Collaborative Adaptive Management Team Assessment of Long-term Monitoring Reviews and Objective

Final Summary Report for Task 2: Compile and Communicate Information Regarding CSAMP Member Objectives

September 1, 2022

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Purpose Statement

The Collaborative Adaptive Management Team (CAMT) Assessment of Long-term Monitoring Program Reviews and Objectives (Assessment) was initiated in September 2021 to:

1. Understand the approaches, findings, and recommendations of previous and ongoing reviews of monitoring programs (Task 1); and
2. Articulate the objectives of Collaborative Science and Adaptive Management Program (CSAMP) members with respect to monitoring (Task 2).

Information from the Assessment will inform future CSAMP discussions aimed at catalyzing improvements to the long-term monitoring network of the Sacramento-San Joaquin Bay-Delta.

This document summarizes Task 2 of the Assessment and is based on a CSAMP Policy Group workshop held in March 2022 and responses to a monitoring questionnaire distributed to CSAMP members in April 2022.

Findings from Task 1 of the Assessment are documented in a summary report released by CAMT in January 2022 which is available at: https://csamp.baydeltalive.com/docs/25921.

The term "monitoring" as used herein includes routine data collection activities as well as data collected through special studies or other targeted research.

Salient Themes

The following lists several themes that emerged from the March 8, 2022 CSAMP Policy Group workshop, responses to the monitoring questionnaire distributed to CSAMP members and dialog among CAMT members regarding the information received. The themes represent common, or reoccurring comments provided by CSAMP members. **They do not necessarily reflect the opinions of all CSAMP members.**

1. **CSAMP members share common objectives for monitoring.** All CSAMP members indicated that they rely on the existing monitoring programs for:
    - Status and trends;
    - Real-time information, including regulatory compliance; and
    - Assessing the effectiveness of management actions.

    CSAMP members also expressed a common interest in ensuring that the various monitoring programs are effective at achieving the three objectives listed above. CSAMP members have expressed differences of opinion about how to balance the allocation of resources to achieving the different objectives, and who should be responsible for funding various data collection activities (see Salient Theme 4 below).

2. **The existing monitoring programs are providing valuable information, but there are gaps in information and opportunities to improve the accuracy and utility of the data provided.** Many of the existing programs such as the pelagic fish surveys, EDSM, tidal marsh monitoring and the acoustic telemetry arrays are critical to understanding ecosystem status and trends and are central to regulatory compliance. That said, more information on gear efficiencies, examination of littoral habitats and additional monitoring techniques would improve the quality and utility of the data provided, and could improve the accuracy of life cycle models and other predictive tools. There is also a recognition among CSAMP members that the Delta environment is changing rapidly with climate change, sea level rise and invasive species, particularly aquatic weeds, and that the monitoring programs should be flexible enough to address such changes.

3. **Additional supplemental data may be needed to fully assess the effectiveness of specific management actions, depending on their objectives.** Long-term status and trends data on species presence and other biological conditions are typically collected at several different time steps over large geographical areas. Management actions frequently operate at shorter time steps (hourly or daily) and/or require finer spatial scales to understand the outcomes of the actions**.** Relying on data from long-term status and trends surveys may not be sufficient on its own to assess the effectiveness of specific management actions. The scale of the monitoring should be relevant to the variables being measured.

4. **There is interest in a frank policy-level discussion regarding the resources dedicated to monitoring and assessment activities, whether current resources are sufficient to track status and trends and support the management decisions that need to be made, whether resources are appropriately balanced between long-term status and trends, real-time compliance and effectiveness data collection activities, and whether additional sources of funding should be pursued.** Several CSAMP members expressed interest in tailored monitoring designed to assess the effectiveness of various management actions on top of the need to track long-term status and trends. In their opinion, this should include sustained resources to analyze, synthesize and disseminate information. This may also include dedicated capacity to support timely and integrated review of monitoring activities and to support an ongoing policy-science dialog, including implementation of review recommendations. Some CSAMP members have noted that current assessment activities are often delayed and fragmented. There is an interest in discussing how to achieve an appropriate balance between various data collection activities, and how best to fund those activities. CSAMP members are interested in examining what monitoring is needed, how its funded and whether additional state and federal funding should be pursued for activities providing broad public benefits, similar to other national estuary monitoring programs.

1. Background

The Collaborative Science and Adaptive Management Program (CSAMP) is a voluntary collaboration of seventeen (18) entities representing state and federal agencies, public water agencies and non-governmental organizations (see Box 1). In the summer and fall of 2021, CSAMP members expressed heightened interest in ensuring that environmental monitoring programs are responsive to current management needs. CSAMP members agreed that multiple reviews of monitoring programs have been conducted over recent decades, but there is not a shared understanding of what these previous review efforts have covered, how they have been conducted, or whether recommended changes have been implemented. To properly inform future monitoring program review efforts and at the direction of CSAMP, the Collaborative Adaptive Management Team (CAMT), which is an element of CSAMP, embarked on an **Assessment of Long-term Monitoring Program Reviews and Objectives** (Assessment).

The first task of the Assessment was to summarize selected previous and ongoing review efforts to set the stage for consideration and planning for future efforts. Findings from Task 1 are documented in a summary report released by CAMT in January 2022, which is available at: https://csamp.baydeltalive.com/docs/25921.

The second task of the Assessment was to **compile and communicate information on the monitoring objectives for CSAMP members**. Findings from both tasks of the Assessment will jointly inform recommendations for next steps as CSAMP and its member entities work collectively to advance a robust process for evaluation and modification of Bay-Delta monitoring programs.

This document summarizes Task 2 of the Assessment and is based on a CSAMP Policy Group workshop held on March 8, 2022 and a set of monitoring questions (see Box 2) **sent to CSAMP Policy Group members in April 2022.** Findings from Task 2, as presented herein, include CSAMP member objectives for, and uses of monitoring data, as well as opinions regarding what is working well and where there are opportunities for improvements. It should be noted that information presented herein represents the perspectives of CSAMP members. These findings should not be viewed as a comprehensive assessment of all stakeholders engaged in, or relying upon data from the Bay-Delta monitoring enterprise. Appendix 1 lists individuals and their affiliations that participated in the March 8, 2022 workshop.

The term “monitoring” as used herein includes routine data collection activities as well as data collected through special studies or other targeted research.

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Box 2. Monitoring Questions

The following questions were used for both the March 8, 2022 Policy Group workshop and written questionnaire distributed to CSAMP members:

1. **Why do you want monitoring? What data do you currently use and for what purposes?**
2. **What are the key questions you would like to see addressed by monitoring?**
    a. **Which do you think are being adequately addressed with current monitoring?**
3. **Are there aspects of the monitoring enterprise that you think are working well?**
    a. **If yes, please specify**
4. **What changes would you like to see to the Monitoring Enterprise to support improved management of the Delta?**
    a. **Are there changes to current monitoring schemes that you would suggest to better serve adaptive management decision making?**
    b. **Are there data that are not being collected that you think should be, and why?**
    c. **Do you have suggestions for how to balance long-term data collection needs (ecosystem health and species status and trends) with monitoring to assess specific management action performance (i.e. habitat restoration, flow actions) to support adaptive management opportunities?**
    d. **Are there examples of management actions or management issues that you think need better monitoring support?**

Written responses to the questions listed in Box 2 above were received from nine CSAMP members (USBR, USFWS, NMFS, CDFW, DWR, WWD, MWD, KCWA and the Coalition for a Sustainable Delta) and CSAMP's NGOs community, who submitted a single response representing six NGO entities (TBI, Natural Resources Defense Council, TNC, Defenders of Wildlife, Golden State Salmon Association and Pacific Coast Federation of Fisherman's Associations). The Coalition for a Sustainable Delta response did not address the questions asked, but rather provided an alternative suggested approach for assessing the current monitoring and developing a revised monitoring framework. Interviews were conducted for three additional CSAMP members (SWRCB, GCID and CCWD) who did not provide written responses. The same questions listed in Box 2 above were used for the interviews.

