction.

Workgroups provide another option for increased policy-science interactions. The CSAMP venue already convenes workgroups comprising Delta stakeholders, including water users and contractors outside of the physical boundaries of the Delta. In 2017, the World Science Forum held a special session to discuss the role of science diplomacy in the future of shared/transboundary water resources. The session established "the role of science diplomacy is to facilitate the establishment of a cooperative environment and partnerships towards enhancing opportunities for cooperative management of shared and transboundary resources" (World Science Forum, 2017). Delta science has an opportunity to promote trust and the development of new ideas by increasing the frequency of transboundary, policy-science interactions.

7. Seek federal funding for science priorities across the Bay-Delta.

The science enterprise in the Delta supports state and federal regulatory decisions as well as operators' management decisions; however, funding for decision-support science is limited, especially on the federal side. The approximate breakdown of all Delta science funding for compliance versus decision-support in a given year is 80% / 20%. Early numbers from the Science Funding Initiative Workgroup suggest federal funds for decision-support science accounted for less than 2% of the total Delta science funding in 2017. While federal agencies, especially the Bureau of Reclamation, provide most compliance funding in the Delta, these are mostly fees recovered from water users contracting with the Bureau.

An additional source of funding for monitoring is the National Estuary Program (NEP). The Bay-Delta joined the National Estuary Program (NEP) in 1988 and the San Francisco Estuary Partnership (SFEP) was formed by USEPA and the State of California under the Clean Water Act. NEP funded programs have been focused on the Bay, commonly referred to as the "lower" estuary, but the NEP includes the inland Delta, or "upper" estuary. To increase efficiency within the Bay-Delta science program, artificial boundaries between the Bay and the Delta should give way to increased emphasis on the interdependency of the distinct areas of the functioning estuary.

Although designated as an estuary of national significance, federal funding for the Bay-Delta watershed, spanning from the Sierra Nevada headwaters to the Farallon Islands ("timber to tides"), lags behind other estuaries and watersheds (see Appendix B). Only the Great Lakes serves a larger population or produces greater economic output (DSC, 2016, p. 8). Bay-Delta science and projects would benefit from federal funding comparable to that for other major national estuaries.

Recommendations to Address Barriers

Barrier / Recommendation	Stakeholder definitions of science	Financing	Science governance definition	Compliance driven agency science	Cumbersome permitting for science / restoration projects	Development of science performance measures	Lack of empowerment	Lack of trust
1. Implement stronger institutional coordination of science across agencies	X		X		X		X	X
2. Establish a competitive and targeted incentive grant program to provide matching resources		X						X
3. Provide ongoing, consistent long-term funding for adaptive science to inform Delta restoration projects		X			X			
4. Develop funding for critical synthesis with priority of projects and agency co-lead responsibility				X		X		
5. Allocate science priorities based on agency and stakeholder areas of expertise, capacity, and jurisdiction	X			X			X	
6. Establish a regular system of workgroups and discussions to bring science and policymakers together			X			X		X
7. Seek federal funding for science priorities across the Bay-Delta		X						

CONCLUDING THOUGHTS

Policymakers and science programs are actively grappling with many of the gaps and barriers described in this report. Interviews with stakeholders showed broad engagement on initiatives to achieve One Delta, One Science. Guidance from the Delta Stewardship Council and Delta Science Program already has moved the science enterprise toward greater integration and collaboration. New legislation like AB 1755 and upcoming bond funding sets up opportunities for ongoing scientific research and adaptive management of the Sacramento-San Joaquin Delta. A recovered estuary will provide broad societal benefits to stakeholders across California and an accountable science enterprise can inform this recovery; therefore, long-term financial support for Delta science is in the public interest. With a commitment of tax revenue to match the resources of agencies, water users, and NGOs, the science enterprise is well-positioned to advance the goals of the Science Action Agenda and Delta Science Plan through specific, targeted efforts.

By implementing processes to guide the development of future science and enabling more frequent, trust building, transboundary engagement, the benefits science and collaborative initiatives can be better realized.

GLOSSARY OF TERMS[1]

Adaptive management liaisons - 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 adaptive management programs and projects including Delta Plan covered actions.

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

Best available science - The best scientific information and data for informing management and policy decisions at a given point in time. Best available science shall be consistent with the guidelines and criteria found in Appendix 1A of the Delta Plan (2013).

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

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

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

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

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

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

[1] To promote and maintain a common lexicon, the definitions provided in the glossary are quoted directly from the 2016 Delta Science Plan Glossary. [Any deviation from the DSP definition is noted in brackets.]

