MEMORANDUM

TO: Collaborative Adaptive Management Team
FROM: CAMT Salmon Subcommittee
DATE: December 11, 2020
RE: Coordinated Salmonid Science Planning Assessment for the Delta

The Collaborative Adaptive Management Team (CAMT) began the Coordinated Salmon Science Planning (CSSP) process in order to systematically identify, integrate and logically prioritize salmonid science, monitoring and management activities in the Delta region to support robust collaborative planning for the allocation of limited resources for salmonid conservation and management.

The "Coordinated Salmon Science Planning Assessment for the Delta" (CSSP Assessment) was commissioned by CAMT as an initial step toward this broader and more ambitious goal. Using a combination of expert interviews and literature review, 109 activity statements were compiled and then distilled down to 44 unique candidate science, management, and monitoring "Q statements". These Q statements covered a range of topics including habitat restoration strategies, water project operations, monitoring needs, and high-priority scientific investigation. The CSSP Assessment then relied upon a structured survey of salmonid experts and stakeholders to illicit perspectives regarding the relative benefits, barriers to implementation and level of agreement on the 44 Q statements.

The CSSP Assessment describes the Q survey methodology and reports preliminary findings on a subset of evaluated activities based on the following themes:

1. High benefit and high agreement
2. High agreement and high implementability
3. High benefit and low agreement

The assessment should be viewed as an interim milestone of the CSSP process. It highlights areas of salmonid science, management, and monitoring activities that survey results suggest would have high benefits if advanced. The assessment also provides recommendations for increasing alignment across parallel prioritization efforts (e.g., CVPIA Structured Decision Making, Sacramento River Science Partnership Science Plan, Delta Smelt Structured Decision Making) and suggests next steps. However, the assessment does not provide a comprehensive analysis of survey results, specific implementation plans, or suggestions on addressing activities with the least agreement. Accordingly, the Salmon Subcommittee offers the following considerations when reviewing the report:

1. The geographic scope of the CSSP Assessment was restricted to the Delta. Therefore, salmonid science, monitoring and management needs related to rivers and the marine environment (e.g., harvest and hatcheries) were not considered. These topics will likely be important to assess in future planning efforts focused on salmonid stressors and recovery.

2. Though a sophisticated and novel methodology, the Q survey methodology is fundamentally a survey of stakeholder and expert opinion. Unlike Structured Decision Making (SDM), the Q method does not rely on, or provide a quantification of benefits likely to result from different management actions or activities. We recognize the challenges in the use of this methodology due to lack of familiarity with the approach, the large number of statements to sort, and different interpretation of statements' meanings.
3. Because the report only describes Q statements associated with the three themes above, results for most Q statements are not evaluated or reported on in the Assessment. Further analysis of the results for these additional Q statements is warranted because they align closely with CAMT objectives and relate to key salmonid uncertainties identified by previous collaborative investigations (see Assessment, Table 2-1).

Despite its limitations, the CSSP Assessment provides CAMT with useful information and an exciting and novel window into the perspectives and relative alignment of Delta stakeholders. Furthermore, the CSSP Assessment helps to shed light on the categories of actions that have the potential to generate benefits for fish while also building greater coherence among stakeholders by focusing on areas of common interests. Based on these results, the Subcommittee has identified the following opportunities to pursue (in parallel):

1. Explore activities where there is high agreement about high benefits and/or high implementability
2. Conduct additional analyses of Q survey results

Further analysis of the Q survey data is needed to fully realize potential benefits to CAMT in breaking down barriers to more effective collaborative decision-making. In particular, analysis of the full survey results would contribute to discovering areas of common ground, or of divergence, that have not previously been recognized or discussed in CAMT.

Coordinated Salmonid Science Planning Assessment for the Delta

October 26th, 2020

Prepared for the Collaborative Adaptive Management Team (CAMT) under the Collaborative Science and Adaptive Management Program (CSAMP).

ESSA

KEARNS & WEST

Prepared for:
The Collaborative Adaptive Management Team (CAMT)

Coordinated Salmonid Science Planning Assessment for the Delta

Final Report

October 26th, 2020

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Executive Summary

Key Takeaways

- This study is the first step in a Coordinated Salmonid Science Planning (CSSP) process to systematically identify, integrate, and logically prioritize potential salmonid science, monitoring, and management activities in the Delta region.
- A set of previously proposed activities formed the basis of a rigorous survey that solicited perspectives on the relative importance of activities from 50 experienced salmonid science and management practitioners across a range of organizations.
- Survey results were statistically analyzed to reveal practitioner perspectives on relative benefits and barriers to implementation for these activities as well as the level of agreement or disagreement across organizations regarding these benefits and barriers.
- Key recommendations arising from this work are for the Collaborative Adaptive Management Team (CAMT) and its sub-committees to:
    1. Determine how the results of this planning assessment should be used alongside other lines of evidence in decision-making, including the role of additional analyses on resulting data.
    2. Use survey results along with other lines of evidence to identify a smaller subset of activities to carry forward into detailed implementation planning.
    3. Advance holistic science and management by aligning parallel planning and prioritization processes to ensure preferred actions balance trade-offs.
    4. Define a long-term framework for adaptive management of salmonids in the Delta and beyond that keeps pace with emerging science.

Overview

The Sacramento San Joaquin Delta is a complex and highly modified ecosystem that is home to many important species, including salmonids. The long history of human alteration of delta landscapes has had significant impacts on these species and where salmonids were once plentiful, many are now imperilled and in need of conservation action. The many agencies and overlapping programmatic authorities working to support salmonid recovery region have given rise to numerous initiatives, each with their own specific objectives, approaches, and resulting recommendations for priority actions. However, a lack data, of alignment across organizational mandates, and of coordination across prioritization initiatives have all contributed to the challenge of understanding which activities represent the best investments for the resilience of salmonids across the Delta as a whole.

The objective of the **Coordinated Salmonid Science Planning (CSSP) process is to systematically identify, integrate, and logically prioritize potential salmonid science, monitoring, and management activities in the Delta region to support robust collaborative planning for the allocation of limited resources dedicated to salmonid conservation and management.**

This initial Coordinated Salmonid Science Planning Assessment has focused on collating, sorting, and prioritizing the numerous activities proposed in prior work completed by CAMT (SST 2017ab, CAMT 2018) and by myriad other organizations working on salmonids in the region. Our approach to prioritization has relied on the distribution of structured surveys asking these same organizations to assess the relative benefits of these activities for salmonids and agreement on these benefits and present the results for consideration by decision-makers tasked with allocating limited resources across activities.

A key benefit of this approach has been to explicitly recognize and document the complexity of different values and viewpoints across these organizations regarding what activities are both important and feasible, which can have a significant bearing on both implementation and outcomes. By illuminating perceived benefits as well as areas of agreement and disagreement across practitioners in the region, this work can help to facilitate collaborative work in areas of shared perspective while providing an opportunity to better understand differing perspectives and develop science and planning strategies aimed at increasing shared understanding and coherence among these parties.

Approach

We used a combination of expert interviews and literature review to extract and compile a list of unique candidate science, management, and monitoring activities proposed by previous science-based planning initiatives in the Delta to provide the starting material for prioritization (see supplementary data file accompanying this report). Recognizing the history of disagreement among stakeholders regarding the importance and feasibility of different activities, we selected a rigorous survey-based approach that excels at assessing the relative benefits of activities within the context of diverse viewpoints. The surveys deployed in this project asked experienced salmonid science and management practitioners to rank activities according to **four prioritization criteria: (1) Magnitude of Benefits, (2) Learning Benefits, (3) Multispecies Benefits, and (4) Implementability**. The survey received responses from 50 participants representing a wide range of key stakeholder affiliation groups, including federal and state agencies, public water agencies, NGOs, and other experts to help reflect the important diversity of viewpoints on salmonid recovery priorities in the Delta. Survey responses were analyzed to yield mean scores for each candidate activity for each of the four criteria as well as a measure of **agreement or disagreement across stakeholder groups** for each score. These elements were used as the basis for priority sorting and ranking into shortlists representing combinations of the four criteria into **three themes**. The full list of proposed activities used to generate shortlists as well as full sorting results (including activities not shortlisted) are provided as one of two **supplementary data files provided with this report** for further consideration and analysis by interested parties (Raw Survey Results available from this LINK, and Data Analysis Results available from this LINK).

Although the results of this study can be considered to reflect a snapshot of current thinking around priority activities for salmonids in the Delta, they should be viewed as as one of multiple lines of evidence informing decisions about activities to consider further for implementation. Further constructive dialogue amongst the members of CAMT and its sub-committees are needed to determine how this line of evidence feeds into or fits alongside others parallel prioritization efforts, including efforts to collect and analyze field data, modelling exercises and structured decision-making processes. We are confident this report will be valuable in helping to structure and filtering long lists of possible activities.

Key Findings

For each of the three themes below, sorting against the four criteria produced a shortlist for all activity types combined as well as separate shortlists for each of the three activity types (science, monitoring, and management). Of the overall list of 109 activities evaluated, 44 appear on at least one thematic shortlist representing a mix of the three activity types. Key findings are summarized here for the all-activities shortlists *only*, and the full set of results are presented in Section 3.2 and in the **supplementary data files** accompanying this report (Raw Survey Results available from this LINK, and Data Analysis Results available from this LINK).

Theme 1: Beneficial Activities with the Most Agreement about Benefits

This theme focused on activities ranked as more beneficial across selected criteria with the greatest level of agreement across affiliation groups, reflecting the **highest potential for collaborative efforts to achieve the most benefits** for salmonids. However, many of these actions were also ranked as difficult to implement and will likely be larger, multiyear endeavors. The 12 shortlisted activities are related to the key action areas shown below.

- Improving migratory and rearing **habitat connectivity,**
- Creating or enhancing **quality of and access to floodplain habitat**,
- Monitoring **prey availability and growth rates** for juvenile salmonids, and
- Reducing the impacts of **invasive species and aquatic weeds**.

Theme 2: Activities with High Agreement on Low Barriers to Implementation

This theme focused on activities that most affiliation groups agreed would be **easier to implement and might represent quick wins contributing to improvements in salmonid management and resilience** that could be implemented alongside the execution of more complex projects. The 12 shortlisted activities fall into the key investigation areas shown below. Notably, several activities related to telemetry tracking are also shortlisted under Theme 1.

- **science activities related to migration tracking**,
- **understanding the effects of contaminants** and
- reducing **injury and mortality related to impingement or entrainment**

Theme 3: Beneficial Activities with the Least Agreement on Benefits

This theme focused on activities ranked as **highly or moderately beneficial across selected criteria with the lowest levels of across-group agreement** in benefit scores. Identifying and characterizing areas of greatest disagreement is just as critical as finding areas of common ground in that it allows practitioners to identify and work to lower barriers to the implementation of high-benefit activities. For example, some of these activities may be good candidates for additional science that can help reduce uncertainties and resolve areas of disagreement. The 15 shortlisted activities fall into the key topics shown below.

- monitoring or reducing the **impact of predators** on juvenile salmonids (most activities)),
- studying and monitoring **juvenile habitat use** in the Delta, and
- water and **flow / conveyance management** activities.

Alignment with Parallel Prioritization Processes

This report also reviews commonalities across the CSSP assessment and selected parallel prioritization efforts, including: (1) The Sacramento River Science Partnership Science Plan, (2) The CVPIA Structured Decision Making Initiative, and (3) the CAMT Structured Decision Making Initiative for Delta Smelt. Key intersections include efforts related to the themes outlined below and more context on the nature of intersections and opportunities for greater alignment are provided in the report.

- habitat restoration,
- flow management,
- floodplains and food supply,
- migration and habitat connectivity, and
- reducing the impacts of predators and aquatic weeds

Recommendations & Next Steps

The results of this study will assist CAMT to more effectively consider the human dimensions of natural resource management decisions in their deliberations on the selection, sequencing, and implementation design of projects intended to benefit salmonids in the Delta as recommended in the Delta's Science Action Agenda.

Key recommendations arising from this report are to:

1) Deliberate further on how the results of this study should be used in decision-making, including the role of additional analyses on resulting data.
2) Use the CSSP assessment alongside other lines of evidence to identify a smaller subset of activities to carry forward into implementation planning.
3) Advance holistic science and management by aligning parallel planning and prioritization processes to ensure preferred actions balance trade-offs.
4) Define a long-term framework for adaptive management of salmonids that keeps pace with emerging science.

Through its unique mandate and diverse membership, CAMT and the broader CSAMP working groups are well positioned to provide leadership on these steps and act as a unifying force for increasing coordination and alignment among the many planning initiatives being pursued by its member organizations. Efficiently coordinating these efforts with the aim of accelerating on the ground actions will help to further support the resilience of salmonids as well as other species and habitats that contribute to a functioning Delta ecosystem.

1 Introduction

1.1 Background

The Sacramento San Joaquin Delta is a complex and highly modified ecosystem that supports many important species, including salmonids (SFEI-ASC 2014 and 2016). The complexity and ongoing environmental change within this system gives rise to uncertainty that poses challenges to timely and effective management and decision-making. Because many management issues are pressing, managers cannot wait for complete information before they act. The many agencies and overlapping programmatic authorities working to reduce threats to salmonids in the Delta region and beyond have given rise to numerous initiatives incorporating, each with their own specific (and sometimes conflicting) mandates, objectives, indicators, tools, assessments, and resulting priority actions. However, the sheer number, complexity, and lack of consistent coordination across these initiatives has made it challenging to understand which science, monitoring, and management actions are most important or most supported by stakeholders not only within the sphere of individual agency mandates, but for salmonid recovery within the Delta ecosystem as a whole.

The **Collaborative Science and Adaptive Management Program (CSAMP)** has emerged as one important initiative supporting the coordination of adaptive management approaches. It represents one of the only organizations in the region with broad representation of all interested parties and provides one of the best forums for cross-agency and cross-disciplinary work on these issues. CSAMP was initiated in 2013 as an alternative approach to resolving science-based disputes in the management of Delta resources and continues to focus on science and adaptive management issues related to current and future biological opinions for Central Valley Project (CVP) and the State Water Project (SWP) operations.. CSAMP consists of a Policy Group and a science-oriented Collaborative Adaptive Management Team (CAMT) which continue to operate under the following mandate (Connor 2013, CSAMP 2017):

- To provide a **forum** for communication among California state and federal fish/water agencies, Non-Governmental Organizations (NGOs) and Public Water Agencies;
- To act as a **catalyst** to address the most contentious and urgent management relevant science issues; and
- To provide timely **compilation and dissemination of information** for decision makers on contentious and urgent science issues.

CAMT has already completed work to clarify the current state of science, management, and outstanding uncertainties for salmonids in the Delta (SST 2017ab, CAMT 2018), and now recognizes the need for a science assessment to identify, integrate, coordinate, and prioritize these efforts across the Delta and beyond to pave the way for selection and implementation of select activities.

1.2 Purpose and Scope of the CSSP Assessment

1.2.1 Objective

The objective of the **Coordinated Salmonid Science Planning (CSSP) Assessment is to systematically identify, integrate, and logically prioritize potential salmonid science, monitoring, and management activities in the Delta region to support robust collaborative**

planning for the allocation of limited resources dedicated to salmonid conservation and management. This objective is operating in service of the broader biological goal to wisely select and implement actions that benefits the survival and productivity of at-risk salmonids in the Delta region and beyond. Before work can be undertaken to quantify hypothesized benefits of actions (e.g., through modelling) or select specific actions for implementation, it is a practical necessity to first filter long candidate lists of diverse activities into categories or themes that support finer resolution implementation planning.

As a foundational planning assessment, our efforts sought to collate the diverse range of management, science, and monitoring activities that have been proposed, work with representatives of key organizations using interviews and surveys to assess the relative benefits of these activities and agreement on these benefits, and present the results for consideration by decision-makers tasked with allocating limited resources across activities. This work differs from past and parallel efforts in its focus on integrative synthesis, its inclusion of multiple activity types (management, research, monitoring), and its commitment to supporting more collaborative planning and decision-making. Importantly, our approach to prioritization of key activities considers not only practitioner assessments of the **overall benefits of the activities**, but also considers the **level of agreement** across practitioners about these benefits as well as practitioner assessments of the degree of **'implementability'** or these activities (see Section 3.1 for more information on methods). This additional data is expected to help practitioners weigh the scientific merit of activities within the context of their real-world constraints.

In providing the information needed to support better collaborative planning and decision-making, this assessment also fulfills many of the broader objectives of the Delta Stewardship Council's Science Action Agenda. While our work to collate the diverse range of activities proposed in prior efforts contributes to increased science synthesis in the Delta (Action Area 2), another important contribution includes the exploration of participant agreement data to increase understanding of the human dimensions of natural resources management in the Delta (Action Area 1) which encompasses identifying stakeholder perspectives when developing policy and management alternatives. Hence, this work can be examined to reveal both the rationale for taking action in terms of perceptions around (1) Magnitude of Benefits, (2) Learning Benefits or (3) Multispecies Benefits, or subjectively analyzed for the implementability opinions of different participants (or all of these).

1.2.2 Focal Geographies, Species, and Life Stages

Central Valley salmonids have complex life histories that encompass the many distant spawning streams where they are born, the larger mainstem tributaries and in-Delta habitats that serve as rearing and migratory corridors for juveniles. Salmonid life histories also rely on the estuary and ocean environments where adults feed and grow before various species and run types some years later begin their return spawning migrations. Human activities and environmental conditions across all these environments and life stages contribute to the overall status of salmonids in the region. However, this work faced time and resource constraints requiring us to focus on one part of this larger picture.

The primary geographic focus of this project is on **the Delta itself (including the Yolo Bypass/Cache Slough complex) and the portion of salmonid life histories occurring therein**. Although this planning assessment also recognizes the importance of actions in upstream mainstem rivers and tributaries which also influence conditions and salmonid survival, other planning processes were underway to address these needs at the tributary scale (see

Section 3.3 for more detail). Thus, this planning assessment helps to focus on gaps in detailed salmonid science, management and monitoring needs for the unique context of the Delta region.

Our initial review of proposed activities focused on literature for the following species listed roughly in order of priority: Winter-run Chinook Salmon, Spring-run Chinook Salmon, and Steelhead as well as Fall-run and Late Fall-run Chinook Salmon.

1.2.3 How Will This Planning Assessment Be Used?

This Planning Assessment has focused on collating, sorting, and prioritizing the numerous activities proposed in prior work completed by CAMT (SST 2017ab, CAMT 2018) and by myriad other organizations working on salmonids in the region. A key benefit of this approach has been to explicitly recognize and document the complexity of different viewpoints across these organizations regarding what activities are both important and feasible, which can have a significant bearing on both implementation and outcomes. By illuminating perceived benefits as well as areas of agreement and disagreement across practitioners in the region, this work can help to facilitate collaborative work in areas of shared perspectives while providing an opportunity to better understand differing perspectives. This knowledge will help develop science and other strategies aimed at further increasing shared understanding and coherence amongst these parties.

In addition to highlighting areas of alignment across these organizations, this report also offers an initial assessment of commonalities across the CSSP assessment and selected parallel prioritization efforts, including: (1) The Sacramento River Science Partnership Science Plan, (2) The CVPIA Structured Decision Making Initiative, and (3) the CAMT Structured Decision Making Initiative for Delta Smelt. In documenting these commonalities, our report highlights avenues for increased cooperation or coordination on specific activities recommended across these initiatives. This is an obvious next step with regards to linking in-Delta and out-of-Delta habitats.

This assessment was *not* funded nor intended to make recommendations on projects for implementation or deliver implementation, design, and monitoring details for specific activities. Instead, **the results of this collaborative analysis are intended to provide a well organized and better filtered starting point for more focused discussions of priorities by members of the CAMT Salmonid Sub-Committee in the context of its broader mandate**. Depending on the level of rigor sought and the predominant evidentiary paradigm of the group, this may or may not require these members to engage in other analyses to quantify the hypothesized benefits of short-listed activities identified in this assessment (e.g., through further modelling). Geographically expanded (basin-wide) discussions to explore both methodological and thematic alignments will enable practitioners to develop even more detailed guidance on specifically what actions to coordinate and implement and in what sequence. In expanding the scope, a key trade-off practitioners will face will be between velocity (how long to take and how many resources to invest “to be sure”) and rigor (importance of “knowing the anticipated effect sizes of actions with good certainty” before acting). These broader value and adaptive management considerations were beyond the scope of this assessment.

In Section 4, we outline some recommended next steps for advancing these planning efforts moving forward.

2 A Landscape of Perils and Possibilities: Management Context for Salmonid Science in the Delta

2.1 Salmonids in the Delta, Today and Tomorrow

2.1.1 Current Status of Central Valley Salmonids

The San Francisco Bay-Delta Estuary and its upstream tributaries within the broader Central Valley support a diverse assemblage of salmonids, including winter-run, spring-run, fall-run and late fall-run Chinook salmon as well as steelhead (NMFS 2014). Many salmonid populations have declined to a fraction of their historical abundance following decades of significant alterations to their freshwater habitat through human use and land conversion as well as commercial and recreational harvest. The Delta is dramatically different from its historical state as a vast network of tidal marshland that provided valuable salmonid rearing habitat (SFEI-ASC 2014 and 2016). Several populations of salmonids are now considered either endangered (Sacramento River winter-run Chinook salmon) or threatened (Central Valley spring-run Chinook salmon and California Central Valley steelhead) under the federal Endangered Species Act,), raising the stakes for effective management interventions to support salmonid resilience and recovery (NMFS 2014).

2.1.2 Contemporary Conservation Concerns Facing Salmonids in the Delta

Today, these salmonids continue to face numerous and increasing numbers of stressors that may pose a threat to their long-term viability and jeopardize their continued existence in the Delta region and beyond (NMFS 2014, DSC 2018). These are summarized briefly below (but see NMFS 2014 for a more comprehensive review):

- **Dams block large areas of historic spawning and rearing habitats** (SFEI 2014).
- **Over 95% of the Delta's tidal marsh and floodplain habitat has been lost or drastically altered** (Bay Institute 1998, Whipple et al. 2012, SFEI 2014).
- **Delta flows have been significantly altered in some times and places by water management activities and associated anthropogenic structures** (Mount et al. 2012; Windell et al., 2017).
- **Water quality has been degraded due to of discharges from historic mining, ongoing agriculture, and urban development** (Windell et al. 2017).

- **Ocean and freshwater harvest impacts on adult survival and diversity in age-at-maturity pose further stress for wild salmonid populations** (Windell et al. 2017).

- **The use of hatcheries to support declining salmonid populations has compromised the remaining wild population through competition and interbreeding with hatchery fish** (Mount et al. 2012, Windell et al. 2017).

- **Non-native species introduced to the Delta have disrupted food webs, contributed to habitat changes, and preyed extensively on salmonids** (Mount et al. 2012).

- **Climate change is anticipated to worsen many of these existing stressors** (Dettinger et al. 2016, Mount et al. 2012).

All of these factors have contributed to extremely low estimated survival of juveniles migrating through the Delta (SST 2017), which affects overall stock productivity, reduces cohort replacement rates, and jeopardizes long-term population persistence. Ensuring the long-term survival and resilience of salmonids in the Delta region will require a concerted effort to address stressors listed in this section in order to restore and sustain salmonid habitats and ecological processes that once supported them.

2.2 Key Salmonid Science Uncertainties

Scientific and management uncertainties are ecological unknowns about the ecosystem of concern. Drivers of these uncertainties may include incomplete knowledge about the variability of natural systems the system (natural variation uncertainty), incomplete knowledge of the key drivers and causal relationships within the systems (structural uncertainty), the result of our inability to challenges in effectively and accurately measuring elements of such systems (observation uncertainty), and a lack of understanding of the response of the systems (and key components thereof) to management actions (implementation uncertainty; Regan et al. 2002, Link et al. 2012, Fackler 2014). It is critical to identify, understand and reduce these uncertainties that can otherwise limit the effectiveness of management actions.

There are many past and ongoing efforts to identify key questions and uncertainties related to the study and management of salmonids in the Delta (Wiens et al. 2017). For example, in 2017 CAMT's Salmonid Scoping Team undertook a collaborative expert review of technical information relating juvenile salmonids in the Delta to identify findings, gaps, and technical disagreements and to make recommendations for addressing these uncertainties (SST 2017a, SST 2017b). In 2018, CAMT hosted a salmonid research activity workshop that also revealed key management needs. Table 2-1 summarizes some of the key uncertainties that have been identified through these efforts, including identifying the primary type of uncertainty they represent. These uncertainties can help to inform the selection and implementation of the science, management, and monitoring activities examined in the next chapter of this document.

Table 2-1. Key uncertainties relating to salmonid recovery in the Delta. Uncertainties are organized by their class and list the salmonid life stage that they impact, as well as the reference that identifies the uncertainty. All of the uncertainties impact both Steelhead and Chinook salmon.