2. Summary of CSAMP Policy Group Workshop Input

The following reflects input received from individual CSAMP Policy Group members during the March 8, 2022 CSAMP Monitoring Workshop. Items listed are not intended to represent consensus opinions.

1. Existing monitoring programs are serving a diverse array of purposes including supporting regulatory permit requirements and providing information on overall ecosystem health.
2. CVP and SWP contractors are funding the vast majority of the monitoring, including activities that are not directly related to assessing the impacts of project operations.
3. We need both short-term monitoring targeted at informing management of the projects and long-term data, but we should look at the value of the information to whom and set funding obligations accordingly to achieve a more equitable split.
4. We should step back, assess what's needed, how the monitoring is funded and whether additional state and federal funding should be pursued for activities providing broad public benefits, similar to other national estuary programs such as Puget Sound. This could be done as part of Task 3.
5. We could benefit from a more systematic approach to monitoring and monitoring reviews. What are we trying to achieve with specific monitoring and synthesis activities.
6. We need to be realistic about the resources we have to conduct monitoring and synthesis. Step back and ask whether the resources expended are sufficient to support the management decisions that need to be made.
7. Reviews need to be timely with a greater sense of urgency. Currently changes are being made at the same time that review recommendations are being developed. Timeliness requires capacity and commitment.
8. We need dedicated staff and resources to create space for an ongoing policy-science dialog regarding monitoring activities, including implementation of review recommendations. This should include sustained resources to analyze, synthesize and disseminate information (i.e. the "assessment" part of an environmental monitoring and assessment program). Assessment activities are often delayed and fragmented in our system.
9. We should be open to, and embrace cultural change where it may be needed, but recognize that it can be challenging and requires a good communication plan from the Director's level.
10. We need to better support adaptive management and improve learning. We may need to consider reallocating resources and funding obligations to free up funds to better support adaptive management.
11. Consider a standing manager-scientist partnership, across agencies.
12. We need more sophisticated conceptual models of the system (e.g. ecosystem processes, species life histories) and monitoring should be designed to track these.
13. Monitoring reviews should include participation of individuals charged with collecting the data so that recommendations are grounded in reality, including logistical considerations.
14. Don't limit ourselves to the current state. Think outside the box.
15. We need to consider that the Delta is changing rapidly, and we should look at confounding factors.

3. Summary of Monitoring Questionnaire Responses

3.1 Why CSAMP members want monitoring data, and what they use it for

The three primary objectives noted by CSAMP members for monitoring data were to support:

1. Status and trends;
2. Regulatory compliance/real time management; and
3. Evaluating the effectiveness of management actions.

A few CSAMP members also noted that they use monitoring data to support:

4. Modeling; and
5. Targeted research

All CSAMP members polled indicated that they relied on monitoring data to provide information on long-term status and trends and ecosystem change, including emerging climate conditions. Members noted that this information is helpful for tracking Bay-Delta species that are characteristic, representative, or of special concern, and tracking the underlying ecosystem processes that affect species viability. Those CSAMP members with regulatory responsibilities such as the National Marine Fisheries Service (NMFS) also indicated that they rely on status and trends data to inform regulatory processes including section 7 consultations, progress towards meeting demographic and threats-based recovery criteria, and 5-year status reviews.

With regards to regulatory compliance/real time information, monitoring data is used by state and federal agencies responsible for issuing permits, such as the State Water Resources Control Board (SWRCB) and the US Fish and Wildlife Service (USFWS), and by permittees such as the US Bureau of Reclamation (USBR) and the California Department of Water Resources (DWR) to ensure compliance with specific terms of their permits. Data used includes real time information on physical parameters such as flows and salinity, and biological parameters such as salmon and steelhead presence and distribution in the Delta. Real time information is also used by DWR and USBR to support water operations management decisions regarding water storage and deliveries.

Several CSAMP members also indicated the need for monitoring data to evaluate the effectiveness of management actions, including information on whether there is a biological response to an action (e.g. response in the distribution or abundance of Delta smelt to the Suisun Marsh Salinity Control Gate Action). Some members also noted the role of effectiveness monitoring in an adaptive management context where such information can help to assess outcomes of multiple actions or actions with a high degree of uncertainty. Specific responses provided by CSAMP members are provided in Appendices 3 and 4.

3.2 Key questions CSAMP members want to see addressed by monitoring, and which are being adequately addressed with current monitoring

Most of the questions that CSAMP members identified that they would like to see addressed by monitoring were related to either status and trends or effectiveness monitoring of management actions. Questions related to status and trends tended to focus on basic characteristics of the ecosystem such as:

- What are the biological communities of the Bay-Delta and watersheds? How have these communities changed over time, why did they change, and are they continuing to change?
- What are the population trajectories for listed fishes and species of management interest (e.g., Delta Smelt, Longfin Smelt, all runs of Central Valley salmonids, Green and White Sturgeon)?
- What are the trends in key water quality components of the Delta (e.g., turbidity)?

A number of the questions focused specifically on understanding food web dynamics and population characteristics for specific species, including abundance estimates for adult and juvenile life stages.

Questions related to effectiveness monitoring tended to focus on whether management actions, including regulatory actions are having their hypothesized effect(s). For example:

- Does proposed operation of the Suisun Marsh Salinity Control Gate (SMSCG) expand the overlapping critical habitat elements of Delta Smelt and how did fish communities respond?
- Does restoring tidal habitat result in changes to the density, composition, or distribution of planktonic organisms?
- What is the impact of Delta Smelt supplementation on overall population densities, distribution, and abundance?
- How does the spatial distribution and/or levels of salinity change in response to drought management actions (e.g. salinity barriers)?

Specific management actions mentioned, in addition to the SMSCG included: North Delta Food Web enhancement; tidal marsh restoration; floodplain restoration and food supplementation from flooded rice lands; and spring, summer, and fall flow actions.

Other specific questions identified by CSAMP members included:

- What are the effects of extended dry conditions and the effects of invasive aquatic vegetation on habitat suitability for species of interest?
- What are the effects of contaminants on species of concern?
- What suites of mechanisms are limiting the production of delta smelt, longfin smelt and other native fishes of the Bay-Delta?

- What suites of mechanisms are limiting salmonid and sturgeon survival in the Bay-Delta?
- Where do supplemental Delta Smelt migrate to outside of the release site and supplementation specific studies?
- Understanding how specific management actions affect species of concern (Delta Smelt, Longfin Smelt, Winter Run and Spring Run Salmon).
- Understanding flow management effects on the ecosystem and the mechanisms therein.
- What are the effects of management actions such as spring pulses?