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

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

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

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

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

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

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

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

Protection or protecting - Preventing harm to the ecosystem, which could include preventing the conversion of existing habitat, the degradation of water quality, irretrievable conversion of lands suitable for restoration, or the spread of invasive nonnative species.

Restoration or restoring – See definition for "ecosystem restoration".

Science - the use of evidence to construct testable explanation and prediction of natural phenomena, as well as the knowledge generated through this process (National Academy of Sciences 2008). Science can be (a) *experimental* where natural phenomena are described by observations, (b) *theoretical* where models or generalizations are formed, (c) *computational* where complex theoretical formulations are resolved and (d) *data explorative* (or e-Science) where theory, experiment and simulation are unified. New knowledge is also discovered through data mining, visualization of complex processes and other emerging computational methodologies (adapted from Hey et al., 2009).

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

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

Science diplomacy – the use of scientific collaborations among nations to address common problems and to build constructive international partnerships. [As used herein the term is applied and limited to

state/federal and Bay/Delta boundaries. This definition is quoted directly from the University of Arizona Global Challenges webpage: https://global.arizona.edu/science-diplomacy/what-is-science-diplomacy]

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

Stakeholder - One who has a share or an interest in a given activity.

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

The State of Bay-Delta Science - A summary and synthesis of the current state of scientific knowledge for the Delta, focused on the grand challenges of policymakers. *The State of Bay-Delta Science* was first published in 2008 by the CALFED Science Program, and will be updated by the Delta Science Program every four years. [The latest State of Bay-Delta Science (SBDS) was published by the Delta Stewardship Council in 2016.]

Water export - The amount of water that a hydrologic region transfers to another hydrologic region.

Watershed - The land area that drains into a stream, river, or sea. The watershed for a major river may encompass a number of smaller watersheds.

Water supply reliability - See text box in Chapter 3 of the Delta Plan (p. 65), "What Does It Mean to Achieve the Goal of a More Reliable Water Supply for California?"

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APPENDICES

Appendix A: List of agencies with personnel interviewed for this report

Interviewees were not asked to represent the views of their respective organization.

Interviewees in alphabetical order by last name	Organization(s)
Krystal Acierto	California Department of Finance
William Anderson	State Water Resources Control Board
Steve Brandt	Delta Independent Science Board
John Cain	American Rivers
John Callaway	Delta Stewardship Council, Delta Science Program
Susan Chan	California Assembly Budget Committee
Tracy Collier	Delta Independent Science Board
Joshua N. Collins	San Francisco Estuary Institute
Steve Culberson	Interagency Ecological Program
Rebecca Fris	California Department of Fish and Wildlife
Virginia Gardner	Delta Protection Commission
Greg Gearheart	State Water Resources Control Board
Michael George	State Water Resources Control Board
Thomas Gibson	California Natural Resources Agency
Les Grober	State Water Resources Control Board
Brent Hastey	Yuba County Water Agency - South; ACWA
David J. Hayes	NYU State Energy & Environmental Impact Center
Sally Jewell	Former U.S. Department of the Interior
Chris Kwan	Delta Stewardship Council
Jay Lund	UC Davis Center for Watershed Sciences
Natasha Nelson	Delta Protection Commission
Ted Sommer	California Department of Water Resources
Jay Ziegler	The Nature Conservancy

Appendix B: Federal Crosscut Budget Summary

System	*Average Annual State Funds*	*Average Annual Federal Funds*	*Total Federal Funds for Specified Period*
Bay-Delta	$250 million / year	$314.7 million / year	$6.294 billion (1998-2017)
Chesapeake Bay	$1.2 billion / year	$473.3 million / year	$2.8 billion (2011-2016)
Coastal Louisiana	$202 million / year	$1.285 billion / year	$10.276 billion (2008-2015)
Florida Everglades	$712 million / year	$231 million / year	$5.8 billion (1993-2017)
Great Lakes	N/A	$932 million / year	$5.6 billion (2011-2016)
Puget Sound	$31.7 million / year	$6.4 million / year	$102.5 million (2003-2018) NEP $198 million (2006-2016)

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Appendix C: Relevant Meetings Attended

2018 Senate Natural Resources and Water Committee Informational/Oversight Hearings
2018 Delta Science Plan Review and Update Public Workshop
Delta Independent Science Board (DISB)
Delta Plan Interagency Implementation Committee (DPIIC)
Delta Protection Advisory Committee (DPAC)
Delta Science Funding Initiative Workgroup
Delta Stewardship Council (DSC)