Type of Uncertainty	Uncertainty	Life Stage	References
Implementation	Effects of changes in water project operations (and subsequent habitat changes) on predation pressure.	All	SST 2017a
Implementation	Magnitude of change in flow, water velocity, or water quality needed to elicit a response by migrating juvenile salmonids.	Smolt	SST 2017a
Implementation	Optimal means of operating Clifton Court Forebay radial gates (e.g., day/night cycle, tidal cycle).	Smolt / Adult	CAMT 2018
Implementation	Effect(s) of changes in export rates on salmonid route selection and survival.	Smolt / Adult	SST 2017a
Implementation	Potential biological benefits of influencing migration route selection through installation of the Head of Old River Barrier (HORB) in South Delta channels.	Smolt	SST 2017a
Natural Variation	Nature and degree of differences in the behaviour and survival of wild and hatchery fish or fish originating from different parts of the watershed.	All	SST 2017a; CAMT 2018
Natural Variation	Effects of hydrodynamic factors (e.g. water velocity) on rearing juvenile salmon.	Fry/Parr	SST 2017a, CAMT 2018
Natural Variation	Uncertainty about future conditions due to climate change, human population growth, changes in demand for water, etc.	All	CAMT 2018
Observational	How San Joaquin River inflow and exports affect migration and survival of acoustically tagged juvenile salmon and steelhead over a wider range of conditions.	Smolt	SST 2017a
Structural	Use of the Delta by fry and desired habitat characteristics for rearing in the Delta.	Fry	CAMT 2018
Structural	Contribution of water project operations to the total mortality of juvenile salmonids.	Juvenile (Fry / Parr / Smolt)	SST 2017a
Structural	Effects of OMR reverse flows on salmonid survival and route selection in the Delta (outside facilities).	Smolt / Adult	SST 2017a
Structural	Variability in survival under higher levels of I:E, inflow, and exports is not well-characterized.	Smolt / Adult	SST 2017a
Structural	Effects of Head of Old River Barrier operations on water quality parameters (other than salinity, dissolved oxygen).	All	CAMT 2018
Structural	Effects of water quality on fish distribution (as opposed to habitat or flow effects).	All	CAMT 2018
Structural	Effects of hydrodynamics on distribution of contaminants, and subsequently, the effects of contaminants on fish.	All	CAMT 2018

2.3 Key Salmonid Management Activities and Organizations

A wide range of management activities are available to help address the key conservation concerns facing salmonids while they are present in the Delta. Each of these activities is associated with its own uncertainties, and related science and monitoring intended to reduce these uncertainties. Many of these activities are already being implemented in the region by a diverse group of practitioners and organizations, while many more have been proposed for future implementation in a wide range of white papers, strategy reports, and planning documents. This section provides a brief overview of the key management actions and organizations relevant to salmonids in the Delta system to help set the context for the results presented in the following chapter.

Key Management Activities Related to Salmonids in the Delta

Key classes of management activities considered in this report are summarized below, each of which is associated with science and monitoring activities too numerous to name here.

- **Operational Management**: Operational management encompasses the operation of water pumps, diversions, bypasses, weirs, dams, and other water conveyance infrastructure that alters the distribution and volume of flows across the Delta. Operational management also entails building connectivity between bypasses and the river to allow free movement of fish and reduce stranding events, while screening irrigation diversions to reduce the risk of entrainment (Windell et al. 2017, CNRA 2017). Managing water operations to provide adequate environmental flows and connectivity helps to ensure mainstem passage for migrating adults while reducing false attraction flows and straying through Delta bypasses. The natural flow paradigm treats flow as the "master variable" needed to drive natural variation of hydrologic regimes to protect native biodiversity and the evolutionary potential of aquatic and riparian ecosystems (Arthington et al. 1991, 2006; Richter et al. 1996, 1997; Stanford et al. 1996; Poff et al. 1997; Tharme 2003; Petts 2009; Fleenor et al. 2010; Carlisle et al. 2010; Poff and Zimmerman 2010; Poff et al. 2010).
- **Habitat Management and Restoration**: Restoring shallow-water habitat (i.e. tidal, off-stream, floodplain, etc.) and riparian habitat increases the amount of juvenile rearing habitat capable of providing abundant and high-quality prey as well as structural refuge from predation, provided sufficient flows are available for this habitat to remain submerged (Windell et al. 2017, CNRA 2017). This class of management action encompasses both tidal habitat, such as the projects included in the California EcoRestore initiative, and floodplain off-channel habitat, per NMFS Final Recovery Plan for winter-run, spring-run, and steelhead and the Central Valley Flood Protection Plan Conservation Strategy (NMFS 2014, CNRA 2017).
- **Invasive Species and Predator Management**: Predation is estimated to account for a substantial proportion of the mortality experienced by juvenile salmonids (SST 2017a). Predation mortality can be exacerbated by predator 'hotspots' including artificial structures, scour holes, or dense stands of non-native submerged aquatic vegetation that provide predators with habitat and cover for ambush. Efforts to control predator populations and 'contact points' may help to reduce juvenile salmonid mortality in the Delta (CVPIA 2019, Michel et al. 2020ab).

Other important classes of management actions related to salmonids but outside the scope of this report include **Hatchery Salmonid Management**, **Harvest Management, and Water Quality Management.** Although these types of actions are not among the management actions we prioritized, some science and monitoring actions still relevant to these topics do appear in later sections.

Key Organizations Working to Support Salmonid Resilience

The management activities noted above are implemented by a wide range of **key organizations whose mandates encompass the management and conservation of** salmonids in the Delta. Representatives from many of these organizations were consulted over the course of this project through interviews, webinars, and structured ranking surveys.

- At the ***federal level***, a variety of agencies engage in various activities intersecting with salmonid management, restoration, and recovery. These include the Bureau of Reclamation (BOR) and U.S. Army Corps of Engineers (USACE), which are largely concerned with flood control and water supply management actions and infrastructure; the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS), which are largely concerned with the monitoring, restoration, and management of fish and wildlife populations and habitat; and the U.S. Geological Survey (USGS) and Environmental Protection Agency (EPA), which are largely concerned with water quality monitoring and improvement initiatives.
- At the ***state level***, various agencies and organizations conduct activities relating to monitoring, restoration, flood control, protection of endangered species, wildlife management, and science coordination, as well as water quality, rights, and supply. These include the Central Valley Regional Water Quality Control Board (CVRWQCB); the California State Water Resources Control Board (SWRCB); the Central Valley Flood Protection Board (CVFPB); the State and Federal Water Contractors Agency (SFCWA), the California Department of Fish and Wildlife (CDFW); the California Department of Water Resources (CDWR); the Delta Stewardship Council (DSC) and Delta Independent Science Board (DISB); and the Sacramento-San Joaquin Delta Conservancy.
- At the ***local government level***, agencies whose activities affect salmonids in the Delta include public water agencies (particularly the Metropolitan Water District of Southern California (MWD), regional sanitation boards, and water district organizations which are responsible for water delivery, sanitation, flood management and water conservation.
- Lastly, salmonid conservation activities are further supported by various ***non-governmental organizations*** (e.g., the San Francisco Estuary Institute, the Golden Gate Salmon Association, Trout Unlimited, American Rivers, and others), academic researchers, consultants, and other interest groups.

Considering the number of contributors striving to benefit salmonids in the Delta, it is not surprising that there are concurrent efforts aiming to prioritize future work. Alignment of this report with these parallel prioritization processes is discussed further in Section 3.2.2

2.4 **Towards A Shared Vision for Salmonid Science in the Delta**

As with other scientific enterprises in the Delta, practitioners of science, monitoring, and management activities related to salmonids in the Delta aspire to the overarching vision of "*One Delta, Once Science*" advocated in the Delta Science Plan (DSC-DSP 2019). In the context of salmonids in the Delta, this vision entails a scientific community that works together to contribute to a common body of credible scientific knowledge about salmonids and works alongside decision-makers, managers, stakeholders and the public to support science-based policy for management of salmonids (DSC 2019).

This vision was echoed in the comments of practitioners interviewed for this project (see Appendix A), who expressed **widespread support for developing a cohesive science-based vision for salmonids in the Delta through a collaborative and transparent planning process with stakeholder buy-in**. Given the range of interview responses, this shared vision would include a commitment to aligning salmon science and recovery activities throughout their geographic range (i.e., amongst alternative planning frameworks); long-term monitoring to help evaluate the effectiveness of actions and hypotheses surrounding critical uncertainties; the use of emerging technologies to support data collection, synthesis, and sharing (e.g., otolith marking, acoustic tagging, and open data portals); and greater synthesis and integration of both data and decision support tools in order to develop holistic predictive frameworks, help identify gaps, set priorities, and coordinate across organizations to prioritize actions taken that result in increased productivity and reduced risk to salmon and steelhead. Several notable efforts are already underway to help support broad and cohesive synthesis of the myriad ongoing activities related to salmonids in the Delta and other ecosystems components. These include the Salmon and Sturgeon Assessment of Indicators by Life Stage (SAIL) synthesis and monitoring gap assessment (Windell et al. 2017), the Delta Independent Science Board's Monitoring Enterprise Review Inventory Tool (DISB 2017, 2019), the Delta Stewardship Council's Science Tracker (DSC-DSP 2019, DSC 2020), and numerous public data portals to help share existing datasets (e.g., Bay Delta Live and the Environmental Data Initiative). However, these tools largely focus on past and ongoing efforts to help improve coordination and do not explicitly track or prioritize potential activities.

Although there is much to be gained by cataloguing and coordinating existing efforts, practitioners also recognize the pressing need for more deliberately forward-looking approaches to Delta science, monitoring, and management in response to accelerating and increasingly irreversible environmental change (DISB 2019a, 2020). The CSSP assessment responds to this call by providing an initial rapid screening of numerous potential future salmonid science, management and monitoring activities through surveys of salmonid science and management practitioner perspectives to identify areas of alignment and inform collaborative planning and decision-making moving forward.

Natural resource researchers are also increasingly recognizing that the uptake of science into effective policy and management depends on a holistic approach that considers both the human and natural systems (Matsaert 2002, Eddy et al. 2014). Whereas traditional natural resource studies focused exclusively on ecological components, researchers must also strive to understand the institutional context of the ecological problem (e.g., local perspectives, diversity of organizational structures and mandates, relevant legislation and policy, political implications) and to integrate findings from across diverse disciplines and organizations (e.g., social science, economics) (Eddy et al. 2014, Biedenweg et al. 2020). Thus, in addition to considering the ecological benefits of salmonid research and recovery activities, the CSSP assessment also places these activities within the broader institutional contexts that are likely to influence their adoption. This includes an initial attempt to: (1) assess **the level of agreement on the potential benefits of different activities across organizations**, (2) assess the **degree of barriers to implementation** associated with each activity, and (3) **begin to consider the alignment of these activities with parallel prioritization efforts** led by other organizations.

By striving to support the selection and coordination of future salmonid science, management, and monitoring activities across the Delta, the CSSP assessment also aims to increase awareness of proposed activities across the organizations from which they were drawn; build a greater understanding of both the scientific and institutional contexts that should inform the selection and implementation of preferred activities, and support more proactive collaboration, scientific synthesis, and adaptive management for an uncertain future (DSC 2019, DISB 2015).

3 Prioritizing Science, Management and Monitoring Activities for Delta Salmonids

3.1 Approach

Principles for Prioritization in Complex Systems

Salmonid conservation requires the selection of a preliminary **portfolio of activities** capable of balancing the emergent and ever shifting trade-offs that are characteristic of complex systems such as the Delta (Beechie et al. 2008, DuFour et al. 2015, Woo et al. 2019, Munsch et al. 2020). Because conservation funding, capacity, and timelines are limited, this selection process inevitably involves the prioritization of some activities over others. Effective prioritization frameworks provide a **systematic, repeatable, and transparent rationale** for triaging the large number of potential activities into shortlists of the most beneficial activities to pursue (Beechie et al. 2008, Roni et al. 2013). Given that the Delta's ecological, informational, and political landscapes are constantly changing, science and management priorities must also be iteratively revisited as environmental pressures shift in space and time, as research and monitoring generates new information about the effectiveness of actions, and as administrative mandates and funding opportunities evolve (Roni et al. 2013). To accomplish these characteristics, prioritization frameworks for conservation must be applied to candidate activities that are supported by pre-existing **evidence**.

The goal of evidence-based conservation practice is to help practitioners make decisions and implement actions that are grounded in systematic and critical analysis rather than personal experience or anecdote (Salafsky et al. 2019). In any field of study there are many types of evidence, each with their own strengths and limitations (Glasgow and Emmons 2006). Evidence used in conservation can be broadly characterized as "relevant information used to assess one or more hypotheses related to a question of interest" (Salafsky et al. 2019). This information includes basic data, primary studies, syntheses of evidence, and bodies of evidence-based theory or principles (Table 2). Determining the **weight of evidence** supporting a particular conservation activity involves assessing the reliability of the sources, the strength of the findings (direction, magnitude), and their relevance (Suter 2016).

Candidate science, monitoring, and management activities are generally selected based on the existence of one or more of the evidence types shown in Table 2. While selecting a *longlist* of activities is **evidence-based**, prioritizing these activities into a *shortlist* is a decision-making exercise that is usually **criteria-based**. In evidence-based conservation, a weight of evidence criterion is ideally part of the screening procedure, but many other factors in addition to this criterion must be considered.

Table 2. A typology of evidence used in conservation management

Evidence Type	Description
Basic data	Raw observations (e.g., details about conservation targets, threats, stakeholders, actions).
Primary studies	The core information for evidence-based practice. Includes documentation of specific research that describes the research question, situation, method, results, and conclusions of each case (e.g., peer-reviewed scientific publications of randomized controlled trials, grey-literature case studies, informal field notes).
Evidence syntheses	Analyses of primary studies related to a specific question (e.g., formal systematic review, subject-wide evidence syntheses, informal summaries of available evidence, creation of decision trees and decision support tools).
Theory/principles	Articulations of known evidence-based principles for a given discipline (e.g., rules of thumb, codified guidance and principles).

Source: Adapted from Salafsky et al. (2019)

Evidence-informed decisions integrate the best-available scientific information with the expertise, local knowledge, and **values** of environmental practitioners (Dicks et al. 2014). Because planning participants each bring their personal and organizational values to decision-making forums, it is important for prioritization frameworks to recognize and explicitly account for the role of diverse participant values in the prioritization process. This is particularly salient given abundant evidence that a lack of institutional alignment and trust is more often cited as a cause for failures in natural resource management than a lack of scientific understanding (Lachapelle et al. 2003, Allen and Gunderson 2011). Diverse participant values should not be viewed as an inconvenient wrinkle in an otherwise evidence-based process as they are by many traditional natural resource management planning frameworks, but instead treated as **an additional layer of evidence** capable of informing prioritization. By examining patterns of alignment and misalignment in values alongside information about scientific merit, our approach seeks to explicitly address the role that values can play in moving from recommendations about evidence-based activities to implementation of those activities.

A standard conservation planning process starts with the identification of a nested hierarchy of goals, objectives, strategies, and performance measures, then evaluates alternative approaches to select a shortlist of conservation activities (e.g., Gregory et al. 2012). In Structured Decision-making (SDM), for example, prioritization is often done by first applying multiple criteria at the objectives level (Gregory et al. 2012). Adaptive Management planning places more emphasis on **reducing uncertainty** over time and typically begins with identifying the most critical uncertainties that can be used to formulate testable hypotheses, and this shortlist of uncertainties then informs the articulation of management goals and objectives.

Prioritization can be approached from the top or the bottom of the nested hierarchy. Top down prioritization, which is more commonly applied, has the advantage of iteratively narrowing the scope and only considering those activities that are relevant to the goals and objectives that have been identified. This approach can make it easier to manage potentially unwieldy longlists of candidate activities but is often expensive (e.g., multi-year participatory processes), can introduce significant participant bias to the identification of objectives, and risks oversimplifying complex systems. In bottom up prioritization, assumptions about goals and objectives are made last and are explicitly informed by multi-criteria selection of candidate activities - activities that are already associated with supporting evidence (e.g., peer reviewed studies, other studies, reports, plan documents, expert interviews). This approach reduces participant bias by starting with an evidence-base and minimizes the risk of oversimplifying the system. It can also make subsequent planning steps cheaper and more efficient because it 'frontloads' much of the effort dedicated to assembling an evidence-base, a step that must occur in either case.

Prioritized shortlists like those developed in this study are not definitive instructions on how to allocate salmonid conservation resources, they are inputs to broader planning processes like those described above, wherein decision-makers will identify performance measures then (ideally) draw on any additional lines of available evidence to organize the shortlists into activity portfolios. These subsequent deliberations provide an added level of selective scrutiny and detail to yield final portfolios of science, management, and monitoring activities that can be sequenced and implemented. A conservation plan's final set of activity portfolios will likely include many of the activities that were highly ranked during this study, and may also include some activities that ranked poorly but are nevertheless deemed important for reasons surfaced later in the planning process (e.g., new biological evidence, weight of evidence assessments). For this reason, the shortlists we report should be interpreted as a starting point that relies on a particular type of evidence, that is, participant views about how evidence-based candidate activities meet or fail to meet a set of criteria – namely the **magnitude of benefits** provided by the activity, the extent to which it will deliver **multi-species benefits**, and the **learning benefits** that it will promote. The method we used to elicit participant viewpoints, a variant of Q Method, is described below.

The Q Method Survey Technique

Methods for identifying priority science needs exist along a continuum from simple focus group exercises with a few experts to expensive, multi-year decision analytic modelling approaches (Tompkins et al. 2018, Peterson et al. 2019, McDonnel 2019). All these approaches usually involve some form of multi-criteria assessment used to structure decisions about which conservation activities are most important to implement first under different scenarios.

The method chosen for the CSSP assessment, a variant of **Q Method**, is capable of screening a very large number of diverse activities in a way that captures participant preferences about environmental decision-making across multiple and diverse viewpoints. Q Method was first developed for use in psychology (Stephenson 1935, 1953), but has since been adopted across a wide range of disciplines, including natural resources management (Webler 2009, Chamberlain et al. 2012, Bennett et al. 2016, Zabala et al. 2018). The idea of harnessing Q Method to aid in multi-criteria prioritization of conservation activities originates with Brown (1989) and later Neff (2011, 2014) who applied it to understand how scientists evaluate research priorities using different criteria.

A survey-based approach, Q Method combines qualitative and quantitative analysis to return a deeper, more nuanced set of responses from a broader group of participants than can be accomplished using typical opinion surveys like Likert scale or multiple-choice questionnaires, or expert focus groups. It improves upon these methods by forcing participants to make tough trade-offs across a set of rigorously developed statements during an online or in-person sorting exercise ("Q sort") (Figure **2**). Respondents are required to arrange "Q statements" (e.g., "Increase riparian planting”), in a pyramid shaped grid along a scale like that shown in Figure **2**. Many configurations are possible, but a standard Q survey scale might range from Most Agree (e.g. +4) to Most Disagree (e.g., -4), with Neutral at zero. As shown in Figure **2**, the scale can be adapted to reflect different prioritization criteria, in this case multi-species benefits.

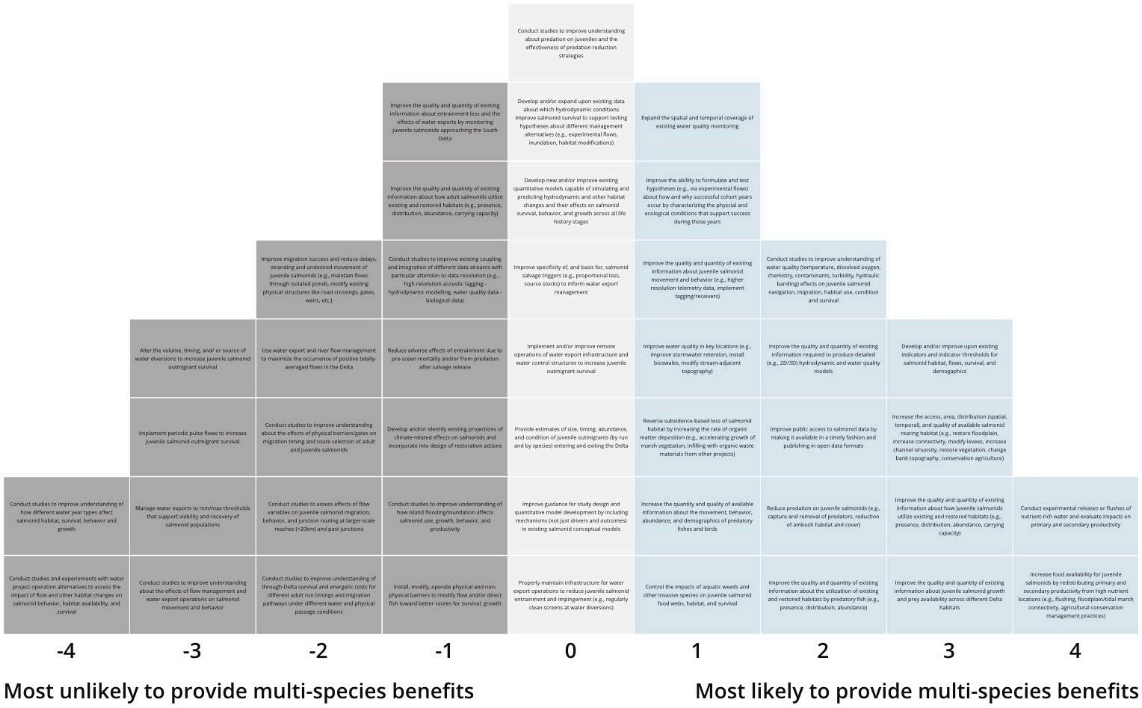


Figure 1. An example completed Q sort illustrating the pyramid shaped grid in which survey participants are asked to sort statements, and the opposing scale that forces trade-offs (in this case between most unlikely and most likely to provide multi-species benefits)

Q Method is efficient, inexpensive, and can be used to assess a diverse range of activities, many of which cannot be represented as rule sets in life cycle or other decision analytic models. A particularly valuable feature of the approach is that it permits multiple individual respondents to contribute to more than one viewpoint regardless of their professional affiliation. This characteristic makes Q Method helpful in breaking down barriers to collaborative decision-making that can often be caused by perceived organizational stereotypes during face-to-face meetings (Tompkins et al. 2018, Peterson et al. 2019, McDonnel 2019, O’Leary and Bingham 2003).

By directly confronting the challenging problem of participant subjectivity (Zabala et al. 2018), Q Method is aligned with collaborative styles of decision-making that hinge on interests-based dialogue, conflict resolution, and consensus (Carr et al. 1998, Selin et al. 2000, Leach et al. 2002, Susskind et al. 2003, Beierle and Cayford 2002). Considered by some to be “the best-developed paradigm for the investigation of human subjectivity” (Dryzek and Holmes 2002), the approach is more related to interests-based techniques that focus on discovery of common ground without making *a priori* assumptions about preferences. Usefully, it can also identify areas of divergence.

Q Method accomplishes these things without sacrificing scientific rigor because it leverages existing evidence-based conservation activities to develop the actual content of the survey.

The smaller set of statements participants are asked to sort during the survey collectively represent the distillation of ideas contained in the original longlist of conservation activities. As such, survey results can be used to develop criteria-based scores that are then mapped back to each candidate activity for priority ranking (Figure **2**). Below, we describe in more detail the five main steps involved in designing and implementing the Q Method approach we used.

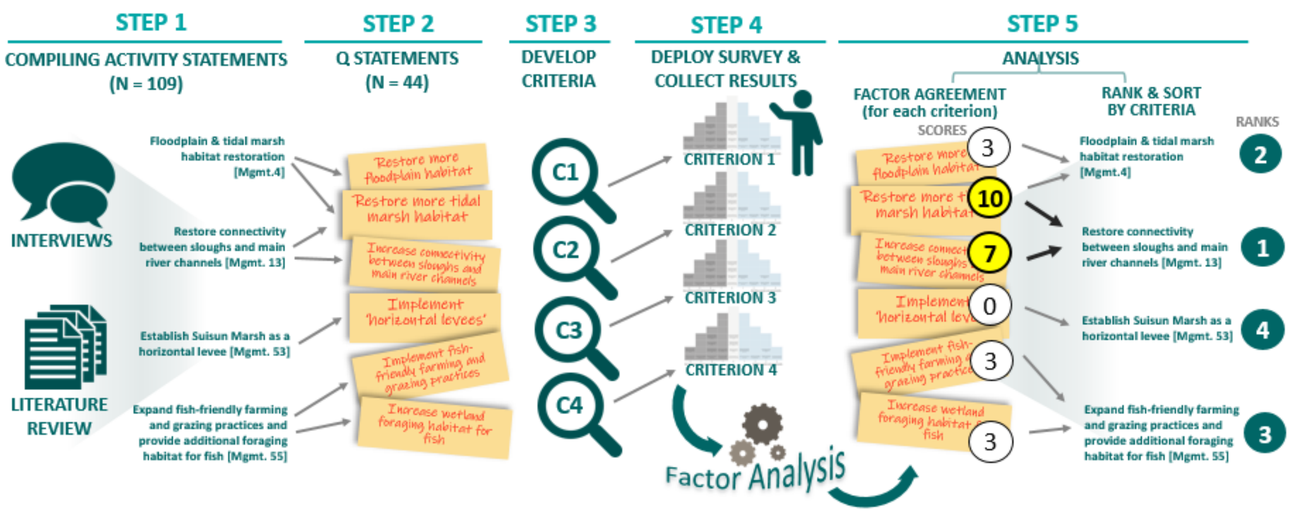


Figure 2. A schematic summarizing the key steps for using the Q Method as a prioritization technique for natural resource management activities, where the numbered steps correspond to those described further along in this section. The central element is a web-based Q Survey where statements are sorted across a structured pyramid-shaped grid that forces participants to make trade-offs when ranking the relative benefits of different activities across a bidirectional scale (see Zabala et al. 2018 for a more detailed yet accessible review).

Step 1: Assembling and Refining the Set of Key Activities to Be Prioritized

A formal systematic review of all evidence related to salmonid conservation in the Delta was not within the scope of this study. Instead, to rapidly assemble a set of candidate salmonid science, management, and monitoring activities we developed an **evidence-base** using **scoping interviews** with key salmonid scientists and managers working in the Delta region, and in-depth **literature review** of key references. Interview participants included 34 individuals from over 15 organizations which were selected by the CAMT Salmonid Sub-Committee (see Table A1 in Appendix A). We asked these participants for their perspectives on: a) key uncertainties in salmonid management, b) priority science, management, and monitoring actions, c) their vision for the future state of salmonid science in the Delta, and d) recommendations for key literature to consult. To constrain the literature review to the most relevant documents, the CAMT Salmonid Sub-Committee further identified and triaged key literature to arrive at a final set of over 40 foundational references that included prior management plans and strategies, agency science and research reports, and peer-reviewed literature (see Appendix B).