When asked about which questions are being adequately addressed with current monitoring, respondents suggested that questions regarding what biological communities are in the estuary (both planktonic and fish communities) are well documented (including trends in these communities over time), but questions regarding population abundance estimates and drivers of change, particularly for ecosystem processes and management interventions, are not as well addressed by the current monitoring. As one CSAMP member said:

> *"We have done a very good job describing what species we have in the estuary's biological communities. We have gotten better over time with understanding drivers of variation in salmon survival, but there is still good work that could be done. We have done okay with drivers of ecosystem change but the programs were not really designed to get at that kind of ecological detail and so results have varied."*

As another CSAMP member said:

> *"Long-term monitoring programs are often leveraged for effectiveness monitoring of management actions, though more work needs to be done to understand the power of these datasets to detect responses, ensure appropriate regional balance, and possibly provide for short-term, supplemental, data collection to ensure robust effectiveness monitoring."*

One CSAMP member suggested that rather than asking for "*key questions*" or "*management questions*" or "*questions of management relevance*", we should be thinking in terms of "*what decisions that you make are adequately informed by the monitoring and/or are sensitive to uncertainty that could be reduced with monitoring data*?" Specific responses provided by CSAMP members are provided in Appendices 2 and 3.

3.3 Aspects of the monitoring enterprise that CSAMP members think are working well

CSAMP members identified several aspects of the existing monitoring enterprise that in their opinion are working well, particularly for status and trends. Specific information, and/or programs mentioned included:

- Physical parameters, such as flow, salinity and temperature are adequately covered by current monitoring programs.
- Existing monitoring provides useful information for real-time operations.
- Abundance indices provide useful information on population trends and distribution.
- Carcass surveys and Red Bluff juvenile monitoring screw trap data are good for assessing broad scale increases or decreases in juvenile salmon production and adult returns.
- Rotary Screw Trap (RST) data from upstream of the Delta combined with the Delta Juvenile Fish Monitoring Program (DJFMP) sampling in the Delta do a good job of showing timing of presence of different species/runs and lifestages.
- EDSM works well for monitoring status and trends, assessing spatial distributions, and providing information for population modeling of Delta Smelt.
- Acoustic tag (AT) arrays are good in terms of how they have been redesigned. The implementation of more tag studies has also been good.
- Yolo Bypass monitoring is a good example of an effective monitoring and research hybrid program.
- We have done a very good job describing what species we have in the estuary's biological communities. The Bay Study is maybe the best macroscopic look at the estuary's biota.
- Monitoring for adult winter-, spring-, and fall-run Chinook salmon abundance has produced long-term datasets for key watersheds.

Several CSAMP members also mentioned areas where in their opinion monitoring was being done well with regards to specific management actions, data management and the adoption of new technologies. Comments included:

- There has been increased transparency in data transparency, QA/QC of data, and improved synthesis of data.
- Agencies are moving towards open and transparent data accessibility practices that will lead to greater reproducibility and the use of this information in informing water and fish management decisions.
- Current plans for the SMSCG and north Delta food web enhancement provide the basis for evaluating the efficacy of the actions.
- The monitoring associated with the Fish Restoration Program (FRP) was designed in an adaptive management framework to understand the benefits of tidal marsh restoration required under ESA and CESA permits for operation of the SWP. The framework also allows for the methods to be replicated by others as other habitat restoration projects are constructed.

3.4 Changes that CSAMP members would like to see to the Monitoring Enterprise to support improved management of the Delta

The following sections present CSAMP member suggestions regarding: (1) current monitoring schemes; (2) specific data needs; (3) how to balance long-term data needs with monitoring to support specific management actions; and (4) management actions that need better support.

3.4.1 Suggested changes to current monitoring schemes to better serve adaptive management decision making

CSAMP's NGO members noted that ongoing, long-term monitoring efforts should not be discontinued or radically changed, but augmented by elements such as improved larval sampling and wider use of isotopic fingerprinting. NGO members noted two specific areas where monitoring program should be relevant to resource management:

1. Incorporation of relevant goals and objectives: monitoring data should be relevant to assessing progress toward or attainment of scientific or policy thresholds for desired biological or ecological response; and
2. Adaptive management – more effort should be made to:
    a. incorporate decision trees: monitoring data should be relevant to decision triggers that catalyze new or modified management actions in response to change in status and trends and progress toward goals and objectives.
    b. incorporate conceptual models and hypothesis testing to monitoring regimes, i.e., monitoring data should be relevant to hypothesized effects associated with planned management actions.

Suggestions made by other CSAMP members tended to focus on:

1. Improved integration and accountability, including more continuity and higher resolution discussion at the policy-science-monitoring interface; and
2. Improved effectiveness monitoring.

Comments regarding **integration and accountability** included:

- Examine if there are overlapping or redundant monitoring programs or projects, and if so, how to integrate them into one monitoring program to achieve the same results while saving resources and costs (e.g. there are several monitoring programs related to delta smelt that are fairly similar).
- Discuss how to best manage all the monitoring programs or projects in the Bay-Delta to achieve a set of common goals the science and natural resource management community desires.
- Monitoring is currently being funded and maintained by different parties under different contracts.
- Adaptive management decision-making would benefit from more sustained attention to monitoring programs and ensuring their relevance.

Comments regarding **effectiveness monitoring** included:

- Develop a clear understanding from the stakeholder community of what information is needed to better test and evaluate the effectiveness of management actions to inform potential changes.
- Develop a clear understanding among all stakeholders about what level of certainty is needed before new special studies or monitoring efforts are initiated.
- Changes are needed to improve monitoring of species abundance. Methods used to collect data need to be tailored to the species for which data are being collected, and what level of certainty is needed with the estimate.
- As it stands, evaluation of the effectiveness of many management actions is done by leveraging existing status and trends monitoring rather than by targeted monitoring specific to evaluating the intended biological outcomes of the management action and informing adaptive management.

Other suggestions included:

- Are emerging technologies and modeling tools being used to the fullest and most strategic extent possible? For example, can remote-sensing tools be deployed for multiple purposes to map ecosystem components (e.g., HABs, aquatic vegetation, turbidity)? What about modeling tools for spatial interpolation of conditions? Could strategic use of technology and tools reduce the need for on-the-ground monitoring?
- The outcomes of the special studies that were a result of the 2017 Salmon & Sturgeon Assessment of Indicators by Lifestages (SAIL) should be synthesized and evaluated to determine whether programmatic changes to the monitoring networks for salmon and sturgeon are needed.
- Current programs for nutrients and contaminants should be evaluated at a comprehensive scale (full Bay-Delta region) to develop recommendations for ensuring appropriate spatial coverage, avoiding duplicative data collections, and assessing coverage for key constituents.

3.4.2 Suggestions for additional data that should be collected, and why

The following provides a listing of data that CSAMP members indicated they think should be collected, and why:

- Data on Aquatic Vegetation and Harmful Algal Blooms (HABs)
  - There is no sustained program for monitoring coverage and species composition of aquatic vegetation, yet we know that this aspect of the ecosystem is growing and having a major effect on ecosystem function.
  - A consistent program for harmful algal blooms and their toxicity needs to be implemented, with effective and timely pathways for reporting out, including the potential for an early warning system and public notifications. Ideally, a HABs monitoring program would help illuminate the drivers of bloom events.
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- Data on Gear Efficiency - All monitoring programs, including EDSM, need to conduct auxiliary experiments to quantify gear efficiency and availability to the gear for target management species. This is a major theme of most monitoring programs, not just those in the Delta. Resolving major sources of observation error, such as size-based selectivity of nets or gear avoidance, improves the accuracy of estimates derived from monitoring data and leads to greater resolution of the variation in catches related to abundance. Quantifying gear efficiency can facilitate more accurate assessments of trends and status and more precise life cycle model estimates of population dynamics. NMFS noted that "*limited trap efficiency runs (or access to those runs) make it difficult to use RST data for estimating abundance, and even (given changes in flow-related trap efficiency) to compare between years at a given RST location".*
- Data on Food Web Dynamics - How nutrients and hydrodynamics result in productivity that supports fish populations and how these rates of production vary in space and time is not well understood. Significant changes in the fish community seem to be related to changes in food web, so understanding the mechanics and drivers of the food web can reduce the uncertainty about how important these changes are to native fish.
- Data on Specific Life Stages and Data to Improve Life Cycle Models – The NGOs noted that there is "*generally good coverage of occurrence and distribution, but need to improve monitoring of early life history stages (e.g., larval smelt, salmon fry)*" Data could also include life cycle monitoring and life stage survival (or bottlenecks) and parentage-based tagging and expansion of our genetic tool sets.
- Data on Steelhead and Spring-run salmon in the San Joaquin Tributaries - More data on abundance, distribution, productivity, and diversity need to be collected to understand their biological status and inform management decision making. This includes evaluation of the resident form of O. mykiss to the viability of the anadromous form.

3.4.3 Suggestions for how to balance long-term data collection needs (ecosystem health and species status and trends) with monitoring to assess specific management action performance (i.e. habitat restoration, flow actions) to support adaptive management opportunities

Several CSAMP members suggested that there is need to balance sources of the funding. Specific suggestions included:

- Establish long term dedicated funding to perform action-specific monitoring, and associated adaptive management, including funding for data synthesis, analysis, reporting, and public portal access opportunities.

- Prioritize funding from the projects for monitoring to assess management action performance and to support adaptive management. Public funding or funding from other sources can be used to support the long-term data collection needs.
- Expand allocation of responsibility for long term monitoring program funding.

Other responses included:

- Greater coordination and innovation of monitoring will be needed to meet the balance of long-term data collection and specific management action performance.
- Modeling can play an important role in balancing. We can apply historical data to quantitative models to simulate long-term trends and evaluate the performance of management actions to support adaptive management opportunities.
- The balance should be based on the usefulness of the information - data is only as good as its analysis. We need to improve our ability to analyze the data collected and incorporate that data into decision making.
- Monitoring to assess specific management action performance and species status and trend and ecosystem health may have some overlapping, but also some independent measures. Not all measures will meet all needs, so agencies responsible for certain needs (ecosystem, species, management actions) should provide sufficient information so mutual interests and independent interests can be identified.
- Consider maintaining a core set of stations that collectively represent the physical and biological habitat of the system and that are used to document trends over time. This core set of stations could be enhanced as needed for effectiveness monitoring of management actions. Developing a system like this would take significant work and discussion for each parameter of interest (e.g., water quality, plankton, and fish species of interest would all need separate and devoted attention).

3.4.4 Examples of management actions or management issues that CSAMP members think need better monitoring support

CSAMP members identified the following example management issues as needing better monitoring support in their opinion:

- Adaptive management of tidal wetland restoration sites may need enhanced investigations of effective and efficient monitoring techniques for coverage of aquatic vegetation (e.g., consistent use of UAVs). There also need to be special studies for investigation of experimental control actions.
- Toxicity and prevalence of Harmful Algal Blooms specifically for drought management actions may need increased support in some years and would benefit from robust data collections when salinity barriers are not in place, for the sake of comparison.

- Dedicated support for analysis, synthesis, and reporting of monitoring data is also needed and should be hard-wired into development of any new monitoring program.
- Increasing access to managed floodplains and rice fields offers great potential for improved juvenile salmonid growth, but risks to adult and juvenile survival need to be monitored.
- The changes that are occurring in the ecosystem as a result of climate induced changes need better documentation in order to improve forecasting and development of management actions
- Expand overall monitoring, and the number of qualified parties contributing funding, and create a consistent hub (One Delta One Science).
- Flow based management decisions need support. We need to collect and analyze data to determine if there is a cause-and-effect relationship that gives rise to the flow-abundance relationships to hopefully identify the underlying biological mechanisms.
- More discussion regarding spring run JPE. JPE estimates drive operations, but there are shortcomings in RST detection. Good at catching fry, but not yearlings. Need to capture all the life stages of interest.
- Consider some scenarios using the WRLCM to test sensitivities. This would help prioritize investments. Test through simulation before we implement changes to monitoring.
- Ensure the practitioners (monitoring and analyst staff) are part of the conversation.
- Provide more openness and collaboration, including data sharing (e.g. allow stakeholders to participate in iTag discussions regarding acoustic telemetry array).

Appendix 1. List of Attendees at March 2022 Workshop

The following tables provide a list of individuals, with their affiliations, that attended the March 8, 2022 CSAMP Workshop on monitoring objectives.

Table 1 – CSAMP Policy Group members that attended the March 8, 2022 workshop on monitoring objectives.

Full Name	Affiliation
Steve Arakawa	Assistant General Manager, Metropolitan Water District of Southern California
Tom Birmingham	General Manager, Westlands Water District
Gary Bobker	Conservation Director, The Bay Institute
Ernest Conant	Regional Director, US Bureau of Reclamation
Mike Conroy	Pacific Coast Federation of Fishermen's Association
Joaquin Esquivel	Chair, State Water Resources Control Board
Lenny Grimaldo, for Karla Nemeth	California Department of Water Resources
Jessica Pearson, for Susan Tatayon	Delta Stewardship Council
Jennifer Pierre	General Manager, State Water Contractors
Bill Phillimore	Coalition for a Sustainable Delta
Donald Ratcliff, for Paul Souza	US Fish and Wildlife Service
Kate Spear, for Barry Thom	National Marine fisheries Service
Deanna Sereno, for Marguerite Patil	Contra Costa Water District
Carl Wilcox, Representing Chuck Bonham	California Department of Fish and Wildlife

Table 2 – CAMT members and CSAMP member staff that attended the March 8, 2022 workshop on monitoring objectives.

Full Name	Affiliation
Bruce DiGennaro	Essex Partnership (Facilitator)/CSAMP Program Manager
Jerry Robbins	San Luis & Delta-Mendota Water Authority
Chuck Hansen	Consultant to State Water Contractors
Laurel Larson	Independent Lead Scientist, Delta Stewardship Council
Steve Culberson	IEP Lead Scientist/Delta Science Program, Delta Stewardship Council/CAMT Member
Amanda Bohl	Delta Stewardship Council
Samuel N Luoma	NGO representative/CAMT Co-Chair
Erin Foresman	State Water Resources Control Board
Heather Casillas	US Bureau of Reclamation
Shelly Cartwright	Westlands Water District
Mark Lubell	UC Davis
Brooke Jacobs	California Department of Fish and Wildlife
Patrick Coulston	CA Department of Fish & Wildlife
Jennica Moffat	Delta Science Program, Delta Stewardship Council
Darcy Austin	State Water Contractors/CAMT Member

Full Name	Affiliation
Shawn Acuna	Metropolitan Water District of Southern California
Karen Gehrts	CA Department of Water Resources
Deanna Sereno	Contra Costa Water District
Lynda Smith	Metropolitan Water District of Southern California
Dana Lee	FishBio – Friant Water Authority
Erwin Van Nieuwenhuyse	US Bureau of Reclamation
Frances Brewster	Santa Clara Valley Water District/CAMT Co-Chair
Rene Henery	Trout Unlimited/CAMT Member
Yuan Liu	Contra Costa Water District
Brad Cavallo	Cramer Fish Sciences - Metropolitan Water District of Southern California
Deanna Sereno	Contra Costa Water District
Scott Hamilton	Hamilton Resource Economics – Coalition for Sustainable Delta
Stephen Maurano	National Marine Fisheries Service
Lauren Hastings	Delta Science Program, Delta Stewardship Council
Joshua Israel	US Bureau of Reclamation

Appendix 2. Questionnaire Responses Received from CSAMP Members Organized by Question

1. Why do you want monitoring? What data do you currently use and for what purposes?

Status and Trends

Entity	Response
DWR	• DWR values tracking the status and trends of physical conditions and biological communities in the Delta to understand ecosystem change, particularly regarding how changed could impact SWP operations and the outcomes of tidal wetland restoration projects, as well as other ecosystem services, such as drinking water.