We reviewed this key literature for recommended science, management, and monitoring activities related to salmonid conservation, which we then extracted into a tracking spreadsheet with relevant metadata (e.g., target species, focal stressors, key locations). We then cross-referenced the initial list of candidate activities against interview responses to document overlaps and identify additional activities mentioned by interview participants that should be added to the list. This list was reviewed and further refined through an iterative review process by a group of **CSSP refiners,** a subset of members from the Salmonid Sub-Committee approved by the Salmonid Scoping Team and selected to broadly represent different participating groups, and to provide more direct oversight to the prioritization process on behalf of the broader Sub-Committee. The full review process resulted in a final list of **Candidate Activity Statements (N = 109)**, which were further classified into science (N = 25), management (N = 56), or monitoring (N = 28) activity types.

It is important to emphasize that these **Activity Statements were based on *pre-existing and scientific understanding of salmonid science, management, and monitoring priorities*** identified in the *selected* source material as necessary for supporting the conservation of Delta salmonids. The scientific foundation underlying each statement may vary in terms of its conclusiveness, and the degree to which the supporting evidence is conclusive (i.e., weight of evidence) was not a prioritization criterion explored in this study. Also, survey respondents were not expected to have *complete scientific knowledge*, they were selected for their expertise in the science and/or management of Delta salmonids and were encouraged to respond based on considerations they felt were important given their individual experience in the Delta. The ability of respondents to state preferences based on a wide range of considerations is a key strength of the Q Method approach (Zabala et al. 2018). Over-reliance on scientific conclusiveness can obscure the subjective nature of environmental decision-making and contribute to disagreement and decision paralysis across disenfranchised interest groups, duelling models, or competing research teams. Nevertheless, understanding the weight of evidence behind candidate science, monitoring and management activities should be an additional layer of screening applied during subsequent planning phases.

Step 2: Developing Evaluation Prioritization Criteria to Set Q Survey Context

Evaluation criteria were developed in collaboration with the Salmonid Sub-Committee and CSSP refiners to reflect their collective perspective on the most important factors driving decisions about which science, management, and monitoring activities to pursue in the Delta. These criteria are:

- **Criterion 1 – Magnitude of Benefits:** Refers to the potential for proposed science, monitoring, and management actions to contribute to the recovery of salmonids at the population level or to help identify actions most likely to contribute to detectable levels of population recovery.
- **Criterion 2 – Learning Benefits:** Refers to the potential for proposed science, monitoring, and management actions to accelerate learning about key cause-effect mechanisms influencing salmonid survival, behaviour, and diversity throughout the Delta system. This criterion is directly related to evaluating how well activities can address key uncertainties related to these mechanisms in the Delta. However, the survey does not explicitly link activities to the uncertainties they would help to address, a topic that should be explored in future work.
- **Criterion 3 – Multi-Species Benefits:** Refers to the potential for proposed science, monitoring, and management actions to generate multi-species benefits and conversely, will pose a low chance of unintended negative consequences or trade-offs to priority salmonids other than those that are the primary target of the activity described.
- **Criterion 4 – Implementability:** Refers to the extent to which a project is considered easy to implement (i.e., are there hurdles to implementation based on regulatory/permitting complexity, on-the-ground logistical challenges, good models or precedent, potential litigation, need for willing cooperation of private property owners, cost, political will, etc.).

Although all activities were ranked across all four criteria, our data analysis also examined some types of activities against subsets of these criteria as described further in Step 6. As noted at the beginning of this chapter, decision-makers may wish to consider other criteria during subsequent planning phases (e.g., scientific conclusiveness/contestation).

Step 3: Translating Activities into "Q-Statements" and Building Q Surveys

Ranking and sorting the 100+ candidate activities arising from Step 1 would quickly overwhelm most survey takers. Q Method involves a data reduction step where longlists are refined into more manageable representative shortlists. Applying best practice discourse analytic techniques from the social sciences (Brown 1980; Titscher et al. 2000), we translated the full set of candidate activities into a much smaller set of **representative** statements. This process involved:

(1) *conversion* of each detailed description of candidate activities into short **Activity Statements**,

(2) *coding* those statements under a set of broad categories (e.g., predation), and

(3) *consolidating* the Activity Statements in each category into a shorter, representative set of **Q statements** for that category that capture the common themes emerging across each category (e.g., by condensing 5 activity statements related to predation into one Q statement).

In our case, translation of the full list of 109 Activity Statements resulted in a final set of 44 Q statements (the "Q set"). The initial set of Activity Statements and Q statements were subject to multiple rounds of review by the Salmonid Sub-committee's team of refiners to ensure that translations maintained the intent of the original statement and would be meaningful to the broader audience of practitioners who would be invited to participate in the survey. Once Q statements were carefully finalized, one Q Survey was developed for each of the 4 major criteria above that asked participants to rank the Q Statements within the specific context defined by each criterion (e.g., by ranking from most likely to most unlikely to provide learning benefits, multi-species benefits, etc.). These **draft Q surveys were first pilot tested** by refiners to better understand the methodology and ensure the instructions were clear. Feedback from pilot testing led to further refinements of both Q Statements and the Q surveys before the surveys were cleared for full deployment.

Step 4: Deploying Full Q Survey

The final Q survey was **distributed to 61 key and representative scientists, managers, and other experts** identified by the Salmonid Sub-committee as playing an important role in the future of Delta salmonids (Appendix C). All participants received links to the four surveys (one for each criterion) by email along with a preliminary set of instructions. The surveys were built and deployed using a proprietary software called Q Method Software, which we selected after a review of alternative platforms. The survey was **open for three weeks and received 50 responses** from across all affiliation groups for an overall response rate of 82% (see Appendix C). This high response rate permits us to draw relatively strong inferences about the representativeness (among participating groups) of different viewpoints that emerged from the survey data.

When responding to each of the four surveys, participants were presented with a consent form, fields to enter names, affiliations, and general roles (i.e., science, management, or a mix of both), the context for the survey, and a link to a participant guide called How to Do a Q-sort. Participants were then asked to pre-sort all Q statements into three stacks as an initial priming exercise, where each stack represented a **neutral** response, **most unlikely**, or **most likely** to meet the criterion. Next, participants sorted these stacked statements into a pyramid shaped grid like the one shown in Figure 1. The grids' scales ranged from -4 to +4, where -4 represented most unlikely to meet the criterion, 0 represented a neutral response, and +4 represented most likely to meet the criterion.

Since each bin along the scale had a limited number of slots, participants were forced to make tough decisions about placement, which is intentional. For example, if a participant placed a statement in the -1 bin (i.e., the "unlikely" part of the grid), they may actually feel that statement is likely to meet the criterion but less so relative to all the other statements that are filling up the neutral and "likely" parts of the grid. It is this relative comparison forced by Q Method that provides a more accurate picture than can be accomplished using standard questionnaires of how, given a particular criterion, people *actually* prioritize things. After completing the Q sort, participants finished the survey by submitting their responses.

Step 5: Analyzing Results

Once the Q survey closed, we statistically analyzed all responses to detect different viewpoints, and then used results to develop two **agreement-based metrics** for multi-criteria prioritization. The central analytic step in Q Method is the application of factor analysis **to identify prominent groups of survey responses ("factors") that represent distinct aggregate viewpoints in the data** (Brown 1980, Zabala et al. 2018). In this case, "viewpoints" represent the extent to which participants associated with each viewpoint felt candidate conservation activities are likely or unlikely to meet one of the four criteria. The number of viewpoints detected depends on the extent to which individual survey responses are similar or different. If each survey response were entirely unique compared to all other responses, there would be as many viewpoints as responses. Generally, between 2 and 5 viewpoints are detected.

Many Q Method studies stop at identifying and then characterizing different viewpoints (e.g., Mattson et al. 2011, Chamberlain et al. 2012, Buckwell et al. 2020). These outputs can be useful for informing management alternatives, policy appraisal, and conflict resolution (Zabala et al. 2018). However, Q survey results also make it possible to *quantify* where general agreement exists and where there is wide divergence of opinion. We leveraged this characteristic to develop the two agreement-based metrics described below (1, 2), and a shortlist selection method using these metrics (3):

(1) Metric: Level of Agreement across Aggregate Viewpoints

For each survey, we assigned a score to all Q statements based on the extent and type of agreement across viewpoints. When factor analysis is applied, each viewpoint is associated with a complete set of Q statement ratings that represent the central tendency of the ratings from all respondents associated with that viewpoint (Figure 3). We input these representative ratings to a decision tree to assign final agreement scores. A score of 0 indicates general **across-viewpoint agreement** the statement would fail to meet the criterion (e.g., unlikely to provide multi-species benefits), 3 indicates unclear agreement one way or the other (e.g. due to diverging or neutral representative scores across viewpoints), 7 indicates general agreement the statement would somewhat meet the criterion, and 10 indicates general agreement the statement would strongly meet the criterion.

1 Survey (i.e. 1 Criterion)

	View 1	View 2	View 3	Final Score
Stmt 1	-3	-4	-3	0
Stmt 2	-3	0	+4	3
Stmt 3	+1	+1	+2	7
Stmt 4	+3	+4	+4	10

Figure 3. An illustration of how each Q statement is assigned a final agreement score based on the extent and type of agreement across viewpoints.

(2) Metric: Level of Agreement across Individual Participant Responses by Affiliation Group

To explore the influence of participant group membership on responses, we applied an "area under the curve" approach (Figure 4**Error! Reference source not found.**) to obtain an **across-group agreement** metric based on the overlap in the distribution of responses across the -4 to +4 survey scale for each Q statement between all pairwise combinations of group affiliations (i.e., Federal Agency, State Agency, PWA, NGO, or Unaffiliated / Other Experts). For each Q statement, we evaluated each group's general level of agreement with all other affiliation groups (using the average of all pairwise percent-overlap values per Pastore 2018, Pastore and Calcagnì 2019), and the overall level of agreement across all groups (using the average across all five groups of the preceding agreement scores).

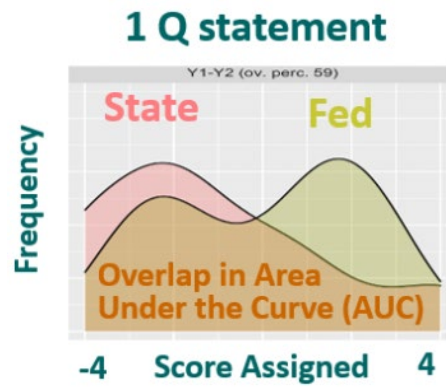


Figure 4. A schematic showing how the across-group agreement metric is calculated from the % overlap in the area under the curve (AUC) between the survey response distributions from participants in two different affiliation groups.

(3) Shortlisting: Ranked Lists of Activities Across Planning Themes

A critical element of the multi-step approach described throughout this chapter is that survey results for one or more Q statements are mapped to one or more Activity Statements (see Figure **2**). **Activity Statements are the primary unit of analysis – they are the list of conservation activities that are to be prioritized.** After assigning single criteria scores to each Activity Statement by mapping **across viewpoint-agreement** scores from Q statements to Activity Statements[1], we can examine results by individual criteria scores or sum these scores to get an All-Criteria Score using the results from three of the four surveys – learning benefits, multi-species benefits, magnitude of benefits. Participants decided that implementability should be considered separately as metadata, and not included in All-Criteria scoring because some of the hardest to implement activities can provide the greatest overall benefits.

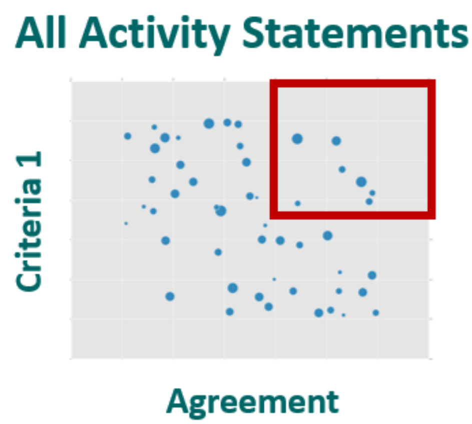


Figure 5. A schematic showing method of obtaining shortlists for each theme using a diagnostic plot. All Activity Statements are plotted against two axes representing the results for the two primary variables of interest for that theme, and then a bounding box is manually drawn around the cluster of Activities that best fit the conditions of the theme and align with natural breaks in the data.

Activities may then be sorted and filtered in different ways based on both criteria scores and / or **across-group agreement** scores to explore different themes in the data. To assist in moving toward candidate activity shortlists, we use visual analyses of diagnostic plots to identify natural

[1] The relationships between Q statements and Activity Statements is many-to-many, so multiple Q statements can be mapped to a single Activity Statement and vice versa. This mapping was completed with CSSP refiners and was done to ensure all the sentiments

breaks in the data (Figure 5). The more specific sorting and filtering rules used for each theme are described in greater detail in the next section.

Supplementary Material – Factor Analysis

As part of the supplementary Excel data file included with this report, we have provided a worksheet containing the results of factor analysis for each Q survey (tab 19_FactorResults). These results show how many factors, or viewpoints, were detected in the survey data, which Q statements distinguished each factor from the others, and consensus Q statements where there was general agreement the statement either meets or does not meet the criterion (e.g., **likely** to provide multi-species benefits or **unlikely** to provide multi-species benefits). In addition, we report the proportion of respondents from each group affiliation and primary role that were significantly correlated with each factor ($p<0.01$) and flag Q Statements that are identified in Section 3.2.4 as having apparent outliers for one or more affiliation groups. Any shortlisted Q statements (under Theme 3, Section 3.2.4) associated with each factor are also identified. The metadata (tab 1_Metadata) for tab 19_FactorResults contains information about how we defined 'distinguishing statements' and 'consensus statements' as well as the total number of participants in each affiliation group/primary role for ease of reference. Also available in the Excel file are a Q statement dictionary with IDs (tab 2_Qst_Dictionary), and a sheet showing linkages between Q statements and Activity Statements (tab 3_Qst_ActivitySt_Index).

3.2 Results

Rather than presenting the results of this survey approach as a single ranked list, this section of the report presents the results of our survey approach as viewed through the lenses of **three different planning themes** proposed by members of the Salmonid Sub-Committee (including refiners) as well as representatives of parallel planning processes (See Section 3.3). These themes allow us to explore areas of agreement and disagreement among organizations working together towards salmon resilience in the Delta to help identify opportunities for greater coordination and collaboration. These themes are:

- **Theme 1: Beneficial Activities with the Most Agreement about Benefits**
- **Theme 2: Beneficial Activities with Low Barriers to Implementation**
- **Theme 3: Beneficial Activities with the Least Agreement about Benefits**

Taking this thematic approach allows our reporting to more accurately reflect the diversity of objectives, positions, and considerations that feed into natural resource decision making in the Delta and provides more latitude for pursuing alternative planning strategies, whether in sequence or in parallel. For each of these themes, this section provides rationale for interest in that theme, details on the sorting and filtering rules applied to activity statements to generate shortlists for that theme, the shortlists themselves, and a preliminary interpretation of outcomes.

By reflecting the views of the diverse and experienced salmonid science and management practitioners who participated in our survey, these shortlists reflect a snapshot of current thinking

contained in each Activity Statement were appropriately captured by one or more Q statements, and to ensure that the same Q statements are repeated across multiple Activity Statements as appropriate. Not all statements had many-to-many linkages. In cases where multiple Q statements were assigned to a single Activity Statement, we calculated a combined score using the average of the Q statement **across-viewpoint agreement scores**.

around priority activities for salmonids in the Delta. However, it should be noted that the activities shortlisted through this process (and indeed the full starting list of proposed activities) may not address the full range of key management uncertainties identified in Section 2.2. Bearing this in mind, the results of this study should be considered as one of multiple lines of evidence informing decisions about activities to consider further for implementation.

The full list of proposed activities used to generate shortlists is provided as a **supplementary data file accompanying this report** for further consideration and analysis by interested parties.

3.2.1 Synthesis of Cross-Cutting Observations and Insights

Of the overall list of 109 previously proposed activities evaluated, 44 appear on at least one thematic shortlist. Roughly half of all activities are management oriented, while the remaining half are evenly split across science and monitoring activities.

Activities ranked under Theme 1 as having the **greatest perceived benefits for salmonids included many that are similar to past and existing efforts, including increasing connectivity, quality, and productivity of migratory and rearing habitats**. However, many of these activities were ranked as challenging to implement.

There is significant overlap in the shortlists of Themes 1 and 2, with six science activities appearing on both shortlists and ranked as having high benefit, high agreement, and high implementability. These activities may indicate opportunities for rapid gains through collaborative initiatives among organizations whose needs and views are in alignment. The overlapping activities are all related to **understanding salmonid distribution and migration via acoustic telemetry and particle tracking models** and include:

- Expanding and enhancing real-time movement monitoring using acoustic telemetry,
- Expanding and enhancing movement monitoring of juvenile salmonids at finer spatial scales (<2 km) using acoustic telemetry,
- Expanding and enhancing telemetry tracking of salmonids in the context of flow dynamics, particularly in areas directly affected by management actions, and
- Completing studies to directly inform enhanced particle tracking models that can help to predict salmonid responses to environmental and flow conditions.

Activities shortlisted under Theme 3 are more varied than other themes and represent **activities that may require building additional understanding and alignment before deciding how they can be effectively addressed or whether they are appropriate to implement**. These activities do not share direct overlap with those in any other theme, but do exhibit some other interesting patterns and relationships:

- **Activities related to predation monitoring and management featured heavily among the activities with least agreement on benefits**, regardless of perceived benefits, despite the fact that these activities are a focus of other prioritization initiatives. Moreover, when extending the search image for this theme, activities related to predation comprised an additional 5 of 7 activities ranked as having both low benefits and low agreement. This may relate to ongoing uncertainty about the value of predator management which may be improved by ongoing studies (see Section 3.3 for more details).

- The activity related to management of outside levee agricultural fields for increasing food production for export to fish habitats is notable in contrast to the focus on activities related to fish food production in Theme 1. This result may relate to **outstanding uncertainties about whether agricultural fields can produce food at the necessary scale and seasonal timing to produce significant benefits to salmonids.**
- **Activities related to better understanding the timing, location, and duration of juvenile habitat use in the Delta were also a topic of disagreement**, including use of restored habitats. This result may reflect the ongoing challenges in effectively measuring restoration success in terms of benefits to salmonids.
- Only one science activity appeared on this shortlist, suggesting that **there is relatively little disagreement about the benefits of salmonid science activities relative to management and monitoring activities**. Notably, this activity was related to the use of PIT tags for understanding habitat use, which may reflect the ongoing limitations of investment in this technology (see profile of PIT Tag Studies in Section 3.2.4; Rundio et al. 2017, Johnson et al. 2020).

The detailed results for each theme are unpacked in more detail in the following sections.

3.2.2 Theme 1: Beneficial Activities with the Most Agreement about Benefits

This theme focused on activities that were ranked as more beneficial across selected criteria with the greatest level of agreement across affiliation groups. This theme is meant to focus on activities that have the **highest potential for collaborative efforts**. However, many high-benefit actions were also ranked as among the hardest to implement, such that collaborations will likely take the form of coordinated, multi-year initiatives.

All Activities Combined

When considering all types of activities together, data was ranked by highest to lowest All Criteria Score (sum of Magnitude of Benefits, Learning Benefits, and Multi-Species Benefits) and then filtered for activities with the highest level of agreement based on natural breaks in the diagnostic plot. This approach resulted in a natural cluster of topmost criteria and agreement activities bounded roughly by an All Criteria Score > 17.5 and a level of Across-Group Agreement > 0.525, resulting in a shortlist of 12 Activities that fall into 4 areas. Notably, the all-activities shortlist includes a mix of science, management, and monitoring activities and is focused primarily on activities related to:

(1) Improving migratory and rearing **habitat connectivity** (Sci-30, Mgmt-71)

(2) Creating or enhancing **quality of and access to floodplain habitat** (Mgmt-15, 55, 72, 73, 74),

(3) Monitoring **prey availability and growth rates** for juvenile salmonids (Mon 2, 3), and

(4) Reducing the impacts of **invasive species and aquatic weeds** (Mgmt-56, 77).

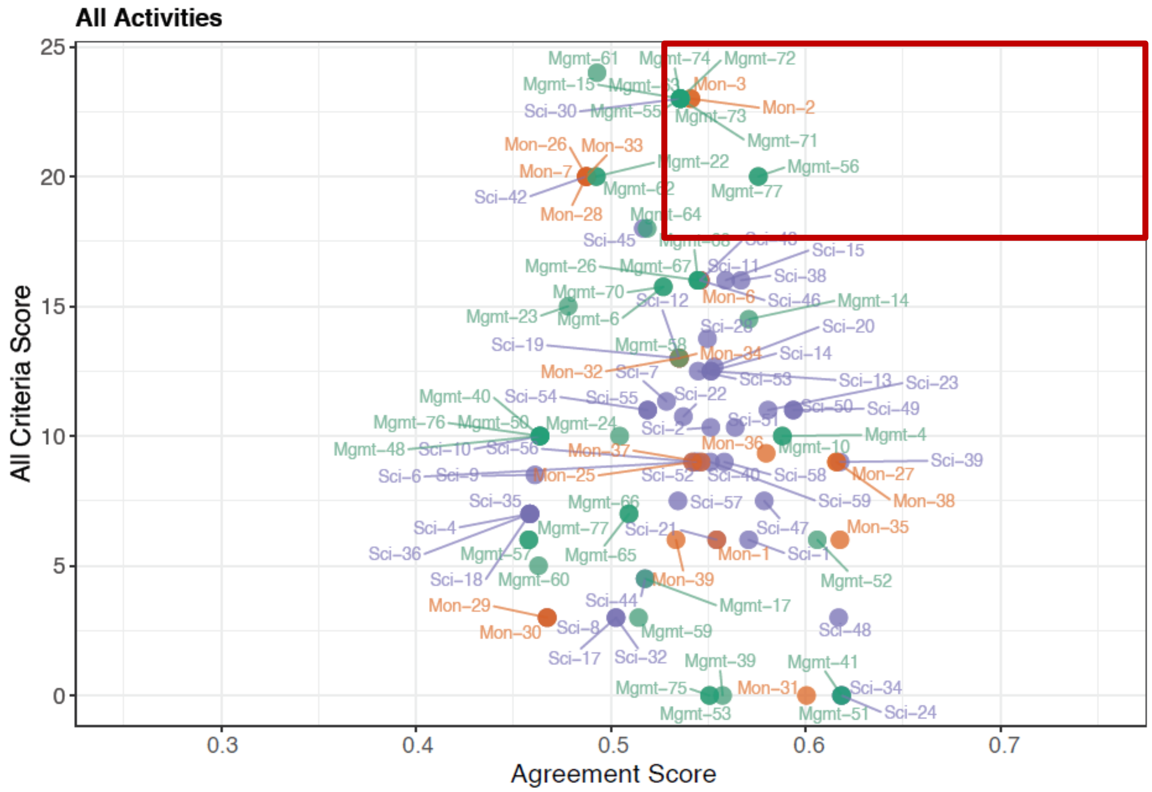


Figure 6: Theme 1 diagnostic plot of overall agreement scores and aggregate All Criteria scores for all activities combined, including a red box bounding the activities included in the shortlist for this theme. Activities are color-coded by activity type (purple = science, green = management, and orange = monitoring) and alphanumeric codes correspond to activity IDs listed in Table 3.

Table 3: All activities shortlist for Theme 1 based on highest All Criteria Score & highest Across-Group Agreement (these variables are bolded).