USBR	• Monitoring is necessary for evaluating the status and trend of species and habitat conditions in rivers and the estuary, where the CVP operations potentially impacts these resources. This includes:
	  • Primary Production (Algal communities that are desirable, less desirable, or harmful)
	  • Secondary Productivity (Zooplankton, Macroinvertebrates, Mollusks)
	  • Juvenile Fish Abundance and Productivity
	  • Community Assemblages

KCWA	• Consistent with Reynolds et al., we recognize the importance of status and trends monitoring (necessary to understand the system over time), • We also use data to determine if there are science gaps that are important for our understanding of the system.
NGOs	• To provide a comprehensive view of the entire life cycle of Bay-Delta species that are characteristic, representative, or of special concern, and of the underlying ecosystem processes that affect species viability.
CCWD	• Support use of data for status and trends.
GCID	• To know how the species are doing. Assess whether populations are increasing or decreasing.
WWD	• To understand and track species responses to factors that affect their viability, including hydrologic, habitat, and biologic conditions. • My team and I track survival, abundance (JPE, etc), entrainment and similar metrics.
CDFW	• Long-term trend data in conjunction with other environmental monitoring data (flow, water operations, WQ, zooplankton, and phytoplankton, and invasive) is important in understanding how species and the ecosystem respond to varying environmental conditions and water operations.

USFWS	• We need monitoring data to stay on the pulse of the status of species and ecosystems and to evaluate and guide efforts to protect and enhance populations.
	  ○ We can't evaluate the decisions we make without scientific information.
	  ○ We can't write BiOps without accurate scientific information.
	  ○ We can't develop or contribute to the development of objective scientific tools and models without accurate and comprehensive scientific information.
	• The data collected by monitoring include catches of fish, effort to collect those fish, location, gear types, and specific environmental information.
	  ○ These data are essential for understanding movement, survival and reproduction processes of fish species in the wild.

	○ Monitoring has successfully identified multi-annual trends, seasonal changes to distributions, and some seasonal recruitment and survival processes of fish in the Bay-Delta.
SWRCB	• Important to understand status and trends from tribs through the Delta, and understand how management actions are affecting species.
NMFS	• Status of the species and status of threats to the species to inform federal ESA processes including section 7 consultations, progress towards meeting demographic and threats-based recovery criteria, and 5-year status reviews.

Regulatory Compliance/Real Time Information

Entity	Response
DWR	• In the Delta, monitoring is critical to meeting permit compliance conditions for the State Water Project (SWP) and informing real-time operations. Examples of monitoring information that are critical to real-time operations of the SWP: ○ Water quality data to inform OMR management (e.g., turbidity conditions can trigger Delta Smelt protection measures) ○ Presence and distribution of juvenile salmonids in tributaries, entry points to the Delta, and in fish salvage operations can trigger specific OMR management measures ○ Larval smelt distribution during spring and early summer months can inform OMR management and protection measures at Barker Slough Pumping plant • Monitoring is a critical component for adaptive management of management actions and having an adaptive management process is required for permit compliance in some cases (e.g., covered actions under the Delta Plan, ITP).
USBR	• Monitoring is important to Reclamation's real-time operations needs and being able to have access to current information on the physical environments (flows, temperatures) and fish abundance and distributions. This includes: • Flow, Temperature, Turbidity, and Salinity at Certain Locations; • Salmon and Steelhead Presence and Distribution in the Delta; • Adult Delta Smelt Presence and Distribution; • Delta Smelt Initiation of Spawning; • Larval and Juvenile Delta Smelt Presence and Distribution; and • Salvage and Genetic Analysis at the Tracy Fish Collection Facility.
CDFW	• To support regulatory and management decision making. • The Department relies on current survey's, trapping, and telemetry data to understand the abundance and distribution of fish species in the Delta and its tributaries, and the risks posed by water operations. This applies particularly to species listed under CESA and ESA and others which are indicators of estuarine health.
MWD	• To inform adequate protections for aquatic resources (e.g. standards set in federal and state permits, and pre-season take limits, such as the winter run JPE). • To document risk of take within season in a manner that allows change in operations to minimize take.
KCWA	• To know if certain permit conditions have been met. • To know if we are complying with regulatory obligations related to operation of the SWP, to evaluate the impacts of project operations on the ecosystem, and to assess whether management actions are having the intended effects.

	• Within the permits we have threshold monitoring that determines changes to operations, such as triggers for OMR protections.
SWRCB	• Required by 1641 and 1485 to assess compliance. Tied to permits. • Most requirements are put on CVP and SWP related to WQCP. • Address impacts that may occur from implementation.
CCWD	• CCDW relies on physical and water quality monitoring data on flows and salinity. • Support use of data for managing SWP and CVP operations. • Hard to find Delta Smelt, therefore most actions are triggered by physical parameters.
NMFS	• To inform decision making regarding the impacts of water operations (both releases from dams and withdrawals at diversions) and key management actions.

Evaluate the Effectiveness of Management Actions/Decision Support

Entity	Response
DWR	• Long-term monitoring information is also leveraged for effectiveness monitoring of some management actions, including: o Summer Operation of the Suisun-Marsh Salinity Control Gates o North Delta Fall Flow Action o West False-River Salinity Barrier
MWD	• To inform whether there is a biological response to an action. (e.g. response in the distribution or abundance of Delta smelt to the Suisun Marsh Salinity Control Gate Action).
KCWA	• Consistent with Reynolds et al., we recognize the importance of effectiveness monitoring (necessary to understand the outcomes of actions). Monitoring in an adaptive management context helps to assess outcomes of multiple actions or actions with a high degree of uncertainty, which is the case in an estuarine system. • Management actions required by the permits, such as the North Delta flow action intended to generate food to benefit Delta Smelt, must be evaluated to see if they work and under what conditions. Refining our understanding, via monitoring, is the only way to design actions that will benefit the species. • We would like to ensure that this monitoring reflects the best available science and is done efficiently, without unnecessary overlap or repetition, and relevant to current management needs.
WWD	• Scientists rely on a broader set of data that are necessary to understand and analyze the effects of actions on and changes of species over time.
CCWD	• Support use of data for specific project effectiveness monitoring and assessing progress toward achieving SWP and CVP goals and permit terms. • CCWD is not currently using Delta fish survey monitoring data. No longer required to monitor facilities due to proven effectiveness.
GCID	• To detect a response by species or life stage to management action or environmental perturbation. • Information on species status helps inform decisions on what actions to take (e.g. ops, restoration).
USFWS	• Monitoring data are critical to informing decision making about management topics such as water operations, delta smelt supplementation, or large-scale restoration efforts.