			Criteria Scores				Agreement Scores Across Affiliation Groups (N = 50 Survey Takers)						
Activity ID	**Activity Statement**	No. Q Statements	All Criteria Score	Learning Score	Magnitude Score	Multi-Species Score	Overall Average Agreement Across Affiliation Groups	Unaffiliated Expert Agreement	Federal Agreement	NGO Agreement	PWA Agreement	**State Agreement**	Implementability Score
Sci-30	Chinook/Steelhead (Chinook/Fall, Winter) -- Evaluate opportunities for and impact of restoring connectivity between sloughs, river channels, and tidal marshes for juvenile rearing, productivity, distribution of secondary production (aka fish food).	1 (q.037)	**23.00**	3.00	10.00	10.00	**0.54**	0.57	0.58	0.40	0.55	0.58	0.00
Mon-2	Chinook/Steelhead -- Monitor prey availability for juvenile salmonids across different habitats in the Delta.	1 (q.033)	23.00	10.00	10.00	3.00	0.54	0.56	0.59	0.43	0.54	0.58	3.00
Mon-3	Chinook/Steelhead -- Monitor juvenile salmonid growth across different habitat types in the Delta.	1 (q.033)	**23.00**	10.00	10.00	3.00	**0.54**	0.56	0.59	0.43	0.54	0.58	3.00
Mgmt-15	Chinook/Steelhead -- Restore floodplain habitat access and extent, specifically through modification of levees.	1 (q.037)	**23.00**	3.00	10.00	10.00	**0.54**	0.57	0.58	0.40	0.55	0.58	0.00
Mgmt-55	Chinook/Steelhead -- Expand management of agricultural fields along migratory corridors to provide seasonal rearing habitat for juvenile salmon	1 (q.037)	**23.00**	3.00	10.00	10.00	**0.54**	0.57	0.58	0.40	0.55	0.58	0.00
Mgmt-63	Chinook/Steelhead -- Use analytical tools such as life cycle models to develop SMART objectives for delta rearing habitat and migration conditions to support recovery of salmonid populations for current conditions and with a target of restored upstream habitat conditions.	1 (q.037)	**23.00**	3.00	10.00	10.00	**0.54**	0.57	0.58	0.40	0.55	0.58	0.00
Mgmt-71	Chinook/ steelhead: Enhance habitat quality for migration and rearing in channelized areas of the Delta	1 (q.037)	**23.00**	3.00	10.00	10.00	**0.54**	0.57	0.58	0.40	0.55	0.58	0.00
Mgmt-72	Chinook/ Steelhead - Create or improve floodplain habitat access through the installation of operable structures	1 (q.037)	**23.00**	3.00	10.00	10.00	**0.54**	0.57	0.58	0.40	0.55	0.58	0.00
Mgmt-73	Chinook/ Steelhead - Expand or improve floodplain habitat productivity through the installation of operable structures	1 (q.037)	**23.00**	3.00	10.00	10.00	**0.54**	0.57	0.58	0.40	0.55	0.58	0.00
Mgmt-74	Chinook/ Steelhead - Re-operate existing infrastructure to increase productivity of inundated lands and / or export primary and secondary production to main channel ("Fish Food" production)	1 (q.037)	**23.00**	3.00	10.00	10.00	**0.54**	0.57	0.58	0.40	0.55	0.58	0.00
Mgmt-56	Chinook/Steelhead -- Implement measures that reduce impacts of invasive species and prevent introduction of new invasive (such as zebra and quagga mussels) to maintain structure of food web and retain prey for juvenile salmonids.	1 (q.002)	**20.00**	3.00	10.00	7.00	**0.58**	0.58	0.65	0.51	0.52	0.62	0.00
Mgmt-77	Chinook/Steelhead -- Reduce aquatic weeds in shallow areas of the Delta to improve rearing habitat for juvenile salmonids and help to minimize predation losses.	1 (q.002)	**20.00**	3.00	10.00	7.00	**0.58**	0.58	0.65	0.51	0.52	0.62	0.00

Science Activities

When considering only Science activities, Salmonid Sub-committee refiners specified the use of the Learning Benefit Criteria Score only for ranking data, followed by filtering for activities with the highest level of agreement based on natural breaks in the diagnostic plot. This approach resulted in a natural cluster of topmost criteria and agreement activities is bounded roughly by a Learning Benefit Criteria Score > 5.33 and a level of Across-Group Agreement > 0.55, resulting in a shortlist of 6 Activities.

These science activities are focused entirely on improving the study (via acoustic telemetry tagging studies) and modelling (via particle tracking models) of **migration behaviour** in response to both environmental cues and water infrastructure operations for Chinook and steelhead.

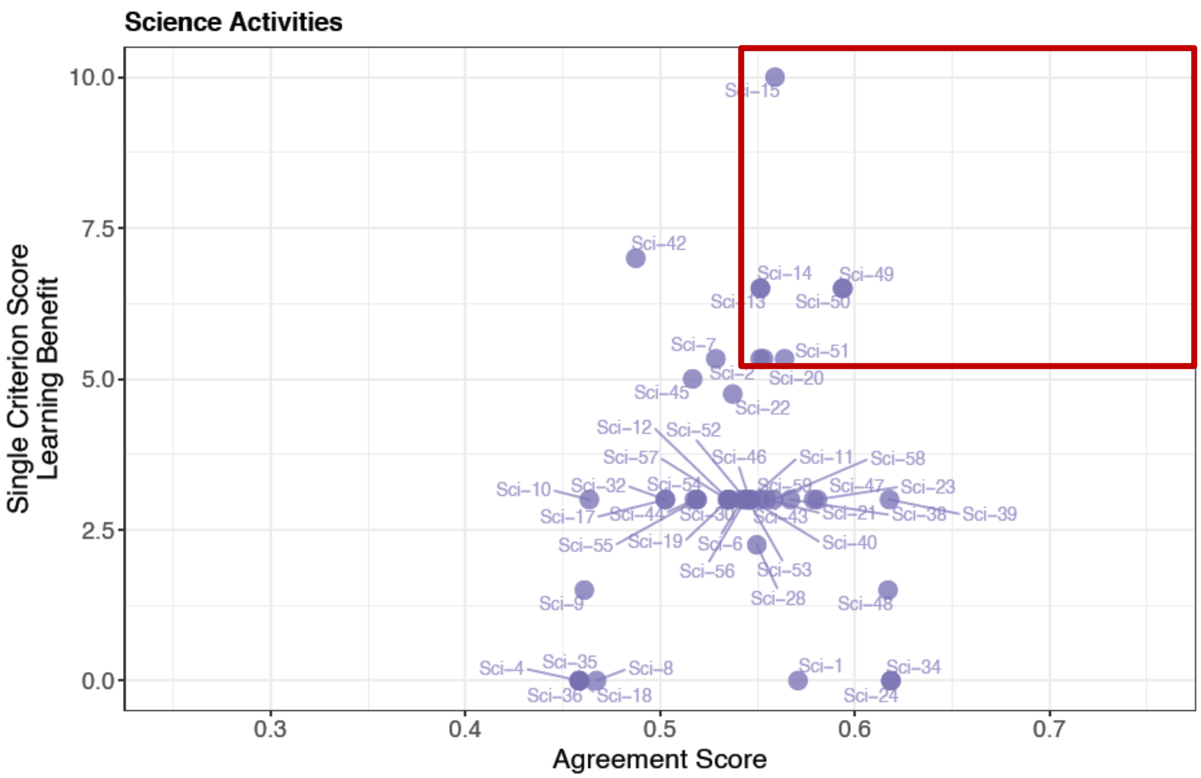


Figure 7: Theme 1 diagnostic plot of overall agreement scores and aggregate All Criteria score for monitoring activities, including a red box bounding the activities included in the shortlist for this theme. Alphanumeric codes correspond to activity IDs listed in Table 4**.**

Table 4: Theme 1 Science Activities Shortlist – High Learning Benefits Score & High Agreement (columns in bold are ones used for generating shortlist). This table includes combined action statements that were identical other than their target species or suggested focal locations.

			Criteria Scores				Agreement Scores Across Affiliation Groups (N = 50 Survey Takers)						
Activity ID	**Activity Statement**	No. Q Statements	All Criteria Score	**Learning Score**	Magnitude Score	Multi-Species Score	**Overall Average Agreement Across Affiliation Groups**	Unaffiliated Expert Agreement	Federal Agreement	NGO Agreement	PWA Agreement	**State Agreement**	Implementability Score
Sci-15	Chinook/Steelhead -- Expand and enhance real-time outmigration survival, behavior, and movement research using acoustic telemetry.	1 (q.056a)	16.00	**10.00**	3.00	3.00	**0.56**	0.54	0.65	0.43	0.56	0.62	7.00
Sci-13/14	Steelhead -- Complete studies that directly inform development of enhanced particle tracking modeling for Steelhead (e.g. Delta rearing and migration behavior, response to barriers, response to habitat enhancements, and response to hydrodynamic changes caused by river inflows or water diversions).	2 (q.056a, 006)	12.50	**6.50**	3.00	3.00	**0.55**	0.55	0.63	0.43	0.53	0.61	5.00
Sci-49 / 50	Chinook / Steelhead - Conduct acoustic tagging studies to identify drivers of rearing and migration behavior of juvenile salmonids at finer spatial scales (<2 km).	2 (q.056ab)	11.00	**6.50**	1.50	3.00	**0.59**	0.60	0.66	0.49	0.58	0.63	5.00
Sci-51	Chinook/steelhead - Conduct acoustic tagging studies in tidal regions of the Delta to assess effects of export-altered hydrodynamics on migration and behavior of juvenile salmonids.	3 (q.056ab, 057)	10.33	**5.33**	2.00	3.00	**0.56**	0.57	0.62	0.47	0.54	0.61	4.33
Sci-2	Chinook/Steelhead -- Couple high resolution acoustic telemetry studies with high resolution hydrodynamic modeling at areas of the Delta directly affected by management actions.	3 (q.006, 012, 056a)	10.33	**5.33**	2.00	3.00	**0.55**	0.55	0.62	0.46	0.53	0.59	4.33
Sci-20	Conduct acoustic tagging studies to assess effects of gates, barriers and diversions on survival and behavior of juvenile salmonids.	3 (q.008, 053, 056a)	12.67	**5.33**	4.33	3.00	**0.55**	0.54	0.61	0.48	0.53	0.60	3.33

Management Activities

When considering only Management activities, Salmonid Sub-committee refiners specified the use of a Two-Criteria Score (the sum of Magnitude of Benefit and Multi-Species Benefit) for ranking data, followed by filtering for activities with the highest level of agreement based on natural breaks in the diagnostic plot. This approach resulted in a natural cluster of topmost criteria and agreement activities is bounded roughly by a Two-Criteria Score > 15 and a level of Across-Group Agreement > 0.525, resulting in a shortlist of 13 Activities.

This management activities shortlist has strong overlap with the all-activities shortlist for Theme 1. The primary themes in this shortlist include:

(1) **restoring or enhancing salmonid rearing and migration habitat** through channel modification and the use of operable structures (Mgmt-15, 55, 63, 64, 71 - 74), and

(2) **reducing the impacts of invasive species and weeds** which can contribute to increased salmonid survival through habitat alteration, competition, or predation (Mgmt-56, 77).

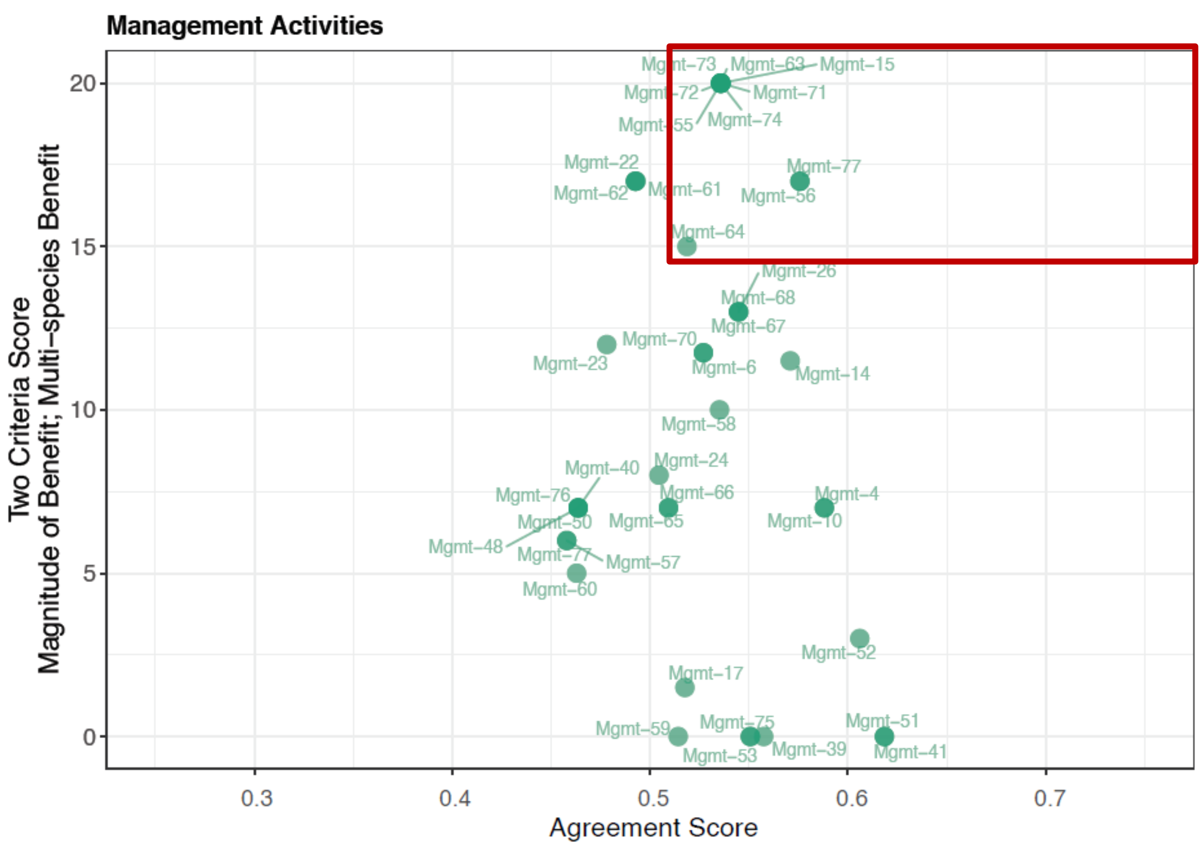


Figure 8: Theme 1 diagnostic plot of overall agreement scores and the Two-Criteria Score (Magnitude of Benefit + Learning Benefit) score for management activities, including a red box bounding the activities included in the shortlist for this theme. Alphanumeric codes correspond to activity IDs listed in Table 5.

Table 5: Theme 1 Management Activities Shortlist – High Two-Criteria Score & High Agreement (columns in bold are ones used for generating shortlist)

			Criteria Scores				Agreement Scores Across Affiliation Groups (N = 50 Survey Takers)						
Activity ID	**Activity Statement**	No. Q Statements	Two Criteria Score	Learning Score	Magnitude Score	Multi-Species Score	Overall Average Agreement Across Affiliation Groups	Unaffiliated Expert Agreement	Federal Agreement	NGO Agreement	PWA Agreement	**State Agreement**	Implementability Score
Mgmt-15	Chinook/Steelhead -- Restore floodplain habitat access and extent, specifically through modification of levees.	1 (q.037)	**20.00**	3.00	10.00	10.00	**0.54**	0.57	0.58	0.40	0.55	0.58	0.00
Mgmt-55	Chinook/Steelhead -- Expand management of agricultural fields along migratory corridors to provide seasonal rearing habitat for juvenile salmon.	1 (q.037)	**20.00**	3.00	10.00	10.00	**0.54**	0.57	0.58	0.40	0.55	0.58	0.00
Mgmt-63	Chinook/Steelhead -- Use analytical tools such as life cycle models to develop SMART objectives for delta rearing habitat and migration conditions to support recovery of salmonid populations for current conditions and with a target of restored upstream habitat conditions.	1 (q.037)	**20.00**	3.00	10.00	10.00	**0.54**	0.57	0.58	0.40	0.55	0.58	0.00
Mgmt-71	Chinook/ steelhead: Enhance habitat quality for migration and rearing in channelized areas of the Delta.	1 (q.037)	**20.00**	3.00	10.00	10.00	**0.54**	0.57	0.58	0.40	0.55	0.58	0.00
Mgmt-72	Chinook/ Steelhead - Create or improve floodplain habitat access through the installation of operable structures.	1 (q.037)	**20.00**	3.00	10.00	10.00	**0.54**	0.57	0.58	0.40	0.55	0.58	0.00
Mgmt-73	Chinook/ Steelhead - Expand or improve floodplain habitat productivity through the installation of operable structures.	1 (q.037)	**20.00**	3.00	10.00	10.00	**0.54**	0.57	0.58	0.40	0.55	0.58	0.00
Mgmt-74	Chinook/ Steelhead - Re-operate existing infrastructure to increase productivity of inundated lands and/ or export primary and secondary production to main channel ("Fish Food" production).	1 (q.037)	**20.00**	3.00	10.00	10.00	**0.54**	0.57	0.58	0.40	0.55	0.58	0.00
Mgmt-56	Chinook/Steelhead -- Implement measures that reduce impacts of invasive species and prevent introduction of new invasives (such as zebra and quagga mussels) to maintain structure of food web and retain prey for juvenile salmonids.	1 (q.002)	**17.00**	3.00	10.00	7.00	**0.58**	0.58	0.65	0.51	0.52	0.62	0.00
Mgmt-77	Chinook/Steelhead -- Reduce aquatic weeds in shallow areas of the Delta to improve rearing habitat for juvenile salmonids and help to minimize predation losses.	1 (q.002)	**17.00**	3.00	10.00	7.00	**0.58**	0.58	0.65	0.51	0.52	0.62	0.00
Mgmt-64	Close the Delta Cross Channel gates in the early fall to minimize attraction of Mokelumne River adult salmon into the American River.	1 (q.058, 024)	**15.00**	3.00	10.00	5.00	**0.52**	0.50	0.57	0.44	0.51	0.57	3.00

Monitoring Activities

When considering only monitoring activities, Salmonid Sub-committee refiners specified the use of the All Criteria Score (the sum of Magnitude of Benefits, Learning Benefits, and Multi-Species Benefits) for ranking data, followed by filtering for activities with the highest level of agreement based on natural breaks in the diagnostic plot. This approach resulted in a natural cluster of topmost criteria and agreement activities is bounded roughly by an All Criteria Score > 12.5 and a level of Across-Group Agreement > 0.525, resulting in a shortlist of 5 Activities.

This monitoring activities shortlist is focused on activities related to:

(1) monitoring the effects of **food availability on growth rates** and other vital rates of juvenile salmonids (Mon-2, 3, 32), including strong overlap of these activities with the all-activities shortlist for Theme 1,

(2) adding **genetic run identification** into monitoring of juvenile salmonids (Mon-34), and

(3) tracking the **effects of water operations on the extent of inundated habitat** under a range of flow conditions (Mon-6).

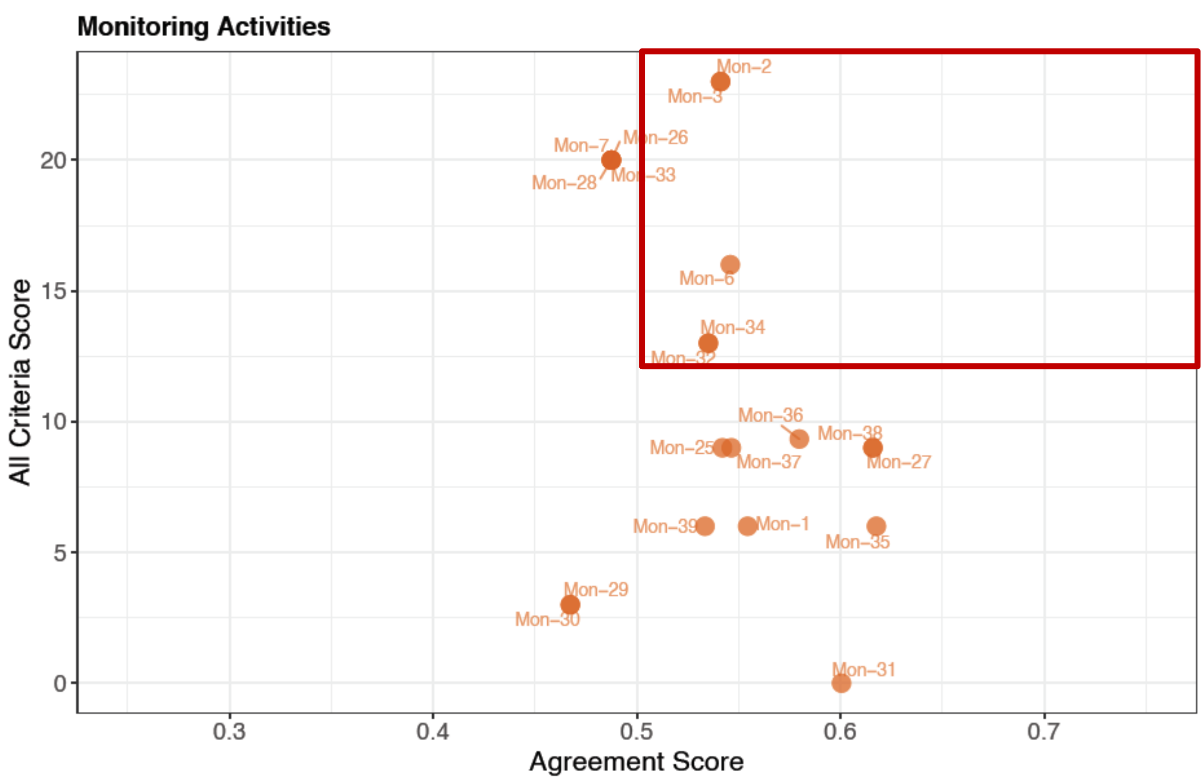


Figure 9: Theme 1 diagnostic plot of overall agreement scores and aggregate All Criteria scores for monitoring activities combined, including a red box bounding the activities included in the shortlist for this theme. Alphanumeric codes correspond to activity IDs listed in Table 6.

Table 6: Theme 1 Monitoring Activities Shortlist – High All-Criteria Score & High Agreement (columns in bold are ones used for generating shortlist)

			Criteria Scores				Agreement Scores Across Affiliation Groups (N = 50 Survey Takers)						
Activity ID	**Activity Statement**	No. Q Statements	All Criteria Score	Learning Score	Magnitude Score	Multi-Species Score	Overall Average Agreement Across Affiliation Groups	Unaffiliated Expert Agreement	Federal Agreement	NGO Agreement	PWA Agreement	**State Agreement**	Implementability Score
Mon-2	Chinook/Steelhead -- Monitor prey availability for juvenile salmonids across different habitats in the Delta	1 (q.033)	**23.00**	10.00	10.00	3.00	**0.54**	0.56	0.59	0.43	0.54	0.58	3.00
Mon-3	Chinook/Steelhead -- Monitor juvenile salmonid growth across different habitat types in the Delta	1 (q.033)	**23.00**	10.00	10.00	3.00	**0.54**	0.56	0.59	0.43	0.54	0.58	3.00
Mon-6	Chinook/Steelhead -- Analyze the effect of water project operations on spatial and temporal extent of inundated habitat under a range of historic inflow/ export conditions and water year types	1 (q.008)	**16.00**	3.00	10.00	3.00	**0.55**	0.60	0.58	0.51	0.43	0.61	0.00
Mon-32	Chinook/Steelhead -- Monitor vital rates (e.g. growth, stress/disease indicators, lipid content, etc.) of juvenile salmonids rearing and migrating in the Delta.	1 (q.061)	**13.00**	3.00	7.00	3.00	**0.54**	0.51	0.57	0.52	0.50	0.57	3.00
Mon-34	Chinook/all -- Incorporate genetic run identification into monitoring activities of juvenile salmonids entering and exiting the Delta	1 (q.061)	**13.00**	3.00	7.00	3.00	**0.54**	0.51	0.57	0.52	0.50	0.57	3.00

Spotlight on Theme 1: Representative Examples of Shortlisted Activities

These spotlight examples provide additional context for a representative selection of shortlisted activities for this theme, corresponding to the activity codes in the preceding tables (e.g., Sci-13), to illustrate the details and diversity of activities included. However, ***these spotlight examples are <u>not</u> intended to imply any additional emphasis or prioritization on these activities***.

Sci-13/14 – Enhanced Particle Tracking Modeling

Description: ***Complete studies that directly inform development of enhanced particle tracking modeling for Chinook and Steelhead steelhead (e.g. Delta rearing and migration behavior, response to barriers, response to habitat enhancements, and response to hydrodynamic changes caused by river inflows or water diversions).*** Past particle tracking models were based on passive dispersal that were not fully representative of fish movement in the Delta. More recent efforts have focused on an agent-based model known as the enhanced particle tracking model (ePTM) that incorporates behavioral elements such as active swimming, daily migration, and selective tidal stream transport that are more representative of the way fish move in the Delta (Perry et al. 2016). This type of model relies on field tagging, tracking, and abundance monitoring data to set and validate the accuracy of behavioral parameters for different species and run types (NMFS 2015). Development of the enhanced particle tracking models for winter-run Chinook began in 2013 (NMFS 2015). Current models are based on Sacramento River studies, but more work is needed for Chinook in the San Joaquin River/South Delta (NMFS 2015) and for steelhead in all areas of the Delta.

Key Organizations: Led by NMFS SWFSC and BOR, with partners DWR, USGS, and Delta Operations for Salmonids and Sturgeon (see Section for 2.3 acronyms).

Key Species: Chinook (outmigrating smolt) / Steelhead (outmigrating smolt)

Stressors: Migration, route selection determine exposure to a wide range of stressors

Prioritization Results: Overall, these related activities are perceived to be an easily implemented, beneficial science endeavor. These activities ranked near the top of the science list for beneficial activities with the most agreement on benefits. They also appeared near the top of the all-activities shortlist for high agreement on low barriers to implementation. This activity is related to Mgmt-63, which is focused on modelling for generating recovery objectives, given that enhanced particle tracking modeling contributes to life-cycle models.

Key Regions: Full Delta, Sacramento River, San Joaquin River

Crossover with parallel processes: The effects of operating diversions are also a key information need for the CVPIA Structured Decision Making, so the studies conducted to inform development of the enhanced particle tracking modeling may also contribute to the Central Valley Project Improvement Act's (CVPIA) Restoration Strategy's work (upcoming CVPIA Adaptive Restoration Strategy). This work is also aligned with key activities of the Sacramento River Science Partnership (SRSP) Science Plan, namely the proposed work to examine the consequences of flow management on in-stream rearing habitat use, as well as the proposed examination of flow models in conjunction with bioenergetics models (Reed 2020).

Header Photo: Particle Tracking Figure, CALFED Science Program Independent Review Panel, 2009.

Mgmt-55/72/73 – Agricultural Floodplain Habitat

Description: ***Expanding management of agricultural fields along migratory corridors to provide seasonal rearing habitat for juvenile salmon and create or improve floodplain habitat access and productivity through installation of operable structures.*** Wildlife-friendly agricultural practices can help mitigate the loss of natural salmonid habitats as well as minimize the negative effects of agricultural water diversions on fish (SFEI-ASC 2016). Experiments in the Yolo Bypass over the last few years sought to investigate the benefits of increasing access for Juvenile Chinook salmon to agricultural floodplain habitat, particularly rice fields (Katz et al. 2013). This work has demonstrated a significantly greater availability of zooplankton prey resources translating into significantly higher growth rates among juvenile salmon rearing on flooded agricultural fields compared to the adjacent Sacramento River (see Katz et al. 2017, Holmes et al. 2020). Similar efforts are also underway to increase salmonid access to floodplain rearing habitat through the Yolo Bypass Salmonid Habitat Restoration and Fish Passage (YBSHRFP) Project (see next project spotlight) (USBR 2018b).