Modeling

Entity	Response
NMFS	• The WRLCM as well as any salmon LCM {CVPIA SIT} needs information relating habitat improvements to fish demographic responses {productivity/survival} across the landscape.
USFWS	• We have been using biological, physical, or chemical data from monitoring programs to develop, calibrate, or apply various models including population dynamics, hydrology, or water quality. • The data sources we use in the modeling effort include CDFW's long-term fish monitoring programs, EDSM, EMP, USGS water data, CDEC data, fish salvage data, hydrodynamic model outputs, and bathymetric data from DWR or USGS.

Targeted Research

Entity	Response

USBR	• There are special studies which can improve the state of the science and address uncertainty in the interpretation of monitoring data. Since 2019, examples of these in the Delta include projects that have received Reclamation full or partial funding through competitive science solicitations projects:
	  ○ Synchrony of native fish movements: synthesis science towards adaptive water management in the Central Valley
	  ○ An evaluation of sublethal and latent pyrethroid toxicity across a salinity gradient in two Delta fish species
	  ○ Evaluating juvenile salmonids behavioral responses to hydrodynamic conditions in the Sacramento-San Joaquin Delta
	  ○ Improving Green Sturgeon Population and Migration Monitoring
	  ○ The Effect of climate change on the life history of spring-run Chinook salmon through time
	  ○ Understanding within- and between-basin migration in white sturgeon: a synthesis of more than 10 years of acoustic tagging data
	  ○ Regulation of controls of cold water through the temperature control device of the Shasta Dam as a means to supporting downstream fish populations
	  ○ Estimating juvenile production and run timing of spring Chinook salmon leaving the Delta
	  ○ Comparing the impact of predation on the outmigration mortality of all Central Valley salmon ecotypes relative to other habitat related covariates
	  ○ Reorienting to Recovery: Developing an inclusive, landscape scale process for Central Valley Salmonids, prioritizing actions and investments to achieve recovery and minimize community and economic impact
	  ○ Non-Invasive Environmental DNA Monitoring to Support Tidal Wetland Restoration
	  ○ From Microbes to Zooplankton, What Defines a Beneficial Wetland?
	  ○ Standard Operating Procedure for Diagnosing and Addressing Predator Detections in Salmon Telemetry Data

NMFS	• Working with collaborators to generate run-specific abundance estimates at Chipps Island and have 3 funded projects to generate trawl efficiency estimates for winter, spring and fall run. This is an important piece to help with the life cycle model to

	constrain freshwater from marine sources of mortality linked to management actions.

2. What are the key questions you would like to see addressed by monitoring?

Status and Trends Monitoring

Entity	Response
DWR	• What are the population trajectories for listed fishes and species of management interest (e.g., Delta Smelt, Longfin Smelt, all runs of Central Valley salmonids, Green and White Sturgeon)? • What are the trends in key water quality components of the Delta (e.g., turbidity)? • Are there indicators of new invasive species that may present management challenges or affect ecosystem services in the Delta?
USBR	• What algae is growing in the Delta and Suisun Bay? • What eats the algae? • What eats what eats the algae? • What fish are in the Delta?
USFWS	• What are the biological communities of the Bay-Delta and watersheds? • How have these communities changed over time, why did they change, and are they continuing to change? • What are the biomass dominant fishes in the Bay-Delta and what habitat and food web opportunities do they exploit to outcompete other less abundant fishes and invertebrates?
MWD	• Monitoring that informs the abundance and distribution of listed fish species, including the extent of species distribution and habitat use during their life cycle.
NGOs	• Monitoring programs should first and foremost provide the factual basis for an accurate status and trends assessment.
GCID	• Characteristics of winter run population (eg. egg to fry survival)
NMFS	• For each species: o Where are there spawning populations? o What is the abundance of juveniles? o What is the outmigration timing (and life stage) of juveniles? • For each population o What is the adult population size? o What is the long-term trend in population size? o What is the hatchery influence in the natural spawning population? o How diverse is the population in terms of genetic and life history diversity (e.g., run-timing diversity)? o Freshwater and ocean survival (escapement). o Spatial structure (Juvenile occupancy and distribution overtime). o Effects of changing ocean conditions on salmonid populations. o Effects of freshwater habitat conditions on salmonid populations. o Areas of juvenile refugia.

Regulatory Compliance/Real Time Monitoring

Entity	Response
USBR	• Is Reclamation implementing management actions using the physical and biological information informing the environmental and fish actions?
MWD	• Monitoring that can inform real time operation of the water project facilities. • We would like to see monitoring designed to: o inform adequate protections for aquatic resources (e.g. standards set in federal and state permits, and pre-season take limits, such as the winter run JPE). o document risk of take within season in a manner that allows change in operations to minimize take.

Effectiveness Monitoring for Management Actions

Entity	Response
DWR	• How does the spatial distribution and/or levels of salinity change in response to drought management actions (e.g. salinity barriers)? • Does restoring tidal habitat result in changes to the density, composition, or distribution of planktonic organisms? • What is the impact of Delta Smelt supplementation on overall population densities, distribution, and abundance?
USBR	• Does proposed operation of the Suisun Marsh Salinity Control Gate expand the overlapping critical habitat elements of Delta Smelt and how did fish communities respond? • Where do supplemental Delta Smelt migrate to outside of the release site and supplementation specific studies?
CDFW	• Understanding how specific management actions affect species of concern (Delta Smelt, Longfin Smelt, Winter Run and Spring Run Salmon). • Of particular interest are operations of the Suisun Marsh Salinity Control Gates, North Delta Food Web enhancement, tidal marsh restoration, floodplain restoration and food supplementation from flooded rice lands, spring, summer, and fall flow actions. • In addition, the original needs for understanding flow management effects on the ecosystem and the mechanisms therein are still needed.
MWD	• Rather than asking for the "key questions" or "management questions" or "questions of management relevance", we suggest thinking of this in terms of "what decisions that you make are adequately informed by the monitoring and/or are sensitive to uncertainty that could be reduced with monitoring data?" • We would like to see monitoring designed to inform whether there is a biological response to an action. (e.g. response in the distribution or abundance of Delta smelt to the Suisun Marsh Salinity Control Gate Action). • Monitoring that can provide information on the biological response to management actions that are being implemented to meet Biological Opinion and Incidental Take Permit requirements, and can inform decisions in an adaptive management framework.
GCID	• What are the effects of management actions such as spring pulses?
KCWA	• Key questions would be related to hypotheses stemming from management actions, are they working? For example, related to the effectiveness of: spring pulse flows in the Sacramento River, predator management/aquatic weed control, Delta Smelt Summer-Fall Habitat action (called out in RPM5), operations of Suisun Marsh Salinity Control Gates, Old and Middle River flow management and triggers, etc.
WWD	• The key question I would like monitoring to address is whether regulatory actions are having the hypothesized effect on species abundance, survival, or viability. Can the

	actions be modified to reduce water supply reductions, without increasing impacts on species?

Targeted Research

Entity	Response
CDFW	• What are the effects of extended dry conditions and the effects of invasive aquatic vegetation on habitat suitability for species of interest? • What are the effects of contaminates on species of concern?
USFWS	• What suites of mechanisms are limiting the production of delta smelt, longfin smelt and other native fishes of the Bay-Delta? • What suites of mechanisms are limiting salmonid and sturgeon survival in the Bay-Delta?