Key Organizations: Work in the Yolo Bypass and beyond has been led by CalTrout in partnership with NOAA, CDFW, DWR, MWD, and other organizations in addition to local landowners. Additional work in the Yolo Bypass is being led by BOR (see Section for 2.3 acronyms).

Key Species: Chinook (rearing) / Steelhead (rearing)

Stressors: Habitat, food availability, water quality

Prioritization Results: These activities ranked towards the middle of the all-activities shortlist for this theme, suggesting that expanding management of seasonal rearing and floodplain habitat is perceived as highly beneficial though not easily implemented. Given its focus on agricultural land, this activity is similar to Mgmt-61 as noted above, which is focused on increasing production of fish food for export to adjacent habitats, and Mgmt-62, which is related to reducing the impacts of small-scale agricultural diversions through timed withdrawals and off-channel storage.

Key Regions: Yolo Bypass

Crossover with parallel processes: Enhanced floodplain productivity resulting from this work is complements resiliency actions identified in the Delta Smelt SDM initiative, namely the North Delta Food Web (NDFW) Adaptive Management Projects that aim to augment flows in the Yolo Bypass (Compass 2018). As a result, this activity is expected to have some spinoff benefits for Delta Smelt, although the same cannot be said of reciprocal benefits for salmonids. The NDFW project occurs in the late summer/early fall when juvenile salmonids are not migrating and therefore not benefiting, while the NDFW pulse flows also have a negative effect on upstream migrating adults by causing them stray into the Yolo Bypass rather than pursue their migration upstream. This is a prime example of the trade-offs inherent in single-species conservation planning, where activities benefiting one species may have unintended effects on others.

The CVPIA Near-Term Restoration Strategy and the SRSP Science Plan both also identify juvenile floodplain habitat information needs (CVPIA Near-Term Restoration Strategy, Reed 2020). While not explicitly a science initiative, implementing this management activity may provide opportunity for further learning about juvenile salmonid floodplain habitat use.

Header Photo: Yolo Bypass by Steve Martarano | USFWS, 2017, licenced under CC by 2.0

Mon-3 – Juvenile Salmonid Growth

Description: ***Monitor juvenile salmonid growth across different habitat types in the Delta.*** Growth and other fish condition metrics are a critical component of understanding the effects of habitat on all life stages of salmonids (Johnson et al. 2017) and subsequently to assessing the impact of habitat restoration projects. The current lack of knowledge about the effects of habitat on fry and juvenile salmonid growth is considered a large data gap (SST 2017b). One key initiative that will help narrow this gap is the Yolo Bypass Salmonid Habitat Restoration and Fish Passage (YBSHRFP) Project, which will use rotary screw traps to monitor the growth rates of juvenile salmonids diverted into the Yolo Bypass through operation of diversions along the Fremont Weir to determine whether rearing salmonids exhibit differences in growth rates when rearing in this floodplain habitat (USBR 2018b). Another similar initiative is the Tidal Parr Cage Growth Study carried out to understand how juvenile salmon growth might differ in the brackish water habitats of Suisun Marsh (Harvey et al. 2019, DWR 2020). Other studies are using structural and chemical otolith analysis to reconstruct salmonid rearing strategies and growth patterns for individual fish, which is less subject to bias than traditional periodic sampling strategies that compare the body sizes of different fish cohorts over time (Perry et al. 2016). Otolith analysis was recently used to demonstrate broader juvenile salmonid use of non-natal rearing habitats in the Delta than previously believed and to show that these habitats provided equivalent growth opportunities as natal rearing habitats (Phillis et al. 2018). These types of insights can inform future habitat restoration strategies.

Key Organizations: The YBSHRFP Project is jointly planned by BOR and DWR (see Section for 2.3 acronyms).

Key Species: Chinook (rearing)/Steelhead (rearing)

Stressors: Rearing habitat

Prioritization Results: This activity was ranked as having a high consensus on its benefits for salmonids, but also ranked as among one of the harder activities to implement. This activity is somewhat related to several activities related to monitoring juvenile salmonid habitat use (Mon-7, 26, 28,and 33) which are shortlisted under Theme 3 as activities rated as having high benefit but relatively less agreement on benefits across organizations surveyed. This may reflect a greater interest in growth data related to habitat use as opposed to information only about juvenile salmonid presence, distribution, or abundance on unmodified and restored habitats.

Key Regions: Full Delta; some past experiments and proposed monitoring work in the Yolo Bypass.

Crossover with parallel processes: This activity is complementary to the SRSP Science Plan science activity that aims to examine how flows interact with existing and restored habitats to benefit juvenile salmonids (Reed 2020). This monitoring may also contribute to better understanding fry, parr, and juvenile salmonid habitat requirements, which is a key information need identified in the CVPIA SDM work (upcoming Near-Term Restoration Strategy).

3.2.3 Theme 2: Activities with High Agreement about Low Barriers to Implementation

This theme focused on activities that most affiliation groups agreed would be **easier to implement and might represent <u>quick wins</u> contributing to improvements in salmonid management and resilience** that could be implemented alongside the execution of more beneficial projects that would be more complex to implement. Within this theme, the variables used in ranking and sorting are identical across all activity types such that plots for the individual activity types are subsets of the All Activities plot, thus we present results here only once.

All Activities Combined

When considering all types of activities together, Salmonid Sub-committee refiners specified the use of the Implementability Criteria Score to rank activities, followed by filtering for activities with the highest level of agreement on the All-Criteria Score based on natural breaks in the diagnostic plot. This approach resulted in a natural cluster of topmost criteria and agreement activities is bounded roughly by an Implementability Criteria Score > 4 and a level of Across-Group Agreement > 0.525, resulting in a shortlist of 12 Activities. The resulting shortlist in Table 7 is comprised primarily of **science activities related to migration tracking**, but also include activities related to **understanding the effects of contaminants** and reducing **injury and mortality related to impingement or entrainment**. Notably, several activities (Sci-13-15, 49, 50) are all also on the Theme 1 shortlist (Table 2).

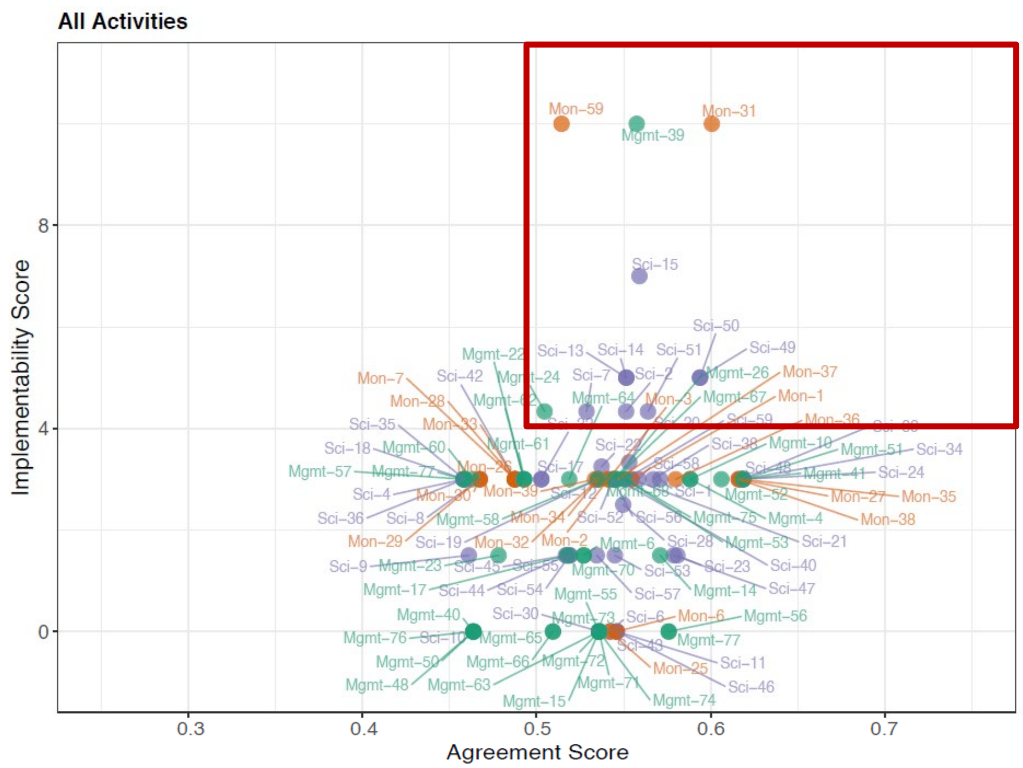


Figure 10: Theme 2 diagnostic plot of overall agreement scores and the Implementability Criteria Score for all types of activities combined, including a red box bounding the activities included in the shortlist for this theme. Alphanumeric codes correspond to activity IDs listed in Table 7.

Table 7: Theme 2 – All Activities Shortlist – High Implementability & High Agreement (columns in bold are ones used for generating shortlist). This table includes combined action statements that were identical other than their target species or suggested focal locations.

			Criteria Scores				Agreement Scores Across Affiliation Groups (N = 50 Survey Takers)						
Activity ID	**Activity Statement**	No. Q Statements	All Criteria Score	Learning Score	Magnitude Score	Multi-Species Score	Overall Average Agreement Across Affiliation Groups	Unaffiliated Expert Agreement	Federal Agreement	NGO Agreement	PWA Agreement	**State Agreement**	Implementability Score
Mon-31	Chinook/Steelhead -- Provide timely public access to monitoring data in open data formats	1 (q.001)	0.00	0.00	0.00	0.00	**0.60**	0.59	0.65	0.59	0.51	0.67	**10.00**
Mgmt-39	Chinook/Steelhead -- Maintain fish screens and related infrastructure at Delta diversions to reduce fish entrainment and impingement.	1 (q.028)	0.00	0.00	0.00	0.00	**0.56**	0.61	0.62	0.50	0.52	0.54	**10.00**
Mon-59	Chinook/Steelhead -- Increase the spatio-temporal coverage, synthesis, and analysis of contaminants monitoring in Delta waterways	1 (q.051)	3.00	3.00	0.00	0.00	**0.51**	0.47	0.53	0.49	0.55	0.54	**10.00**
Sci-15	Chinook/Steelhead -- Expand and enhance real-time outmigration survival, behavior, and movement research using acoustic telemetry.	1 (q.056)	16.00	10.00	3.00	3.00	**0.56**	0.54	0.65	0.43	0.56	0.62	**7.00**
Sci-13 / 14	Chinook /Steelhead -- Complete studies that directly inform development of enhanced particle tracking modeling for Chinook (e.g. Delta rearing and migration behavior, response to barriers, response to habitat enhancements, and response to hydrodynamic changes caused by river inflows or water diversions).	2 (q.056a, 006)	12.50	6.50	3.00	3.00	**0.55**	0.55	0.63	0.43	0.53	0.61	**5.00**
Sci-49 / 50	Chinook / Steelhead - Conduct acoustic tagging studies to identify drivers of rearing and migration behavior of juvenile salmonids at finer spatial scales (<2 km).	2 (q.056a, 056b)	11.00	6.50	1.50	3.00	**0.59**	0.60	0.66	0.49	0.58	0.63	**5.00**
Sci-2	Chinook/Steelhead -- Couple high resolution acoustic telemetry studies with high resolution hydrodynamic modeling at areas of the Delta directly affected by management actions	3 (q.006, 012, 056a)	10.33	5.33	2.00	3.00	**0.55**	0.55	0.62	0.46	0.53	0.59	**4.33**
Sci-7	Chinook -- Examine how juvenile Chinook Salmon respond (survival, behavior, growth) to flow dynamics in different water year types (e.g. differing base flows, pulse flows, flood events, migration pathways).	3 (q.005, 006, 056a)	11.33	5.33	3.00	3.00	**0.53**	0.54	0.61	0.43	0.49	0.58	**4.33**
Sci-51	Chinook/steelhead - Conduct acoustic tagging studies in tidal regions of the Delta to assess effects of export-altered hydrodynamics on migration and behavior of juvenile salmonids.	3 (q.056a, 056b, 057)	10.33	5.33	2.00	3.00	**0.56**	0.57	0.62	0.47	0.54	0.61	**4.33**
Mgmt-24	Chinook/Steelhead -- Reduce injury or mortality caused by entrainment and/or impingement on the screens at large Delta water diversions.	3 (q.024, 028, 047)	10.00	2.00	5.67	2.33	**0.50**	0.54	0.57	0.41	0.47	0.53	**4.33**

Spotlight on Theme 2: Representative Examples of Shortlisted Activities

These spotlight examples provide additional context for a representative selection of shortlisted activities for this theme, corresponding to the activity codes in the preceding tables (e.g., Sci-51), to illustrate the details and diversity of activities included. However, ***these spotlights examples are not intended to imply any additional emphasis or prioritization on these activities***.

Sci-51 – Acoustic Tagging Studies

Description: ***Conduct acoustic tagging studies in tidal regions of the Delta to assess effects of export-altered hydrodynamics on migration and behavior of juvenile salmonids.*** Telemetry studies have yielded important insights into the routing and survival of salmonids migrating through the Delta. Contemporary acoustic telemetry tracking studies build on past interagency efforts to establish, refine, and conduct research with an acoustic telemetry receiver network throughout the Delta as part of the interagency Six-Year Telemetry Study running from 2011 through 2016 (USBR 2018a). This project yielded important insights about the migration of juvenile Chinook and steelhead and now provides critical research infrastructure for carrying out future telemetry studies. Looking forward, there is increasing interest in expanding the capacity of this acoustic network through the Central Valley Enhanced Acoustic Tagging Project to provide real-time telemetry tracking data capable of informing key management decisions in the Delta, particularly as they relate to the operation of flow management infrastructure (CalFishTrack 2020, Johnson et al. 2017), which is reflected in other activities on both Theme 1 and Theme 2 shortlists.

Key Players: Key agencies involved in establishing and maintaining acoustic telemetry arrays include BOR, NOAA NMFS, USFWS, USGS, USACE, CDFW, and DSP-DSC, among others, along with collaborators at UC Davis and others forming part of the California Fish Tracking Consortium, and researchers from other institutions who conduct studies using these networks and contribute data to open data portals like CalFishTrack (see Section for 2.3 acronyms).

Key Species: Chinook (outmigrating smolt) / Steelhead (outmigrating smolt)

Stressors: Exports, hydrodynamics

Prioritization Results: This activity ranked near the bottom of the Theme 2 shortlist and also appeared on the Theme 1 Science Activities shortlist, suggesting the activity is considered relatively easy to undertake but not considered the most beneficial for salmonid recovery. This stands in contrast to the high rankings of several other activities related to acoustic telemetry tracking which appear on the shortlist for Theme 1 (e.g., Sci-2, 15, 20, 49/50), which are more focused on obtaining movement data at higher spatial and temporal scales to inform modelling of hydrodynamic impacts.

Key Regions: Tidally-influenced portions of the Delta

Crossover with parallel processes: Although not explicitly mentioned in other parallel processes we examined, carrying out tracking studies in tidal regions of the Delta would help to understand movement patterns in areas of overlap with the distribution of Delta Smelt. Better understanding this overlap may help to identify management strategies capable of benefiting both species.

Header Photo: Chinook Acoustic Tagging by Steve Martarano | USFWS, 2016,

Mon-59 – Contaminants

Description: ***Increase the spatio-temporal coverage, synthesis, and analysis of contaminants monitoring in Delta waterways to inform management strategies.*** Contaminant runoff from urban settings, agricultural fields, and historic mining sites can affect salmonid behavior, migration routing, growth, and survival, among other things (Fong et al. 2016, Windell et al. 2017). The effects of contaminants may also be exacerbated by flow management operations, which influence contaminant concentrations, residence times, and movement through the Delta (CAMT Salmon Workshop 2018, Buchanan and Skalski 2019). Many uncertainties remain with regards to the effects of contaminants on salmonids in the Delta and further work is necessary to identify point and nonpoint sources of contaminants, understand how hydrodynamics affect contaminant dispersal and impacts on fish at multiple biological and spatial scales, and design management strategies to mitigate these impacts (Connon et al. 2019). To help reduce some of these outstanding uncertainties, a new initiative is now underway by the Metropolitan Water District of Southern California to assess relative contributions of contaminants to environmental risk in the upper San Francisco Estuary and Delta (Landis et al. 2020).

Key Players: Leaders of work on the biological effects of contaminants in the Delta include the MWD, SFCWA, SWRCB, CDFW, California Department of Pesticide Regulation (CDPR), and many academic research institutions (see Section for 2.3 acronyms).

Key Species: Chinook and Steelhead (rearing, outmigrating smolt, adult for both species)

Stressors: Contaminants, water quality

Prioritization Results: This activity ranked near the top of the list of activities with moderate to high benefits and high implementability. However, this activity did not appear on any other shortlist.

Key Regions: Full Delta

Crossover with parallel processes: Science, monitoring, or management activities related to contaminants are not explicitly mentioned among the priorities in any of the parallel processes examined, although this may be implied for activities related to water quality. However, there may be indirect linkages to activities relating to flows and predators, which are prominent across other processes. These potential indirect linkages are based on current understanding of the contributions of operational flow management to contaminant exposure (CAMT Salmon Workshop 2018, Buchanan and Skalski 2019) and the potential role of the sublethal effects of contamination on fish susceptibility to predators (Windell et al. 2017).

Header Photo: Water Treatment & Testing at Folsom Dam by USACE, 2012,

Mon-31 – Open-Access Data

Description: ***Provide timely public access to monitoring data in open data formats.*** The current use of monitoring data to inform salmonid management in the Delta is limited because data are not always disseminated efficiently (Johnson et al. 2017). An open-access model for bringing together data on science, management, and monitoring activities relevant to salmonids in the Delta would enable timely integration of accurate data into management decisions and in doing so help meet priority science actions related to data accessibility and synthesis outlined under Action Area 2 of the Delta Stewardship Council's Science Action Agenda (DSC 2017). Recent passage of the Open and Transparent Water Data Act now provides an additional driver for open-access data with an associated data system currently under development that integrates water and environmental data systems (Tenefoss 2018). The work of the Interagency Ecological Program (IEP) provides a useful template for an open-data model of data dissemination that includes a dedicated Data Utilization Work Group (DUWG) to actively uphold data standards and facilitate data sharing with other organizations to support synthesis and use in decision-making (Baerwald et al. 2020). Several more recent initiatives are underway to help improve data accessibility in the Delta, including the Delta Independent Science Board's Monitoring Enterprise Review Inventory Tool (DISB 2017, 2019b), the Delta Stewardship Council's Science Tracker (DSC-DSP 2019, DSC 2020), and numerous public data portals to help disseminate existing datasets (e.g., Bay Delta Live). To date, there has not been a similar initiative to track all of the myriad management activities conducted across the Delta.

Key Players: The Interagency Ecological Program (IEP), the DSC, the DISB, and the many state and federal agencies supporting Bay Delta Live (see Section for 2.3 acronyms). .

Key Species: Chinook / Steelhead (rearing, outmigrating smolt, adult of both species)

Prioritization Results: This activity ranked the highest in terms of agreement on low barriers to implementation but did not appear on any other lists. This ranking indicates that providing timely public access to monitoring data is considered relatively easy to undertake, but not to be of utmost benefit to salmonid recovery.

Key Regions: Full Delta

Crossover with parallel processes: Fostering communication and information sharing to support life-cycle modeling of spring-run Chinook is identified as a key activity for the SRSP Science Plan. While Mon-31 is less specific activity than that in the SRSP Science Plan, the intent of both is that readily available data will benefit all parties working on restoration/conservation in the Delta.

3.2.4 Theme 3: Beneficial Activities with the Least Agreement about Benefits

Overview

This theme focused on activities that were ranked as **highly or moderately beneficial across selected criteria but had the lowest levels of across-group agreement** in benefit scores. Identifying and characterizing areas of greatest disagreement is just as critical as finding areas of common ground in that it allows practitioners to identify and work to reduce barriers to the implementation of high-benefit activities.

In this regard, **diagnosing the cause of disagreement** is critical to developing a strategy for reducing it. For example, where the causes of disagreement are ongoing scientific uncertainties, targeted science and research activities may help to shed more light on the issue in a way that improves alignment. In contrast, where the causes of disagreement are differences in group positions and values, different approaches including facilitated discussion, mediation, and other forms of relationship-building and consensus-building could help to bring groups into greater alignment.

Moreover, by **looking at discrepancies or divergence** in the raw scores assigned by each affiliation group, **it is possible to understand which parties are most important in driving disagreement** and are thus most critical to include in conversations and strategies seeking to improve alignment. This is also a way to ensure that activities ranked as highly beneficial by one group are not discounted in the across-group rollup. By bringing additional attention and resources to these activities in a way that helps improve alignment, practitioners may shift activities closer to areas of common ground that are the focus of Theme 1.

All Activities Combined

When considering all types of activities together, Salmonid Sub-committee refiners specified the use of the All Criteria Score (the sum of Magnitude of Benefits, Learning Benefits, and Multi-Species Benefits) for ranking data, targeting both moderate and high All Criteria Scores, followed by filtering for activities with the lowest level of agreement based on natural breaks in the diagnostic plot. This approach resulted in a natural cluster of topmost criteria and agreement activities is bounded roughly by an All Criteria Score > 7.5 and a level of Across-Group Agreement < 0.5, resulting in a shortlist of 15 Activities.

As in Theme 1, the all-activities shortlist for Theme 3 includes a mix of science, management, and monitoring activities. These activities include:

(1) different approaches to **monitoring or reducing the impact of predators** on juvenile salmonids (representing the first six activities, or just over one third of the list). A closer look at the activities with low benefits and low agreement which are excluded from the shortlist reveals that most of the additional activities (5/7) are also related to monitoring or reducing the impact of predators.

(2) studying and monitoring **juvenile habitat use** in the Delta.

(3) water and **flow / conveyance management** activities.

Two additional activities with low benefits and low agreement not included in this shortlist relate to the development of climate change predictions and their use for informing water management.

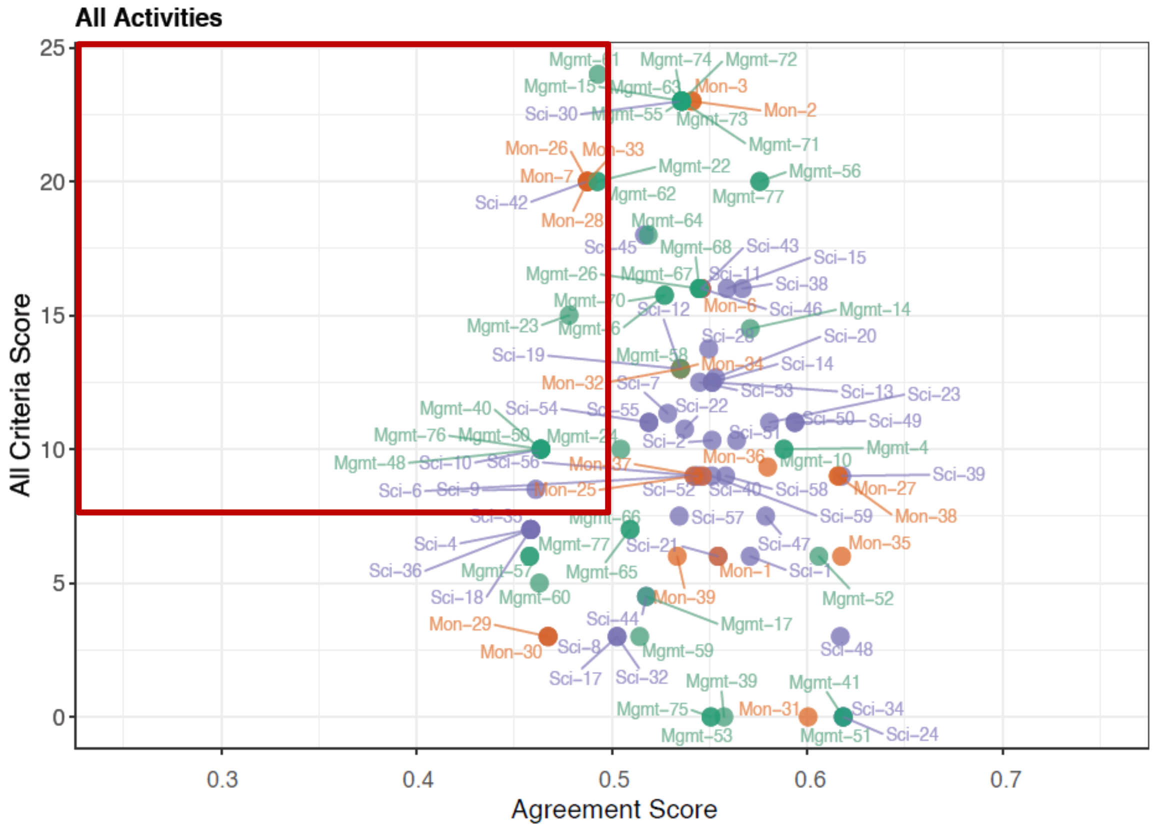


Figure 11: Theme 3 diagnostic plot of overall agreement scores and the All Criteria Score for all types of activities combined, including a red box bounding the activities included in the shortlist for this theme. Alphanumeric codes correspond to activity IDs listed in Table 8.

Table 8: Theme 3 – All Activities Shortlist – Least Alignment in Agreement & High / Moderate All-Criteria Benefit Scores (columns in bold are ones used for generating shortlist). Note that differences beyond the second decimal place shown here in the Overall Average Agreement score are driving the sorting of activities outside of the apparent order suggested by the All Criteria Score.

			Criteria Scores				Agreement Scores Across Affiliation Groups (N = 50 Survey Takers)						
Activity ID	**Activity Statement**	No. Q Statements	All Criteria Score	Learning Score	Magnitude Score	Multi-Species Score	Overall Average Agreement Across Affiliation Groups	Unaffiliated Expert Agreement	Federal Agreement	NGO Agreement	PWA Agreement	**State Agreement**	Implementability Score
Sci-9	Capture and remove predators from predation hot spots in the Delta with the goal of improving survival of juvenile salmonids.	2 (q.045, 047)	**8.50**	1.50	7.00	0.00	**0.46**	0.51	0.51	0.37	0.45	0.47	1.50
Sci-10	Implement studies to quantify and reduce predation mortality for juvenile salmonids salvaged, transported, and released in the Western Delta.	1 (q.047)	**10.00**	3.00	7.00	0.00	**0.46**	0.52	0.52	0.37	0.43	0.48	0.00
Mgmt-40	Install a carbon dioxide injection devices to allow remote controlled anesthetization of predators in secondary channels of export facilities.	1 (q.047)	**10.00**	3.00	7.00	0.00	**0.46**	0.52	0.52	0.37	0.43	0.48	0.00
Mgmt-48	Identify scour hole predation hot spots, fill scour holes to minimize complex hydrodynamics and reduce ambush habitat for predators.	1 (q.047)	**10.00**	3.00	7.00	0.00	**0.46**	0.52	0.52	0.37	0.43	0.48	0.00
Mgmt-50	Remove or modify man-made structures (e.g. old pilings, docks) to reduce ambush habitat for predators.	1 (q.047)	**10.00**	3.00	7.00	0.00	**0.46**	0.52	0.52	0.37	0.43	0.48	0.00
Mgmt-76	Chinook/Steelhead -- Reduce predation on juvenile salmonids (e.g., capture and removal of predators, reduction of ambush habitat and cover)	1 (q.047)	**10.00**	3.00	7.00	0.00	**0.46**	0.52	0.52	0.37	0.43	0.48	0.00
Mgmt-23	Prioritize development of methods that contribute to reduced pre-screen mortality at both the CVP and SWP facilities.	2 (q.024, 047)	**15.00**	3.00	8.50	3.50	**0.48**	0.50	0.54	0.37	0.45	0.52	1.50
Sci-42	Chinook/Steelhead -- Increase use of PIT tags or other appropriate methods for selected studies of smaller fish (sub-smolt) to assess rearing behavior and habitat use.	1 (q.035)	**20.00**	7.00	10.00	3.00	**0.49**	0.47	0.55	0.31	0.55	0.56	3.00
Mon-7	Chinook/Steelhead -- Improve/ expand presence, distribution, and abundance data on juvenile salmonid utilization of existing and restored habitats	1 (q.035)	**20.00**	7.00	10.00	3.00	**0.49**	0.47	0.55	0.31	0.55	0.56	3.00
Mon-26	Chinook/Steelhead -- Conduct monitoring that provides robust information on the timing, location, and duration of Delta habitat use by juvenile salmonids for migration and rearing.	1 (q.035)	**20.00**	7.00	10.00	3.00	**0.49**	0.47	0.55	0.31	0.55	0.56	3.00
Mon-28	Chinook/Steelhead - Identify and develop existing and new monitoring required to provide data on effects of restoration on juvenile rearing in the Delta.	1 (q.035)	**20.00**	7.00	10.00	3.00	**0.49**	0.47	0.55	0.31	0.55	0.56	3.00
Mon-33	Chinook/all -- Monitor timing and abundance of juvenile salmonids utilizing floodplain habitats	1 (q.035)	**20.00**	7.00	10.00	3.00	**0.49**	0.47	0.55	0.31	0.55	0.56	3.00
Mgmt-22	When capacity at CVP is available, shift exports to CVP from SWP to reduce entrainment loss and improve survival of juvenile salmonids that reach the South Delta.	1 (q.024)	**20.00**	3.00	10.00	7.00	**0.49**	0.49	0.55	0.38	0.47	0.57	3.00
Mgmt-62	Chinook/Steelhead -- Reduce impacts of small scale, in Delta agricultural water diversions on water quality, habitat, and ecosystem conditions through timed withdrawals and off-channel storage (e.g., ponds and storage tanks).	1 (q.024)	**20.00**	3.00	10.00	7.00	**0.49**	0.49	0.55	0.38	0.47	0.57	3.00
Mgmt-61	Chinook/Steelhead -- Expand management of outside levee agricultural fields to provide secondary production (fish food) and export it to adjacent fish accessible habitats	1 (q.032)	**24.00**	7.00	7.00	10.00	**0.49**	0.46	0.55	0.49	0.44	0.53	3.00

Science Activities

When considering science activities, Salmonid Sub-committee refiners specified the use of the Learning Benefits Score only for ranking data, targeting both moderate and high All Criteria Scores, followed by filtering for activities with the lowest level of agreement based on natural breaks in the diagnostic plot. This approach resulted in a natural cluster of topmost criteria and agreement activities is bounded roughly by an All Criteria Score > 3.75 and a level of Across-Group Agreement < 0.5, resulting in a shortlist of 1 Activity.

Overall, there was relatively little disagreement surrounding the learning benefit of science activities, which might be expected given that there is a more direct relationship between these two than there might be across activity groups and the other criteria. The one shortlisted activity for this theme was Sci-42, employing **PIT tags to study salmonid habitat use**. This activity is a good example of one that appears to have higher agreement when looking at the median scores of each group for the linked Q statement in Figure 15, but actually has a low across-group Agreement Score when considering the full distribution of responses.

An additional 7 activities with both low agreement and low benefits that were not included in this shortlist are all related to studies of predation risk and effects on juvenile salmonids, demonstrating significant overlap with the results seen for all activities combined.

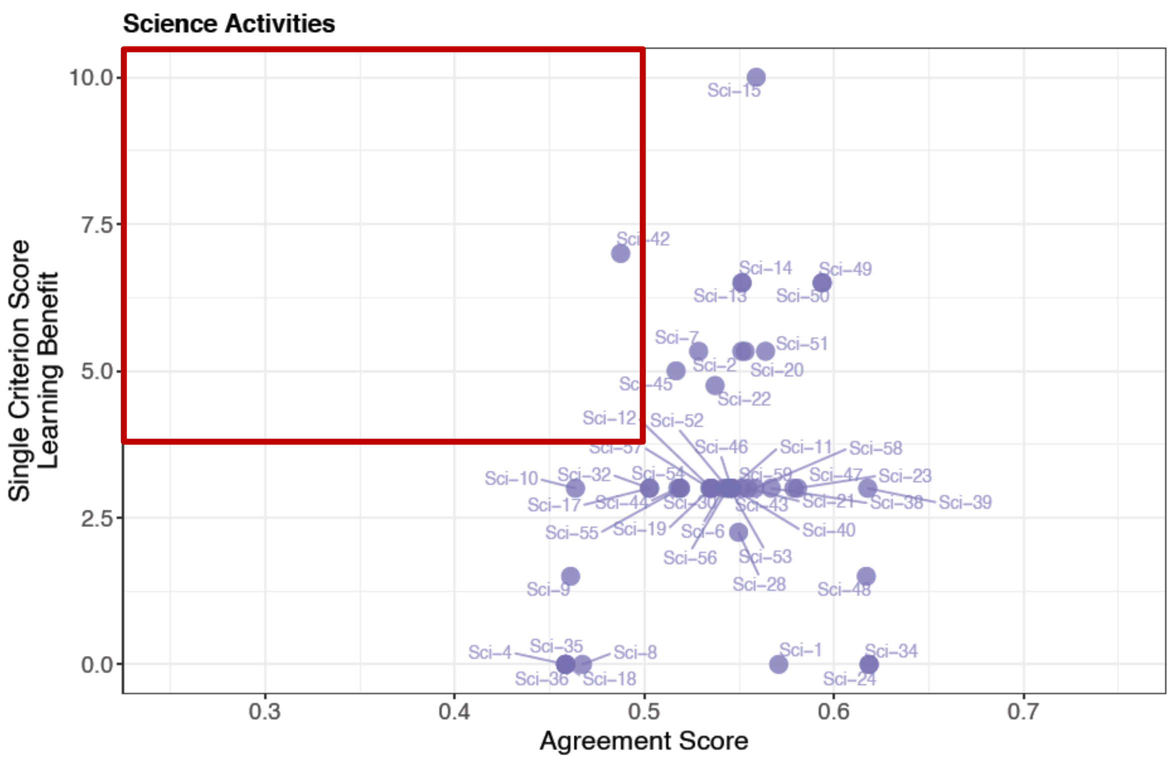


Figure 12: Theme 3 diagnostic plot of overall agreement scores and the Learning Benefit Score for science activities combined, including a red box bounding the activities included in the shortlist for this theme. Alphanumeric codes correspond to activity IDs listed in Table 9.

Management Activities

When considering only Management activities, Salmonid Sub-committee refiners specified the use of a Two-Criteria Score (the sum of Magnitude of Benefit and Multi-Species Benefit) for ranking data, targeting both moderate and high Two-Criteria Scores, followed by filtering for activities with the lowest level of agreement based on natural breaks in the diagnostic plot. This approach resulted in a natural cluster of topmost criteria and agreement activities is bounded roughly by an All Criteria Score > 10 and a level of Across-Group Agreement < 0.5, resulting in a shortlist of 4 Activities.

The shortlist of management activities with the least agreement are evenly split between activities related to:

(1) **reducing entrainment and mortality in and around water intake** facilities, and

(2) **managing water use and inundation on agricultural fields** to reduce the impacts of diversions and increase food production and export back into the Delta.

Of the additional 7 activities with both low agreement and low benefits that were not included in this shortlist, 5 were related to management interventions intended to reduce predation on juvenile salmonids while 2 were related to the development and use of climate change projections to inform water management.

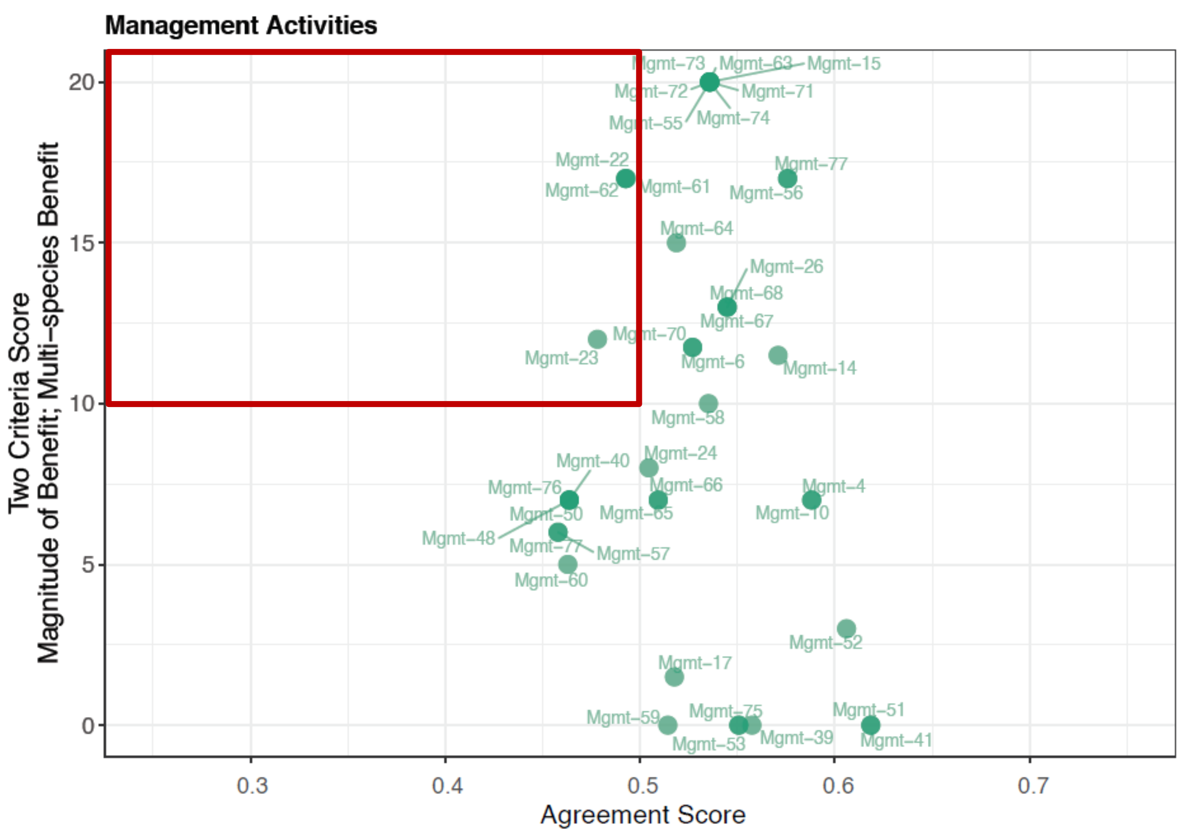


Figure 13: Theme 3 diagnostic plot of overall agreement scores and the Two-Criteria Score (Magnitude of Benefit and Multispecies Benefit) for management activities, including a red box bounding the activities included in the shortlist for this theme. Alphanumeric codes correspond to activity IDs listed in Table 10.

Monitoring Activities

When considering only Monitoring activities, Salmonid Sub-committee refiners specified the use of the All Criteria Score (the sum of Magnitude of Benefits, Learning Benefits, and Multi-Species Benefits) for ranking data, targeting both moderate and high All Criteria Scores, followed by filtering for activities with the lowest level of agreement based on natural breaks in the diagnostic plot. This approach resulted in a natural cluster of topmost criteria and agreement activities is bounded roughly by an All Criteria Score > 10 and a level of Across-Group Agreement < 0.5, resulting in a shortlist of 4 Activities.

The shortlist of monitoring activities with the least agreement has strong overlap with monitoring activities occurring under the All Activities plot for this theme. These activities are focused on **monitoring habitat use by juvenile salmonids**, particularly of restored habitats, as they migrate through or rear in the Delta.

Of the additional 2 activities with both low agreement and low benefits that were not included in this shortlist, 5 were related to monitoring to better understand the behaviour of black bass, striped bass, and fish eating birds as predators of juvenile salmonids.

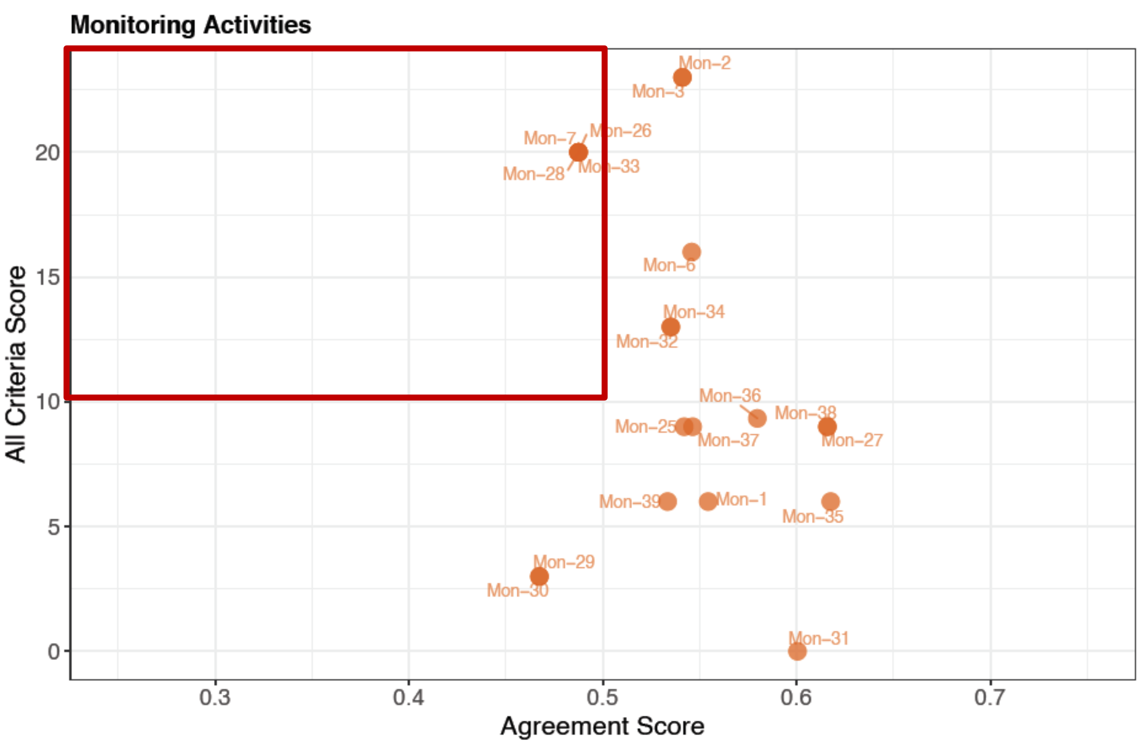


Figure 14: Theme 3 diagnostic plot of overall agreement scores and the All Criteria Score for monitoring types of activities combined, including a red box bounding the activities included in the shortlist for this theme. Alphanumeric codes correspond to activity IDs listed in Table 11.

Table 9: Theme 3 – Science Activities Shortlist – Least Alignment in Agreement & High / Moderate Learning Benefit Scores (columns in bold are ones used for generating shortlist)

			Criteria Scores				Agreement Scores Across Affiliation Groups (N = 50 Survey Takers)						
Activity ID	**Activity Statement**	No. Q Statements	All Criteria Score	Learning Score	Magnitude Score	Multi-Species Score	Overall Average Agreement Across Affiliation Groups	Unaffiliated Expert Agreement	Federal Agreement	NGO Agreement	PWA Agreement	**State Agreement**	Implementability Score
Sci-42	Chinook/Steelhead -- Increase use of PIT tags or other appropriate methods for selected studies of smaller fish (sub-smolt) to assess rearing behavior and habitat use.	1 (q.035)	13.00	**7.00**	10.00	3.00	**0.46**	0.49	0.55	0.31	0.55	0.56	3.00

Table 10: Theme 3 – Management Activities Shortlist – Least Alignment in Agreement & High / Moderate Two-Criteria Benefit Scores (columns in bold are ones used for generating shortlist)

			Criteria Scores				Agreement Scores Across Affiliation Groups (N = 50 Survey Takers)						
Activity ID	**Activity Statement**	No. Q Statements	Two Criteria Score	Learning Score	Magnitude Score	Multi-Species Score	Overall Average Agreement Across Affiliation Groups	Unaffiliated Expert Agreement	Federal Agreement	NGO Agreement	PWA Agreement	**State Agreement**	Implementability Score
Mgmt-23	Prioritize development of methods that contribute to reduced pre-screen mortality at both the CVP and SWP facilities.	2 (q.024, 047)	**12.00**	3.00	8.50	3.50	**0.48**	0.50	0.54	0.37	0.45	0.52	1.50
Mgmt-22	When capacity at CVP is available, shift exports to CVP from SWP to reduce entrainment loss and improve survival of juvenile salmonids that reach the South Delta.	1 (q.024)	**17.00**	3.00	10.00	7.00	**0.49**	0.49	0.55	0.38	0.47	0.57	3.00
Mgmt-62	Chinook/Steelhead – Reduce impacts of small scale, in Delta agricultural water diversions on water quality, habitat, and ecosystem conditions through timed withdrawals and off-channel storage (e.g., ponds, storage tanks).	1 (q.024)	**17.00**	3.00	10.00	7.00	**0.49**	0.49	0.55	0.38	0.47	0.57	3.00
Mgmt-61	Chinook/Steelhead -- Expand management of outside levee agricultural fields to provide secondary production ("fish food") and export it to adjacent fish accessible habitats	1 (q.032)	**17.00**	7.00	7.00	10.00	**0.49**	0.46	0.55	0.49	0.44	0.53	3.00

Table 11: Theme 3 – Monitoring Activities Shortlist – Least Alignment in Agreement & High / Moderate Two-Criteria Benefit Scores (columns in bold are ones used for generating shortlist)

			Criteria Scores				Agreement Scores Across Affiliation Groups (N = 50 Survey Takers)						
Activity ID	**Activity Statement**	No. Q Statements	All Criteria Score	Learning Score	Magnitude Score	Multi-Species Score	Overall Average Agreement Across Affiliation Groups	Unaffiliated Expert Agreement	Federal Agreement	NGO Agreement	PWA Agreement	**State Agreement**	Implementability Score
Mon-7	Chinook/Steelhead – Improve/ expand presence, distribution, and abundance data on juvenile salmonid utilization of existing and restored habitats.	1 (q.035)	**20.00**	7.00	10.00	3.00	**0.49**	0.47	0.55	0.31	0.55	0.56	3.00
Mon-26	Chinook/Steelhead – Conduct monitoring that provides robust information on the timing, location, and duration of Delta habitat use by juvenile salmonids for migration and rearing.	1 (q.035)	**20.00**	7.00	10.00	3.00	**0.49**	0.47	0.55	0.31	0.55	0.56	3.00
Mon-28	Chinook/Steelhead - Identify and develop existing and new monitoring required to provide data on effects of restoration on juveniles rearing in the Delta.	1 (q.035)	**20.00**	7.00	10.00	3.00	**0.49**	0.47	0.55	0.31	0.55	0.56	3.00
Mon-33	Chinook/all – Monitor timing and abundance of juvenile salmonids utilizing floodplain habitats.	1 (q.035)	**20.00**	7.00	10.00	3.00	**0.49**	0.47	0.55	0.31	0.55	0.56	3.00

Assessment of Divergence

As additional context for the interpretation of the results in Theme 3, in this section we drill down into the data to illustrate why Theme 3 Activity Statements had lower scores for the **across-group agreement metrics** shown in the preceding tables. ***However, the data we use for this assessment are different from those reported in the preceding tables.*** The preceding tables for Theme 3 report scores for *Activity Statements* that are derived from the **across-viewpoint**, and **across-group agreement metrics** described in Step 5 of Section 3.1. Here, **for Q Statements only,** we report the averages across all individual responses using *raw survey data*. This means that interpreting how these results are related to the activities being ranked requires readers to cross-reference Q statements with the one or more Activity Statements to which the Q statements are assigned. Cross-referencing can be done using the crosswalk index provided in the ***supplementary analysis data file*** (LINK) accompanying this report (Tab 3_Qst_ActivitySt_Index).

For each Q statement and each of the four criteria, Figure 15 summarizes the **range of average raw survey scores** across affiliation groups (labelled as 'Statement Ranks' on the y-axis). The figure also highlights in yellow shading those Q statements appearing in the activity shortlists that we reported previously for Theme 3, and it emphasizes Q statements which, based on visual inspection, have at least one outlier across the five affiliation groups (green borders). The ranges of these *average* scores should not be interpreted as a measure of overall spread in the results – each data point is associated with its own range that is not shown. For tightly clustered Q statements in Figure 15, it is possible individual disagreement still occurred *within groups* and, at the Activity Statement level, may contribute to final across-group agreement scores which instead relied on an area-under-the-curve approach (described in Step 5 of Section 3.1). Nevertheless, this alternate exploration of the data delivers some useful information.

Based on results shown in Figure 15, it is apparent that divergence across affiliation groups is driven by one of three scenarios:

- On average, one group ranked a Q statement **much higher than the others**
- On average, one group ranked a Q statement **much lower than the others**
- There was **uniform disagreement,** with average Q statement ranks for each group spread out evenly over a wide range

Just 5 unique Q statements underpin the scores for all shortlisted Activity Statements in Theme 3 (i.e., yellow shading in Figure 15). For these 5 statements, the most common driver of divergence is the second case where one group ranked the Q statement much lower, on average, than the others. These Q statements are related to flow management, salmonid habitat, and predation and are summarized in more detail below.

- **q.024 – Alter the volume, timing, and/ or source of water diversions to increase juvenile salmonid outmigrant survival** (most closely linked to MANAGEMENT ACTIVITIES).
    - **Public Water Agencies** ranked the **Implementability** of this type of activity much **LOWER** (~ -2) than other groups (scores clustered between +0.2 and -1)
    - **Public Water Agencies** ranked the **Magnitude of Benefit** of this type of activity much **LOWER** (~ -1) than other groups (scores clustered between +0.5 and +3)

- **q.032 – Increase food availability for juvenile salmonids by redistributing primary and secondary productivity from high nutrient locations (e.g., flushing, floodplain/tidal marsh**

connectivity, agricultural conservation management practices) (most closely linked to MANAGEMENT ACTIVITIES).
  - **Public Water Agencies** ranked the **Implementability** of this type of activity much **HIGHER** (~ +1.8) than other groups (scores clustered between 0 and -2)
  - **Unaffiliated /Other Experts** ranked the **Learning Benefits** of this type of activity much **LOWER** (~ -1) than other groups (scores clustered between 0 and +1.2).
  - **Unaffiliated /Other Experts** ranked the **Magnitude of Benefit** of this activity type much **LOWER** (~ -0.5) than other groups (scores clustered between +1 and +2)

- **q.035 - Improve the quality and quantity of existing information about how juvenile salmonids utilize existing and restored habitats (e.g., presence, distribution, abundance, carrying capacity).** (most closely linked to MONITORING ACTIVITIES)
  - **NGOs** ranked the **Implementability** of this type of activity much **LOWER** (~ -1.2) than other groups (scores clustered between +0.5 and +1.5)

- **q.045 - Conduct studies to improve understanding about predation on juveniles and the effectiveness of predation reduction strategies** (most closely linked to SCIENCE ACTIVITIES)
  - This statement features one of the widest ranges in median scores across affiliation groups of any Q statements. **NGOs** ranked the **Magnitude of Benefits** of this activity type much **LOWER** (-3) than other groups (scores clustered between -1 and +2).