3. Are there aspects of the monitoring enterprise that you think are working well?

Status and Trends Monitoring

Entity	Response
DWR	• Monitoring has provided valuable information on species status and trends, as well as water quality trends (e.g., trend toward increased water clarity). • Taxonomic composition of both planktonic and fish communities is well documented. • Long-term monitoring programs are often leveraged for effectiveness monitoring of management actions, though more work needs to be done to understand the power of these datasets to detect responses, ensure appropriate regional balance, and possibly provide for short-term, supplemental, data collection to ensure robust effectiveness monitoring. • There has been increased transparency in data transparency, QA/QC of data, and improved synthesis of data.
USBR	• We have a firm grasp of what fish are in the Delta and what the fish eat in different Delta habitats.
USFWS	• We have done a very good job describing what species we have in the estuary's biological communities. • We have gotten better over time with understanding drivers of variation in salmon survival, but there is still good work that could be done. • We have done okay with drivers of ecosystem change but the programs were not really designed to get at that kind of ecological detail and so results have varied.
KCWA	• Consistent monitoring of the same parameters for general trends. While this is helpful, it is not targeted.
WWD	• There are physical parameters, especially for steelhead and chinook, that are adequately covered by current monitoring programs, such as flow, entrainment, and temperature.
CDFW	• Needs for open water sampling from the Carquinez Straight upstream to answer recruitment questions are currently being addressed as part of the Five Survey Redesign effort.
GCID	• Existing monitoring (eg. Carcass surveys, Red Bluff juvenile monitoring screw traps data) are good for assessing broad scale increases or decreases, • We are measuring production at Red Bluff, which is ok for a rough metric of how many juveniles are produced, but it's not sufficient for generating egg to fry survival estimates.

CDFW	• The existing monitoring programs in the Delta provide a strong basis for understanding how the ecosystem and species respond to varying flow conditions both long- and near-term.
USFWS	• The Bay Study is maybe the best macroscopic look at the estuary's biota.
USFWS	• EDSM is an example of a monitoring program based on a very robust statistical sampling design (Current CDFW monitoring programs were sufficient for monitoring delta smelt when abundance was greater, so presumably, they will be sufficient if delta smelt recover. On the other hand, the newer USFWS program, EDSM, has proven to be better for detecting delta smelt in recent years as the population plummeted. EDSM appears to work well to monitor status and trends, assess spatial distributions, and provide information for population modeling of delta smelt.)
USFWS	• Yolo Bypass monitoring is a good example of an effective monitoring and research hybrid program.
WWD	• Abundance indices provide useful information on population trends and distribution monitoring provides useful information for use in real-time operations.
CCWD	• EDSM redesign has been good.
CCWD	• AT arrays are also good in terms of how they have been redesigned. The implementation of more tag studies has also been good.
GCID	• RST – know what they are doing, but needs more work.
NMFS	• Monitoring for adult winter-, spring-, and fall-run Chinook salmon abundance has produced long-term datasets for key watersheds.
NMFS	• The Red Bluff RST monitoring program has produced useful monitoring data for juvenile Chinook salmon.
NMFS	• The RSTs upstream of the Delta and the DJFMP sampling in the Delta do a good job of showing timing of presence of different species/runs and lifestages.

Effectiveness Monitoring for Management Actions

Entity	Response
CDFW	• Current plans for the SMSCG and north Delta food web enhancement provide the basis for evaluating the efficacy of the actions. • Plans are currently being developed to address the flow actions through the Delta Coordination Team.
MWD	• Suggest rephrasing this question to "What decisions do you make that are adequately informed by the current monitoring? What decisions that affect your organization are adequately informed with current monitoring? • One example would be the network of real time monitoring stations for salinity and the modeling tools that use the monitoring data to assess potential changes in salinity resulting from management actions.
KCWA	• The monitoring associated with the Fish Restoration Program (FRP) was designed in an adaptive management framework to understand the benefits of tidal marsh restoration required under ESA and CESA permits for operation of the SWP. The framework also allows for the methods to be replicated by others as other habitat restoration projects are constructed. We anticipate this monitoring will provide important data and information on how restoration benefits species and ecosystem processes, which can in turn inform future restoration efforts, including how restoration design can maximize benefits and minimize unintended outcomes such as occupation by invasive species.
GCID	• Salvage facilities – specific to goal

Other

Entity	Response
USBR	• A growing number of individuals within agencies are recognizing and promoting the benefits of incorporating learning and adopting new technologies into the monitoring enterprise.
USBR	• Agencies are moving towards open and transparent data accessibility practices that will lead to greater reproducibility and the use of this information in informing water and fish management decisions.
SWRCB	• Getting better at automating data and availability. • Better data management.

4. What changes would you like to see to the Monitoring Enterprise to support improved management of the Delta?

a. Are there changes to current monitoring schemes that you would suggest to better serve adaptive management decision making?

Entity	Response
DWR	• Overall, adaptive management decision-making would benefit from more sustained attention to monitoring programs and ensuring their relevance. More continuity and higher resolution in discussion at the policy-science-monitoring interface would help ensure that monitoring programs are being implemented in a way that informs decision-making. A governance structure that provides space and authority to these discussions is needed.
NGOs	• Ongoing, long-term monitoring efforts should not be discontinued or radically changed, but augmented by elements such as improved larval sampling and wider use of isotopic fingerprinting • Data that has been collected but not sufficiently reviewed, analyzed or disseminated is limited in utility. Adequate resources are needed to support: o Results review (species identification, measurement) and QA/QC o Easy access to results on website and web maintenance • Analysis of results and their significance by agencies and Science Program
NGOs	• Monitoring programs should be relevant to resource management in at least two critical ways: a. incorporation of relevant goals and objectives: monitoring data should be relevant to assessing progress toward or attainment of scientific or policy thresholds for desired biological or ecological response b. adaptive management – more effort should be made to: i. incorporate decision trees: monitoring data should be relevant to decision triggers that catalyze new or modified management actions in response to change in status and trends and progress toward goals and objectives. ii. incorporate conceptual models and hypothesis testing to monitoring regimes, i.e., monitoring data should be relevant to hypothesized effects associated with planned management actions.
USFWS	• One of the areas that needs to be looked into is to examine if there are overlapping or redundant monitoring programs or projects, and if yes, how to integrate them into one monitoring program to achieve the same results while saving resources and costs. For example, there are several monitoring programs related to delta smelt that are fairly similar.