- **q.047 - Reduce predation on juvenile salmonids (e.g., capture and removal of predators, reduction of ambush habitat and cover)** (most closely linked to MANAGEMENT ACTIVITIES)
  - **Public Water Agencies** ranked the **Learning Benefits** of this type of activity much **HIGHER** (~ +1) than other groups (scores clustered between -1 and -2.5)
  - This statement features a multigroup split and also features one of the widest ranges in scores across affiliation groups of any Q statements. **State Agencies and NGOs** ranked the **Magnitude of Benefits** of this type of activity much **LOWER** (~ -1 to -3) than other groups (scores clustered between +1 and +3).
  - This statement features a multigroup split and also features one of the widest ranges in scores across affiliation groups of any Q statements. **State Agencies and NGOs** ranked the **Multispecies Benefits** of this type of activity much **LOWER** (~ -1.5 to -3) than other groups (scores clustered between +0.5 and +1).

Additional Q-Statements ranked, on average, as having much higher or much lower benefits by only one group included:

Learning Benefits

- q.010b - Improve specificity of, and basis for, salmonid salvage triggers (e.g., proportional loss, source stocks) to inform water export management
  - **Learning Benefits** ranked much **LOWER** by **Unaffiliated / Other Experts** (~-3) compared to other groups (~-1.5 to -0.5)
- q.013 - Improve guidance for study design and quantitative model development by including mechanisms (not just drivers and outcomes) in existing salmonid conceptual models
  - **Learning Benefits** ranked much **HIGHER** by **Unaffiliated / Other Experts** (~+2) compared to other groups (0 to +1)
- q.019 - Develop and/or identify existing projections of climate-related effects on salmonids and incorporate into design of restoration actions

  - **Learning Benefits** ranked much **HIGHER** by **NGOs** (~+1) compared to other groups (~-1)
- q.051 – Expand the spatial and temporal coverage of existing water quality monitoring
  - **Learning Benefits** ranked much **HIGHER** by **NGOs** (~+2.5) compared to other groups (~-0.5 - 0)

Magnitude of Benefits

- q.008 - Conduct studies and experiments with water project operation alternatives to assess the impact of flow and other habitat changes on salmonid behavior, habitat availability, and survival
  - **Magnitude of Benefits** ranked much **LOWER** by **Public Water Agecies** (~-1) compared to other groups (~+1.5 to +2)
- q.019 - Develop and/or identify existing projections of climate-related effects on salmonids and incorporate into design of restoration actions
  - **Magnitude of Benefits** ranked much **HIGHER** by **NGOs** (~+1.5) compared to other groups (~-1 to 0)
- q.029 - Use water export and river flow management to maximize the occurrence of positive tidally-averaged flows in the Delta
  - **Magnitude of Benefits** ranked much **HIGHER** by **NGOs** (~+2) compared to other groups (~- 2 to 0)

Multispecies Benefits

- q.002 - Control the impacts of aquatic weeds and other invasive species on juvenile salmonid food webs, habitat, and survival
  - **Magnitude of Benefits** ranked much **HIGHER** by **Public Water Agecies** (~+3) compared to other groups (~-0.5 to 1.5)
- q.065 - Improve the ability to formulate and test hypotheses (e.g., via experimental flows) about how and why successful cohort years occur by characterizing the physical and ecological conditions that support success during those years
  - **Magnitude of Benefits** ranked much **HIGHER** by **NGOs** (~+3) compared to other groups (~0 to +1)

More context around specific Q statement outliers that are relevant to shortlisted activities in Theme 3 is provided in the sections that follow.

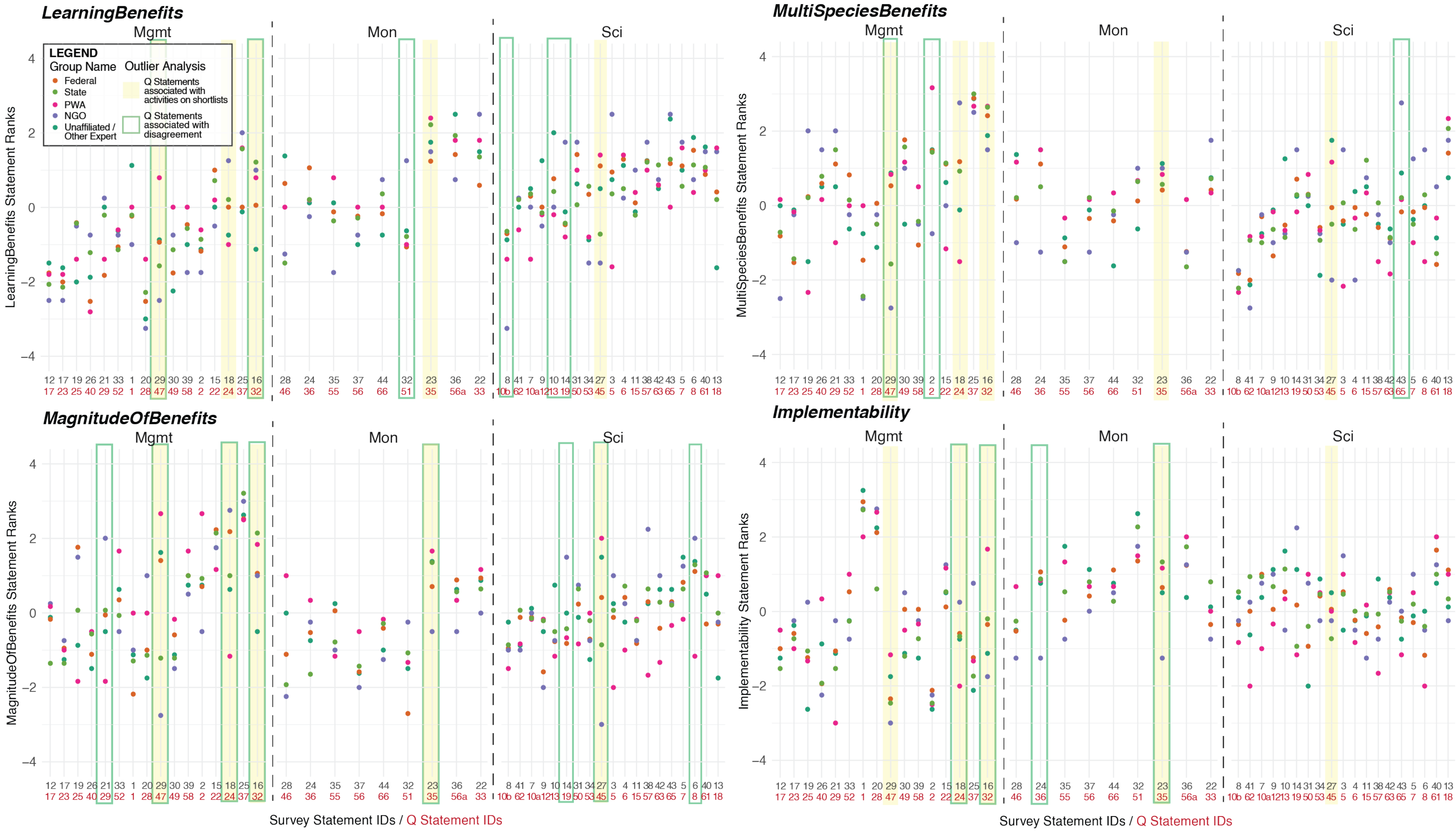
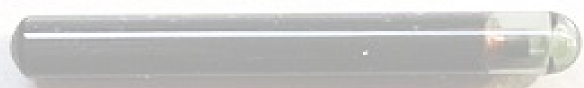


Figure 15: Average raw survey ranks by affiliation group for each of the Q Statements included in the survey. Note that the figure shows both Survey Statement IDs (used only for the survey design) and Q Statement IDs (corresponding to what is shown in shortlist tables in this section and in the supplementary data file distributed with this report). This plot also highlights in YELLOW those Q statements associated with actions on shortlists in Theme 3, and highlights in GREEN those Q statements with apparent outliers for one or more affiliation groups.

Spotlight on Theme 3: Representative Examples of Shortlisted Activities

These spotlight examples provide additional context for a representative selection of shortlisted activities for this theme, corresponding to the activity codes in the preceding tables (e.g., Sci-13), to illustrate the details and diversity of activities included. However, ***these spotlight examples are <u>not</u> intended to imply any additional emphasis or prioritization on these activities***.



Sci-42 – PIT tag studies

Description: ***Increase use of PIT tags or other appropriate methods for selected studies of smaller fish (sub-smolt) to assess rearing behavior and habitat use.*** Passive Integrated Transponder (PIT) tags are a promising option for study of salmonids in the Delta, and particularly juveniles, because of a range of factors: (1) PIT tag burden is low due to their small size and light weight, (2) PIT tagging methods are minimally invasive for the fish relative to acoustic/radio tagging, (3) they use passive technology that allows for monitoring over a fish's full lifespan without the battery limitations of acoustic tags, and (4) unlike coded-wire tags, PIT tags can be detected without sacrificing fish (Dauble et al. 2010, Johnson et al. 2017). This last point is particularly important for increasing the feasibility of tracking studies using wild endangered winter-run Chinook salmon which would provide more informative data than is currently obtained from studies using hatchery-produced Chinook salmon as surrogates (Johnson et al. 2017). That said, a fish must be very close (<1 meter) to a tag reader to be detected, such that this technology is only suitable for implementation in certain locations and contexts (e.g., monitoring fish movement from the head of Old River to recovery at Clifton Court and Tracy Fish Collection Facility, or monitoring habitat use on a specific restoration site) (Dauble et al. 2010). PIT tags have been noted as a useful complementary method to be used alongside otolith analysis to track the influence of movement and habitat use on growth (Johnson et al. 2017).

Key Organizations: Though PIT tags are not yet often used in the study of salmonids in the Delta, NOAA NMFS is leading feasibility studies to determine the potential for more widespread use (Rundio et al. 2017, see Section for 2.3 acronyms).

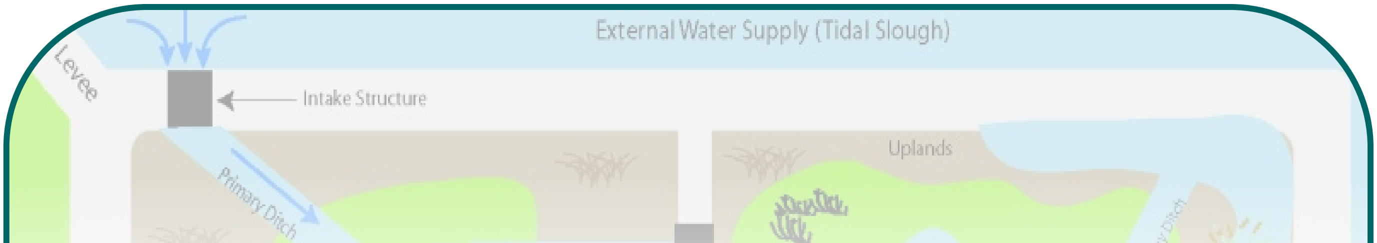
Key Species: Chinook (rearing)/Steelhead (rearing)

Stressors: Habitat use and hydrodynamics

Prioritization Results: This activity ranked in the middle of the list of beneficial activities with the least agreement on benefits, and not appearing on other lists. Agreement may improve once additional feasibility studies and demonstration projects have been completed. Given the potential of PIT tags for tagging small fish, this activity is somewhat related to similar activities listed under this theme which are related to monitoring the juvenile salmonid habitat use, and particularly used of restored habitats (Mon-3, 7, 26, 28, 33).

Key Regions: Full Delta

Crossover with parallel processes: Findings from PIT tag studies of rearing behavior and habitat use may address juvenile salmonid habitat use uncertainties that are identified in the CVPIA Near-Term Restoration Plan and in the SRSP Science Plan (upcoming CVPIA Adaptive Restoration Strategy, Reed 2020).



Mgmt-61 – Outside Levee Agricultural Fields

Description: ***Expand management of outside levee agricultural fields to provide secondary production (fish food) and export it to adjacent fish accessible habitats.*** This activity involves increasing food availability for juvenile salmonids by redistributing primary and secondary productivity from high nutrient locations through coordinated flushing of inundated agricultural fields and improving floodplain / tidal marsh connectivity. A key example of this type of work is the cooperative Fish Food on Floodplain Farm Fields Project. This project sought first to measure productivity on flooded rice fields across the Delta and then find ways to use existing irrigation and flood protection infrastructure to export the resulting food resources from off-channel habitat back into leveed river-channel habitats where it will be accessible to rearing juvenile salmonids (Jeffres et al 2017, CalTrout 2019). The results of pilot experiments have shown this approach can successfully export a significant quantity of zooplankton food resources from off-channel fields into channels and that increased food availability was sufficient to increase the growth rates of caged juvenile salmon by 300 to 500% depending on distance from the flushing site (CalTrout 2019).

Key Players: California Trout, BOR, and a range of associated project partners including cooperating private landowners (see Section for 2.3 acronyms).

Key Species: Chinook (rearing) / Steelhead (rearing)

Stressors: Food availability and abundance

Prioritization Results: This activity ranked lowest on the list of beneficial activities with low agreement on benefits and not appearing on any other lists. The appearance of this activity on the Theme 3 shortlist contrasts with the appearance of several activities related to agricultural floodplain management to expand and increase access to seasonal rearing habitat for juvenile salmonids (Mgmt-55/72/73) on the Theme 1 shortlist. This may reflect a preference for expansion of direct access to food resources on rearing habitats rather than exporting those resources to adjacent habitats, or the potential drawbacks of contaminant dispersal associated with exports. In terms of its focus on secondary production, this activity is also related to Sci-30, which is about restoring connectivity between sloughs, river channels and marshes to boost secondary productivity, as well and Mgmt-74, related to re-operate existing infrastructure to increase productivity of inundated lands and/ or export primary and secondary production to main channel, which both appear on Theme 1 shortlists.

Key Regions: Full Delta

Crossover with parallel processes: This work complements resiliency actions identified in the Delta Smelt (SDM) initiative related to North Delta Food Web Adaptive Management Projects that aim to augment flows through the Yolo Bypass (Compass 2018) to export enhanced productivity from floodplain habitats to generate downstream benefits for Delta Smelt. In addition, the SRSP Science Plan lists identifying relationships between insect/zooplankton abundance and habitat features, potentially including floodplains during inundation, as a science activity of interest. While not directly research-related, the activity profiles here activity may provide opportunity for further learning about secondary production of floodplains.

Header Photo: Managed Wetlands Conceptual Model by CDFG & SRCD, 2010.

Mon-7 – Presence, Distribution, and Abundance of Juvenile Salmonids

Description: Improve / expand presence, distribution, and abundance data on juvenile salmonid use of existing and restored habitats. Long-term presence and abundance data for juvenile salmonids in the lower Yolo Bypass is collected via a rotary screw trap and fyke trap, as well as beach seines in Toe Drain and Tule Canal (USBR 2018). This monitoring is conducted by DWR (USBR 2018). Improving and expanding monitoring efforts of this nature will be informative for addressing a range of uncertainties related to habitat use, modified inundation regimes, and other restoration efforts. This type of activity may involve some degree of temporal and spatial tracking of juvenile salmonids that may benefit from tagging technology for small fish and is considered related to Sci-42 profiled above (increasing use of PIT tags). Both activities were associated with the same survey Q Statement, resulting in identical scores for both.

Key Players: DWR (see Section for 2.3 acronyms).

Key Species: Chinook (rearing)/Steelhead (rearing)

Stressors: Predation, food abundance

Prioritization Results: This activity received a learning benefit score of 7.00, an implementability score of 3.00, and an average across-group agreement score of 0.49, ranking in the middle of the shortlist of beneficial activities with least agreement on benefits and not appearing on other lists. It is also related to several other activities related to monitoring juvenile habitat use that were shortlisted under Theme 3, including Mon-3, 26, 28, and 33. The appearance of this activity type on the Theme 3 shortlist indicates that monitoring the presence, distribution, and abundance of juvenile salmonid in existing and restored habitats is considered highly or moderately beneficial by some, however this is not agreed upon across all groups and this type of activity was ranked as having lower overall benefit than other activities by survey participants affiliated with NGOs.

This contrasts with other activities related to understanding the timing, location, and duration of salmonid movements through acoustic telemetry that ranked highly under Themes 1 and 2 (e.g., Sci-2, 15, 20, 51). This may suggest that there is greater interest in pure location data to inform operational flow management as opposed to using location data to study habitat use or the efficacy of habitat restoration projects, although more context is needed to confirm.

Key Regions: Yolo Bypass / Cache Slough Complex and restoration sites across the Delta

Crossover with parallel processes: This activity is complementary to the SRSP Science Plan activity that aims to examine how flows interact with existing and restored habitats to benefit juvenile salmonids (Reed 2020). This monitoring may also contribute to better understanding fry, parr, and juvenile salmonid habitat requirements, which is a key information need identified in the upcoming CVPIA Near-Term Restoration Strategy.

3.3 Alignment with Activities Being Considered in Parallel Processes

The CSSP assessment marks a stride forward in finding alignment on key activities for recovery and management of salmonids in the Delta. However, in addition to providing specific implementation and monitoring design guidance, the next great challenge is alignment of parallel processes to thoroughly address trade-offs — **identifying what priority actions for one salmonid species or run might mean for other important salmonids, other species (beyond salmonids) and objectives, both *within* and *across* geographies**. The first step towards alignment across both organizations and species of interest is to inventory and understand the similarities and differences among the various packages of objectives, locations, decision-making/prioritization criteria and promising actions of interest emerging from similar initiatives. The CSSP assessment Q surveys help yield insights on potential opportunities and benefits of increasing alignment, including:

- **Reducing Redundancy and Identifying Gaps:** Where initiatives recommend similar activities in similar regions, there are opportunities for greater collaboration to provide either (1) additional capacity for carrying out the work in the same places or (2) divide and conquer to tackle different elements of the problem in different areas. Where there are gaps, initiatives may be adjusted to provide coverage of those gaps as part of a broader portfolio approach to salmonid science and management (see below). Coordinating efforts in this way helps to maximize the benefits of limited science and management resources.
- **Supporting Cross-Linkages and Continuity:** Where initiatives recommend similar types of science, monitoring, or management activities for different regions or species, there are opportunities for collaboration to align study methodologies and designs in a way that maximizes the potential for data comparability, interoperability, and sharing across initiatives. This is especially important given that the scope of individual studies and management actions typically encompass only a small part of the broad geographic ranges that salmonids occupy across their life cycle, and that areas used for rearing are much more distributed across the Delta than previously believed (NMFS 2014, Phillis et al. 2018). Improving data interoperability will help to link findings from different species, life stages, and areas to yield insights at broader population and life cycle scales (Stompe et al. 2020). For example, valuable salmonid data is emerging from monitoring programs that target Delta smelt (Mahardja et al. 2020).
- **Portfolio Effects Across Initiatives:** Each initiative is limited in scope by the mandates of its lead organization(s), which can lead to spatial, temporal, and management disconnects and gaps across the life cycles of species under consideration. Increasing alignment across initiatives can help to build a more purposeful ecosystem-based portfolio of science, monitoring, and management actions that covers all life stages and corresponding cumulative stressors facing salmonids in the Delta (Beechie et al. 2008, DuFour et al. 2015, Woo et al. 2019, Munsch et al. 2020).
- **Support Development of a potential Integrated Central Valley Salmonid Science Plan.** One result of realizing the benefits discussed here is that it provides and opportunity to combine the activities deemed the highest priority among all Central Valley science programs into an integrated range-wide implementation plan in the future. Such a potential basin-wide plan could include quantitative assessment of actions where feasible, and the prioritization and sequencing of actions among species, programs, life stages, and habitats. The overall goal of such an integrated plan would be to prioritize/organize actions to improve the survival, productivity, and the resilience of at-risk species.

This section makes a first attempt at reviewing commonalities across selected parallel prioritization efforts in the Delta and the CSSP assessment, followed by recommendations for next steps to help further increase alignments across these efforts. However, note that some of the outputs of parallel processes were not yet finalized so areas of overlap will change with future iterations.

Parallel Prioritization Efforts

With respect to Delta fishes, key planning and prioritization initiatives include the following closely related efforts:

1. **CVPIA Structured Decision Making (CVPIA SDM)** led by the Science Integration Team (SIT) consortium under purview of the Bureau of Reclamation and the Fish and Wildlife Service.
    - **Focal species of interest:** All four runs of Chinook salmon, steelhead, and sturgeon.
    - **Geographic scope:** Full Central Valley including Sacramento and San Joaquin River basins, with focus on north Delta, Yolo Bypass and ~26 CVPIA salmonid river systems (mainstem and associated tributaries).
    - **Core methodology**: Uses a structured decision making (SDM) framework informed by hybrid expert opinion and decision support models to prioritize habitat-focused project and management recommendations consistent with CVPIA goals for doubling anadormous habitat and achieving self-sustaining populations of anadromous fishes. It relies on habitat data, hydrodynamic and water quality models (CalSim II, HEC-5Q), and a stage-based life cycle model as inputs to a decision-support model (DSM) that projects the population benefits of potential management strategies. This model was recently published in the peer-reviewed literature (Peterson and Duarte 2020), and the full CVPIA Near-Term Restoration Strategy describing resulting management recommendations was released shortly thereafter (BOR and USFWS 2020).
    - **Other considerations:** Does not encompass operations activities or Delta Smelt; socio-economic considerations are partially addressed in the sense of being represented in underlying hydrosystem models like CalSim. To avoid the perception of conflict of interest, the SIT attempted to avoid identification of specific projects in this work.

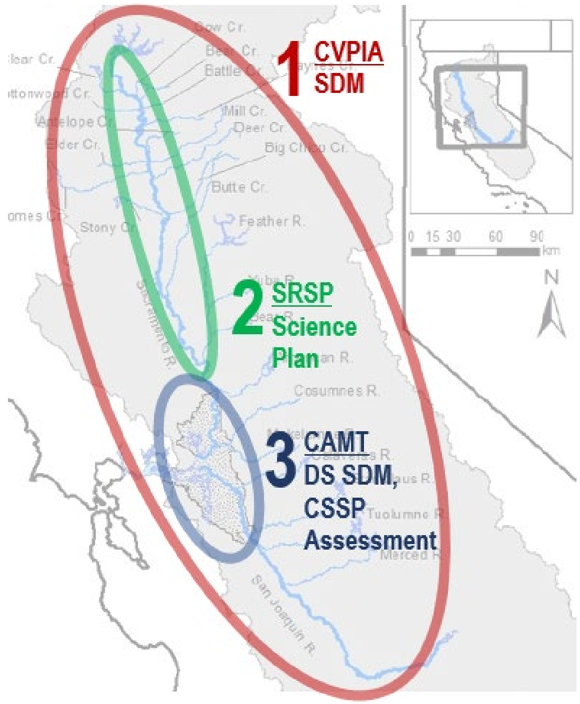


Figure 16: Map showing the overlapping geographies of key planning and prioritization efforts focused on the recovery of delta fishes. Numbers correspond to the initiatives in this section.

2. **Sacramento River Science Partnership Science Plan (SRSP Science Plan)** developed by Denise Reed (Reed 2020).
    - **Focal species of interest:** all four species, runs of Chinook Salmon and Steelhead considered.

- **Geographic scope:** mainstem Sacramento River from Keswick Dam to Verona including the Sutter Bypass.
- **Core methodology:** Expert interviews and review of predictive modeling approaches and data collection programs, framed around three salmonid life-stages: egg to fry emergence, juvenile rearing to outmigration from Keswick Dam to Red Bluff Diversion Dam (RBDD), and juvenile rearing to outmigration from RBDD to Sacramento. The SRSP identifies data collection, research, modelling and synthesis recommendations within each of these three bins that will help detect and understand the effects of management actions. The SRSP does not focus on identifying management actions to benefit species.
- **Other considerations:** Other species, water supply, socio-economic issues not addressed.

3. **Delta Smelt Structured Decision Making (DS SDM)** led by Compass Resource Management (Long and Rudd 2018).
   - **Focal species of interest:** Delta smelt.
   - **Geographic scope:** Delta and Yolo Bypass.
     Core methodology: The initial demonstration project examined the trade-offs among 13 candidate management actions derived from the Delta Smelt Resiliency Strategy within an SDM framework. Both expert elicitation and quantitative bioenergetics modelling (Rose et al. 2013ab) were used to assess the consequences of each candidate action for a range of biological performance criteria for Delta smelt (e.g., % change in biomass, % change in survival, etc.) as well as other criteria (e.g., costs). Work is now ongoing to identify a broader suite of additional candidate actions to evaluate and prioritize using similar methods. Identification of alternative actions and modelling of consequences relies heavily on CAMT core team and other invited technical collaborators.
   - **Other considerations:** Uses traditional SDM trade-off analysis with consideration of both smelt and non-smelt objectives, including salmon and other native estuarine species, water quality, navigation, recreation, cost ($).

Intersections Between the CSSP and Parallel Prioritization Efforts

From the draft reports of these other efforts, there are some actions that are common, e.g., both the CSSP assessment and CVPIA SDM identify keeping juvenile Chinook salmon out of the central Delta using multiple alternative routes from the Sacramento River into the north Delta, such as the Yolo Bypass and Sutter and Steamboat Sloughs. Table 3.12 provides a ***preliminary*** summary of the key activities and information types across alternative parallel prioritization processes underway in the Delta using the best information available at the time of writing. Importantly, this comparison focused on activities and information relevant to the **Delta** and does *not* include activities related to tributary spawning and rearing that are more prominent in these other plans.

Table 3.12: Initial review of key themes and activities across other parallel prioritization processes.

CVPIA Structured Decision Making (Delta)[1]	Structured Decision Making for Delta Smelt (Delta)[2]	SRSP Science Plan (Sacramento River)[3]
Priority Restoration Actions *(focused on Chinook salmon)* • Restore juvenile habitat in mainstem Sacramento River, American River, lower Feather River, Stanislaus River Stanislaus River downstream through San Joaquin River at Vernalis, Battle and Clear Creeks. • Reconnecting ephemeral non-natal tributaries to mainstem Sacramento River • Maintaining existing spawning habitats in Upper Sacramento, American, and Stanislaus Rivers; Clear, Butte Creeks. **Priority Information Needs for Modeling** *(for Ch – Chinook and St - Steelhead)* • Juvenile growth, survival, production (Ch, St) • Juvenile movement and territory size (Ch) • Use, growth, survival at Southport Levee (Ch) • Habitat modelling and estimates for key restoration areas (Ch, St) • Habitat change over time (Ch) • Escapement and prespawn mortality (Ch, St), as well as red counts (St) • Genetic trends over time (St)	**Most Favorable Delta Smelt Resiliency Activities** *Based on a pilot SDM approach, additional activities to be evaluated in ongoing work* • Aquatic weed control • North Delta food web enhancement via pulse flows through the Yolo Bypass • Coordinating draining and flooding of managed wetlands to improve food supply (zooplankton) • Habitat restoration of tidal wetlands in north Delta arc.	**Key Scientific Activities & Themes** *Based on literature review and interviews – results not prioritized at this time* • Monitoring stream temperature, flows • Monitoring consequences of flow management for salmonid habitat use and passage • Predation studies • Disease and pathogen studies • Integration of parentage-based methods for genetic stock ID • Bioenergetics modelling • Food supply studies • Tagging, tracking, and modelling of migration • Assessing benefits of floodplain habitats • Coordination, data sharing, synthesis

1 – Per early BOR and USFWS 2020; 2 – per Long and Rudd 2018; 3 – Per early results from Denise Reed / SRSP.

Key intersections between parallel processes and the CSSP assessment are listed below in no particular order. Importantly, many of these activities are interconnected as noted in their descriptions and these interconnections are known to generate time and space trade-offs that must be carefully considered when coordinating implementation planning.

- **Habitat Restoration:** Restoration of key rearing and migratory habitat in the Delta, including floodplain habitats, is a key interest of all parallel prioritization processes considered. In the CSSP assessment, this class of activities was ranked by survey participants as having high benefits and a high level of agreement across organizations regarding its benefits. Recent research showing that salmonids use a wider range of non-natal rearing habitats than previously believed opens up the potential to consider restoration activities in new regions of the Delta, particularly the South Delta (Phillis at al. 2020). Coupling habitat restoration activities with enhanced salmonid monitoring, including acoustic telemetry and genetic stock identification (see below), can help managers to target restoration to specific areas of importance to stocks of conservation concern and then determine how and when those habitats are used following restoration. Restoration in the Delta can help to complement the upriver restoration priorities of the CVPIA and SRSP Science Plan prioritization processes to ensure continuity in habitat quality and suitability across the salmonid life cycle. As upriver restoration activities occur and salmonid life history diversity is expanded, Delta habitats need to be configured now to support the expanded abundance and life history diversity of upriver fish through increased habitat capacity and productivity.

- **Flow Management:** Activities related to flow management feature prominently across all parallel prioritization processes considered, reflecting an ongoing need to better understand the consequences of flow management across a wide range of water years on fish habitat use (particularly of restored habitats), migration, and survival across the Delta and beyond (Munsch et al. 2020). However, in the CSSP assessment, this class of activities (including shifting exports between CVP an SWP, adjusting timing of water withdrawals, adjusting flows and accessibility to agricultural fields) had a high level of disagreement across organizations regarding its benefits (e.g., less agreement from NGOs and PWAs than other groups on the benefits of these activities). Because the effects of flow management in specific areas can have far-reaching consequences in other regions of the Delta, coordination across initiatives focused on different regions, species, and life stages can help to connect the dots (e.g., Alexander et al. 2014, 2018). There has been growing interest in the expansion of telemetry tracking networks capable of providing real-time information (see below) on fish distribution, migration, and especially survival associated with different flow regimes and how these relationships vary across space to help reduce uncertainties about the consequences of flows on salmonids and inform more rapid management interventions when necessary (Johnson et al. 2020).
- **Floodplains and Food Supply**: All prioritization efforts currently underway place a strong emphasis on the restoration and management of floodplain habitats, either for their direct benefits as rearing habitats accessible to juvenile fish and for their potential to produce and export 'fish food' to other areas. In the CSSP assessment, this class of activities was ranked by survey participants as having high benefits and a high level of agreement across organizations regarding its benefits. Focus to date has been on pulse flows in the Yolo Bypass and coordinated draining and flooding of managed wetlands. These activities have the potential to boost productivity of food resources for both salmonids and Delta smelt (Durand 2015), and improved coordination across initiatives could help to identify focal areas that maximize benefit to both species.
- **Migration and Habitat Connectivity:** Fish distributions and migration routes are a key interest of all parallel initiatives considered given that the locations of fish at any given time will determine their relative exposure to a variety of stressors. In the CSSP assessment, this class of activities was ranked by survey participants as having high benefits and a high level of agreement across organizations regarding its benefits. Coordination of ***acoustic telemetry tracking*** studies implemented across different organizations and initiatives would help contribute to greater continuity in our understanding of migration behaviours for a range of flow conditions across the entire salmonid life cycle (e.g., Notch et al. 2020). Although an extensive telemetry network already exists to support this type of research in the Central Valley, recent reviews have found individual tracking studies to focus on a smaller range of hatchery-origin runs that do not capture the full breadth of salmonid life histories and has recommended expanding the current acoustic tracking program to capture migration and timing information over a wider range of runs, life stages, and geographic regions in real time (Johnson et al. 2017). In addition to telemetry, both the CSSP assessment and the

SRSP Science Plan have highlighted the potential of ***genetic run identification*** through parentage-based analysis as another avenue for gleaning information about (1) the reproductive success of individual spawners in tributaries and (2) the distribution and timing of juveniles from stocks of conservation concern as they move through the Delta. This information could help to improve the value of ongoing long-term monitoring programs and contribute to the development of more targeted application of other activities on this list (Johnson et al. 2017), for example, by identifying the most important habitats to restore based on their usage by specific runs of conservation concern. Better coordination of migration and parentage studies across the parallel prioritization efforts currently underway in the Delta and beyond could play a significant role in filling in the current gaps in our understanding of distribution and migration across all species, run types, and life stages.

- **Predators and Aquatic Weeds:** Activities to monitor and mitigate the impacts of predators and potential predator habitat, including artificial structures and aquatic weeds, feature strongly in all three parallel prioritization processes examined. However, in the CSSP assessment, this class of activities was ranked by survey participants as having moderate benefits and a high level of disagreement across organizations regarding its benefits or the efficacy of meaningfully deterring and reducing the invasive species. This disagreement may be due in part to outstanding scientific uncertainties about the benefits of predator control measures for salmonids given recent findings that direct predator removals appear to have little permanence or effect on the survival of juvenile Chinook salmon in the Delta (Michel et al. 2019, 2020ab). However, new studies are underway to clarify whether management of predator ‘contact points’, especially aquatic weeds, may be more effective than active removal of predators for controlling predation on species of conservation concern in both Delta and riverine habitats (USBR and USFWS 2019, Lehman et al. 2020). The results of this work may help to improve agreement about the potential benefits of this activity for both salmonids and Delta Smelt.

Recommendations for Increasing Alignment Across Parallel Prioritization Efforts

In addition to developing specific implementation plans and cost estimates for selected activities, a more formal effort to coordinate and align insights from these processes is needed to address the following needs:

1. **Create a more formal forum for discussing and working on alignment to work towards a more cohesive, integrated salmonid science strategy for the Central Valley that all parties can support.**
    - This topic is in need of ongoing discussion in a more formalized setting, which may take the shape of a working group of interested parties from across the relevant initiatives that meet regularly to promote alignment on objectives, geographies and approach to trade-off characterization. CAMT and its sub-committees should discuss how best to use the results of this study to inform this process, including conversations around collaboration on areas of agreement but also conversations around how to reconcile (or not) areas of disagreement.

2. **Identifying the common currencies (a) criteria used and (b) portfolio of considered actions/activities to understand what is being compared and look for opportunities to improve efficiencies and reduce redundancies.**

    - Not all plans use the same evaluation criteria; some may consider additional ecological or socioeconomic criteria while others do not, and practitioners must take care when comparing the results of these prioritization processes so as not to compare apples to oranges.
    - Not all plans encompass the same types of activities; some focus on science needs, others on management actions, and others on monitoring needs.
    - Not all plans consider the same geographic scope or temporal horizon; some focus on mainstem and tributaries, others focus on the Delta, with or without consideration of the near-shore estuary and open ocean.

3. **Discussing how to better align and standardize hybrid methodologies to allow species and objective trade-off evaluations at broader spatial scales, including:**

    - How to increase data interoperability across initiatives such that data collected using similar methods and made available in similar formats can improve the potential for the data to be used in different models and contexts. This would help to facilitate combined analyses and data synthesis at broader spatial scales.
    - How and when to hybridize qualitative (interviews, robust opinion surveys) and quantitative (modeling) prioritization methods.
    - How to prioritize across actions with differing levels of information, including the activities that are not possible to represent in life cycle models.
    - What results are found to be in common (beneficially reinforcing) and what activities are in contrast (generate negative trade-offs)? Why?

4. **Clarifying the different and complementary roles of SDM and Adaptive Management in moving forwards towards activity selection and implementation planning that is coordinated across parallel initiatives.**

    - Once final results are available for each initiative, they should be compared to identify likely candidates for more collaborative efforts.
    - These activities should be evaluated in greater detail through to identify trade-offs and support discussions leading to final selection of one or more projects for implementation.
    - Once projects are selected, implementation planning should take place within a broader adaptive management framework that considers outstanding data needs and uncertainties, designs implementation and monitoring plans to maximize learning while doing and provides an overarching framework for considering the interrelationships of related efforts by different initiatives.
    - Implementation planning may also reveal the need for real-time decision support tools for managers tasked with evaluating trade-offs among alternative management responses over daily or weekly intervals.

4 Looking Ahead: Suggested Next Steps

Our work on this assessment paves the way for more focused planning efforts for supporting the resilience of salmonids in the Delta. Here, we outline four recommended next steps for advancing these planning efforts moving forward:

1. Deliberate further on how the results of this study should be used in decision-making, including the role of additional analyses on resulting data.

As noted previously, decisions regarding the focus of CAMT's work on salmonids moving forward will be influenced by a broader range of contexts than it is possible to capture in a screening-level assessment of this nature. Although the results of this study reflect a snapshot of current thinking around priority activities for salmonids in the Delta, they should be viewed as as one of multiple lines of evidence informing decisions about activities to consider further for implementation. Further constructive dialogue amongst the members of CAMT and its sub-committees are needed to determine how this line of evidence feeds into or fits alongside others at its disposal, including field data, modelling exercises, structured decision making processes, and parallel prioritization efforts led by other organizations. The end goal would be to **identify a process and next steps for the scoping, design, and implementation of salmonid science, management, and monitoring actions.**

These deliberations may include a recommendation to explore the survey data further before deciding how it should be used. The rich survey data generated by this study offers many opportunities for additional analyses to yield further insights. Although beyond the scope of this study, the full data set provided along with this final report may be re-examined to further explore:

- The sensitivity of ranking results to methodological decisions (e.g., how extreme responses affected results, how multi-Q statement matching to Activity Statements affected results).
- The activities that were not included on shortlists to determine whether some important activities may have been missed due to the criteria selected for this study,
- The responses of specific organizational groups with respect to activities and criteria to help better understand positions and areas of disagreement,
- The level of within-organization disagreement in survey responses in addition to the level of between-organization responses already reported here, and
- The relationship between shortlisted activities or all activities and key salmonid science and management uncertainties identified in the region to understand whether the activities proposed in past studies and plans are adequately addressing these uncertainties.

Once direction on the role of this study is clear, it can be used to inform the selection of a smaller set of activities to focus on for near-term strategic planning.

2. Leverage the CSSP assessment alongside other lines of evidence to identify a smaller subset of activities to carry forward into implementation planning.

Of the original list of 109 activities we evaluated, 44 appear on shortlists for at least one planning theme. These shortlists reflect a snapshot of practitioner perspectives about the science, management, and monitoring activities most beneficial to salmonids in the Delta as well as key areas of agreement and disagreement about these benefits. This information can be used as one line of evidence alongside others, including field data, modelling studies, and the broader socioeconomic and political context within which implementation decisions must be made.

The next steps for integrating the results of this study into a broader implementation planning framework may differ depending on the planning theme(s) of greatest interest to CAMT and its sub-committees, for example:

- **Theme 1: Activities with the Most Agreement about Benefits**

  These are the actions most likely to deliver benefits for salmonids in the Delta that multiple organizations can get behind. Where other lines of evidence show that actions are similarly beneficial, the results of this theme can inform decisions about which among them might be easier to implement due to level of agreement. However, because these actions are often rated more difficult to implement, some may not be feasible in practice while others will require more careful collaborative implementation planning across multiple partner organizations.

- **Theme 2: Activities with High Agreement and Low Barriers to Implementation**

  These actions should be considered first, especially where they overlap with activities appearing under Theme 1, because they may offer opportunities for “quick wins” that can be implemented with less controversy and along faster timelines. Where other lines of evidence support the benefits of these activities, they can be pursued more quickly than those appearing in Theme 1 alone.

- **Theme 3: Activities with the Least Agreement about Benefits**

  This theme demands further facilitated dialogue amongst participant working groups to better understand the nature of disagreements and develop strategies to increase alignment (e.g., specific science questions and research studies to help reduce uncertainties). The results of this theme can also serve as a ‘reality check’ on other forms of evidence. For example, decision-makers may wish to reconsider or add additional science or stakeholder engagement elements to activities determined to have greater ecological benefits but more disagreement about those benefits.

The results of this study will assist CAMT to more effectively consider the human dimensions of natural resource management decisions in their deliberations on the selection, sequencing, and implementation design of projects intended to benefit salmonids in the Delta as recommended in the Delta’s Science Action Agenda. Once activities are selected for implementation, further work would include identifying inter-dependencies among actions and how actions can best be grouped and sequenced, developing work plans and cost estimates, and developing a strategy for addressing opportunities for collaboration or for overcoming perceived barriers to implementation. This would include careful cross-referencing with agency and other efforts to ensure these activities were not duplicating activities that are already happening. Additionally, as the planning process advances up the nested hierarchy from identifying priority activities to developing broader objectives and goals for addressing uncertainties and enhancing salmonid recovery, the extensive work done by CSSP refiners to develop Q statements during this project can feed into subsequent stages. For example, Q statements themselves can be viewed as preliminary articulations of management objectives.

3. Advance holistic science and management by aligning parallel planning processes to ensure preferred actions balance trade-offs

The diverse array of agencies and overlapping programmatic authorities working to support salmonid recovery in the Delta region have given rise to numerous initiatives each with their own specific mandates, objectives, indicators, tools, assessments, and resulting priority actions. Logical and cost-effective prioritization of monitoring and management activities for the advancement of salmonid science and recovery is difficult with so many overlapping mandates, plans, and different plan geographies (Delta, mainstem rivers, newly connected habitats, key tributaries). The challenge further escalates when competing plan authors narrowly frame the bounds of the decision problem around single species or objectives, thereby inadvertently masking (or incompletely considering) the impacts an action taken for one species or objective has on another. The lack of consistent coordination across these initiatives makes it challenging to understand which science, monitoring, and management actions are most important for salmonid recovery within the Delta ecosystem as a whole. Many surveyors of this landscape will naturally be inclined to ask: *"whose Plan takes precedence?" or "which methods yield the most believable answers?".*

No one agency or stakeholder can achieve all science priorities independently or integrate findings effectively to inform decision-making across agencies. While it may work for a time, siloed efforts will make it harder to achieve a wise balance of priorities that efficiently use available funds. To realize the maximum benefits of collaboration and economies of scale from parallel prioritization initiatives, we recommend planning a **strategic alignment workshop** that brings together key leaders from parallel processes to **converge on a common vision for addressing the questions raised in Section 3.3 specifically for salmonids** (e.g., comparison of criteria, types of actions, arriving at a hybrid methodology to apply at multiple spatial scales). These discussions would also elucidate key synthesis information flows and data that should be shared amongst parallel efforts. This is also distinct from efforts like the Delta Stewardship Council's Science Action Agenda work in that the goal of this synthesis is to choose specific actions to implement in order to proceed with coordinated implementation designs for those actions.

The alignment workshop could also revisit the topic of **science governance** even if that simply clarified the **relationships amongst workgroups** to support broader science coordination and integration across agencies and partners (e.g., to reduce "meeting burnout"). Consensus within discrete planning processes without clear science governance arrangements and streamlined science communication is ineffective. Creation of a more regular system of communication amongst planning processes would enrich insights and catalyze innovation around specific topics.

4. Define a long-term framework for adaptive management of salmonids that keeps pace with emerging science

Many practitioners have called for more proactive adaptive management approaches in the Delta as one approach to help address accelerating environmental change (DISB 2015, 2016; Zandvoort et al. 2018, Tamburello et al. 2018, DSC 2019). While there is broad endorsement of an adaptive management culture in the Delta, the implementation of this approach is limited by institutional constraints (e.g., timely permitting and access to funds) as well as a lack of clarity surrounding its role and the interplay between adaptive management and structured decision making. **Once priority actions are identified for implementation** (e.g., via structured decision making or other methods), **managers will still need to know if they work** (e.g., beyond working "in a model" or "in the opinion" of experts) **and when they don't, learn why**. For many priority actions, managers will have a list of important unresolved critical uncertainties that will strongly influence whether an activity will generate the desired learning or restoration outcomes. These actions will benefit from ongoing adaptive management support. A good place to start would be determining whether there are gaps in existing monitoring programs for prioritized activities that would slow learning efforts. Initiatives like the Delta Independent Science Board's Monitoring Enterprise Review Inventory Tool (DISB 2017, 2019) could be consulted to help identify and close these gaps.

Through its unique mandate and diverse membership, CAMT and the broader CSAMP working groups are well positioned to provide leadership on these recommended next steps and act as a unifying force for increasing coordination and alignment among the many planning initiatives being pursued by its participating organizations. These ongoing efforts will help to further support the resilience of salmonids in addition to the other species and habitats that contribute to a functioning Delta ecosystem.

5 References

Note that this list includes only references cited in the text – key references reviewed to extract potential activities for evaluation in surveys are provided separately in Appendix B.

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Appendix A: Interview Participants and Questions

Table A1: List of key experts interviewed at the outset of this project with the dates and times of interviews. Interviewees highlighted in bold are also members of the CAMT Salmonid Sub-committee.

Affiliation	Confirmed Interviewees
Bureau of Reclamation	**Dave Mooney** **Josh Israel**
NOAA	**Maria Rea** **Cathy Marcinkevage** Steve Lindley Rachel Johnson
Fish & Wildlife Service	Dan Castleberry Jeff Mclain
DFW	Kevin Shaffer **Brycen Swart** **Carl Wilcox**
State Water Resources Control Board	Erin Foresman Stephen Louie
DWR	Jason Kindopp Brett Harvey
PWA	Jennifer Pierre Tom Birmingham Chuck Hanson **Alison Collins** Sheila Greene Brad Cavallo
NGOs	**Rene Henery** Dick Poole
Sac Settlement Contractors	**Thad Bettner** **Lewis Bair**
Independent Science Review Board Lobo Review Panel	Steve Brandt Jim Anderson **Pascale Goertler**
DSP	Steve Culberson John Callaway
Salmon Integration Team	Rod Wittler
Other Experts	Mike Chotkowski (USGS) Peter Moyle (UC Davis) Rebecca Buchanan (UW)

Table A2: List of interview questions posed to interview participants above.

CSSP Assessment Interview Questions
1. Can you tell us about ***yourself and your role*** or relationship to salmonid management in the Delta Region? What types of key decisions do you need to make in this role?
2. What are the top 3 to 5 ***key (i) scientific uncertainties and (ii) management uncertainties most affecting salmonid management*** in the Delta region? (Including, for example, scientific uncertainties associated with BiOp, RPAs). For Steelhead? For different run types of Chinook?
3. What are the ***highest priority science investigations*** currently being done or that need to be done to reduce uncertainties related to improving the survival and resilience of salmonids? What species, life stages, and spatial scales are these investigations targeting? (e.g., to efficiently test hypotheses and close knowledge gaps related to management actions in the Delta)
4. What are the ***highest priority Delta conservation and resiliency actions*** needed to support near-term management decisions to improve survival of salmonids? What species, life stages, and spatial scales are they targeting? (e.g., including relative focus on role of water operations versus other types of actions such as habitat restoration, invasive species management, etc.)
5. What is the most ***essential monitoring*** to support assessment of effectiveness of Adaptive Management actions? What species, life stages, and spatial scales are they targeting?
6. In your opinion, what are the most important ***barriers or constraints*** limiting the effective implementation of salmonid management and monitoring activities? For example, lack of funding, ineffective flow of information between data collection and decision-making, logistical challenges, etc.
7. In your opinion, what current salmonid management and monitoring ***activities need to be modified*** (i.e., management or monitoring activities to stop doing, do more or less of, or otherwise adjust)?
8. Do you have further recommendations for ***key studies, reports, planning documents, experts***, or other information sources that should be consulted as part of this work? We are particularly interested in reports on the key uncertainties and stressors mentioned earlier.
9. Could you ***share your priorities for the future state of science in this system?*** That is, what types of information would you in particular like to see more of and have at your disposal going forward to help make the science, conservation, and management decisions your role requires?
10. To close our interview, can you give us your thoughts on your ***desired future state of salmonids in the Delta system,*** particularly given environmental changes that will continue to unfold with climate change?

Appendix B: List of Key References Consulted

This table summarizes the list of 35 key references consulted to extract potential science, management, and monitoring activities to add to the list of activities to be prioritized. This list was condensed from a larger list of 44 references supplied and later triaged by the CAMT Salmonid Sub-Committee to arrive at the final list below.

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3	Salmonid Scoping Team. 2017. Effects of Water Project Operations on Juvenile Salmonid Migration and Survival in the South Delta. Prepared for the Collaborative Adaptive Management Team. Vol. 1.
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16	USFWS. 2019. USFWS Biological Opinion For the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project and State Water Project. Service File No. 08FBTD00-2019-F-0164. October 2019.
17	California Department of Fish and Wildlife, US Fish and Wildlife Service, NOAA National Marine Fisheries Service. 2014. Conservation Strategy for Restoration of the Sacramento-San Joaquin Delta, Sacramento Valley and San Joaquin Valley Regions.
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21	California Department of Water Resources. Clifton Court Forebay Predation Studies - Appendix G
22	U.S. Bureau of Reclamation (USBR). 2018. NMFS Biological Opinion RPA IV.2.2: 2013 Six-Year Acoustic Telemetry Steelhead Study. Contributions by: R. Buchanan, . Brandes, J. Israel, and E. Buttermore. U.S. Bureau of Reclamation. Bay-Delta Office, Mid-Pacific Region, Sacramento, CA. FINAL REPORT. June 2018, 213 pp.
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Appendix C: List of Q Survey Participants

Table C1: Names and affiliations of the 50 participants who participated in the full Q Survey out of 61 invited to participate.

Category	Affiliation	Name
Federal Agency	Fish & Wildlife	Adam Nanninga
		Bryan Matthias
		Jeff Mclain
	NOAA	Barb Byrne
		Brian Ellrott
		Cyril Michel
		Evan Sawyer
		Garwin Yip
		Howard Brown
		Jeff Stuart
		Kate Spear
		Rachel Johnson
		Steve Lindley
	USBR	David Mooney
		Josh Israel
		Mike Beakes
		Rod Wittler
State Agency	DFW	Brooke Jacobs
		Carl Wilcox
		Dan Kratville
		Jonathan Nelson
		Ken Kundargi
	DSP	John Callaway
		Pascale Goertler
		Steve Culberson
	DWR	Brett Harvey
		Erik Loboschefsky
		Jason Kindopp
		Mike Roberts
		Ted Sommer
	SWRCB	Erin Foresman
		Stephen Louie
PWA	Glen-Colusa Irrigation District	Thad Bettner
	Hanson Environmental	Chuck Hanson
	Metropolitan Water District of Southern California	Alison Collins
	Northern California Water Association	Todd Manley
	Santa Clara Valley Water District	Frances Brewster
	Westlands	Sheila Greene
NGO	Baykeeper	Jon Rosenfield
	California Trout	Jacob Katz
	Nature Conservancy	Julie Zimmerman

Category	Affiliation	Name
	NRDC	Doug Obegi
	Water4Fish	Dick Poole
Other Expert	Anchor QEA	John Ferguson
	Cramer Fish Sciences	Steve Zeug
	FlowWest	Mike Urkov
	Independent Consultant	Noble Hendrix
	UC Davis	Peter Moyle
	University of Washington	Jim Anderson
	University of Washington	Rebecca Buchanan
	USGS	Russ Perry

Table C2: Response rates of invited Q Survey participants by affiliation category.

Group Affiliation	Invited to Respond	Response Rate
Federal Agency	19	89%
State Agency	17	88%
PWA	8	75%
NGO	6	67%
Other Expert	11	73%
TOTAL	**61**	**82%**