	• The other area that needs to be discussed is how to best manage all the monitoring programs or projects in the Bay-Delta to achieve a set of common goals the science and natural resource management community desires.
USBR	• Making the results of monitoring schemes less reliant of specific methods and more quantitative, so innovation can occur to make results more accurate and precise over time would help decision makers feel more certain about the information they are presented.
NMFS	• Addressing steelhead and Green Sturgeon data gaps. • There remains significant uncertainty regarding Central Valley steelhead abundance, distribution, productivity and life history diversity (see Israel et al. 2021) as well as the contribution of the resident form of *O. mykiss* to the viability of the anadromous form (See Boughton et al. 2022). • Addressing the steelhead knowledge gaps identified in Beakes and Phyllis (2021) and Ellrott et al. (2021) would help adaptive management decision making. • Limited trap efficiency runs (or access to those runs) make it difficult to use RST data for estimating abundance, and even (given changes in flow-related trap efficiency) to compare between years at a given RST location. • See Johnson et el. 2017 and Windell et al. 2017 (see links in 2a) for overview of current sampling regime and opportunities for improvement.
CDFW	• A clear understanding from the stakeholder community of what information is needed to better test and evaluate the effectiveness of management actions to inform potential changes. • A clear understanding among all stakeholders about what level of certainty is needed before new special studies or monitoring efforts are initiated. • A review of current special studies should be conducted to assess how much more sampling is needed to detect the effectiveness of actions or if the question has been addressed.
USBR	• Developing monitoring that provides the results necessary to know if actions are having their predicted effect could help decision makers learn about the outcomes of the choices made.
WWD	• Changes are needed to improve monitoring of species abundance. Methods used to collect data need to be tailored to the species for which data are being collected. • More comprehensive monitoring related to biological conditions that affect species would be valuable to inform key policy decisions. • Improvements are needed in data collection and syntheses.
GCID	• Better accountability – not getting annual reports and other documentation done. • Better integration. Monitoring is currently being funded and maintained by different parties under different contracts. • There's a disconnect between those collecting data and those wanting to use the data. Those collecting the data may not be aware of issues regarding data use. • Consider a Monitoring JPA. • Chipps Island data being used for purposes it wasn't designed for. Not a production estimate for fish leaving the Delta. Rethink. • Genetics framework is evolving. Consider how the data can it be applied to a larger watershed framework? What fish are making it? Where did the fish go? Better understand what's going on. Establish a genetics library. Lots of opportunity to use the fish collected. • Need an apriori assessment of whether the technique will work for the action,
KCWA	• As it stands, evaluation of the effectiveness of many management actions is done by leveraging existing status and trends monitoring rather than by targeted monitoring

	specific to evaluating the intended biological outcomes of the management action and informing adaptive management.

b. Are there data that are not being collected that you think should be, and why?

Entity	Response
DWR	• There is no sustained program for monitoring coverage and species composition of aquatic vegetation, yet we know that this aspect of the ecosystem is growing and having a major effect on ecosystem function. • A consistent program for harmful algal blooms and their toxicity needs to be implemented, with effective and timely pathways for reporting out, including the potential for an early warning system and public notifications. Ideally, a HABs monitoring program would help illuminate the drivers of bloom events.
USFWS	• All monitoring programs, including EDSM, need to conduct auxiliary experiments to quantify gear efficiency and availability to the gear for target management species. This is a major theme of most monitoring programs, not just those in the Delta. Resolving major sources of observation error, such as size-based selectivity of nets or gear avoidance, improves the accuracy of estimates derived from monitoring data and leads to greater resolution of the variation in catches related to abundance. Quantifying gear efficiency can facilitate more accurate assessments of trends and status and more precise life cycle model estimates of population dynamics.
USBR	• How nutrients and hydrodynamics results in productivity that supports fish populations and how these rates of production vary in space and time is not well understood. Significant changes in the fish community seem to be related to changes into food web, so understanding the mechanics and drivers of the food web can reduce the uncertainty about how important these changes are to native fish.
NMFS	• Life cycle monitoring and life stage survival (or bottlenecks) and parentage-based tagging and expansion of our genetic tool sets. • Steelhead - it seems as though we have very little idea as to how they are doing in the CV ○ More data on steelhead abundance, distribution, productivity, and diversity need to be collected to understand their biological status and inform management decision making. This includes evaluation of the resident form of *O. mykiss* to the viability of the anadromous form. • Document the presence of CV spring-run in the San Joaquin tribs. (eg. Merced).
WWD	• Monitoring needs to be improved to support and improve the various species life cycle models. As historic patters shift, e.g., as the spatial distribution of smelt changes, we need to adapt our monitoring programs to capture those changes.
GCID	• Use current system to grab genetic samples to determine not just what run, but where the fish come from, was it a wild or hatchery fish, and what were the conditions they experienced? • Capture efficiency for RSTs. Develop efficiency estimates so we know abundance of fish entering the Delta. • Mark recapture data would be useful. • Need a better understanding of the metrics we are trying to meet, then match monitoring to that. Need to think about our goal. Look at conceptual models, then rebuild monitoring and actions. • Monitoring for salmonids in the OMR corridor.

c. Do you have suggestions for how to balance long-term data collection needs (ecosystem health and species status and trends) with monitoring to assess specific management action performance (i.e. habitat restoration, flow actions) to support adaptive management opportunities?

Entity	Response
DWR	• Generally, sustained monitoring programs will present a rich baseline data source for effectiveness monitoring and should be robust enough such that some key parameters, such as water temperature, turbidity, and fish densities for species of management interest, have existing datasets that can be leveraged to examine impacts of management actions. In some cases, the precise needs for baseline data are not known before the management actions take place (e.g., what should the hydrology be for comparison years?), and for this reason it is important that monitoring programs are already in place before new management actions are underway. • An idea to explore is maintaining a core set of stations that collectively represent that physical and biological habitat of the system and that are used to document trends over time. This core set of stations could be enhanced as needed for effectiveness monitoring of management actions. Developing a system like this would take significant work and discussion for each parameter of interest (e.g., water quality, plankton, and fish species of interest would all need separate and devoted attention).
USFWS	• It is important to continue to monitor species status/trend and study species response to management actions. Modeling can play an important role in these two aspects. We can apply historical data to quantitative models to simulate long-term trends and evaluate the performance of management actions to support adaptive management opportunities. • The focus of new monitoring should be on what we don't know and still need to know. We may also refine current monitoring methods to answer new questions, and if the adjustments are done correctly, their past and future data can be used.
USBR	• Monitoring to assess specific management action performance and species status and trend and ecosystem health may have some overlapping, but also some independent measures. Not all measures will meet all needs, so agencies responsible for certain needs (ecosystem, species, management actions) should provide sufficient information so mutual interests and independent interests can be identified surrounding the demands of Bay-Delta monitoring. • Greater coordination and innovation of monitoring will be needed to meet the balance of long-term data collection and specific management action performance.
NMFS	• Long term dedicated funding to perform specific monitoring, and associated adaptive management, activities. This work should inform specific management needs crucial to operations which include data synthesis, analysis, reporting, and public portal access opportunities. • Management action effectiveness monitoring could be required by grant funding programs, as is done in the CVPIA program.
SWRCB	• Expand allocation of responsibility for programs funding.
WWD	• The balance should come from available funding and the source of the funding. Funding from the projects (operators, pwas, etc) should be prioritized for monitoring to assess management action performance and to support adaptive management. Public funding or funding from other sources can be used to support the long-term data collection needs. Additionally, this needs to be balanced with the usefulness of the information- data is only as good as its analysis. We need to improve our ability to analyze the data collected and incorporate that data into decision making.

GCID	• Do we have data resolution sufficient to test specific hypotheses? Don't force the data. Is the monitoring tied to the actions?

d. Are there examples of management actions or management issues that you think need better monitoring support?

Entity	Response
DWR	• Adaptive management of tidal wetland restoration sites may need enhanced investigations of effective and efficient monitoring techniques for coverage of aquatic vegetation (e.g., consistent use of UAVs). There also need to be special studies for investigation of experimental control actions. • Toxicity and prevalence of Harmful Algal Blooms specifically for drought management actions may need increased support in some years and would benefit from robust data collections when salinity barriers are not in place, for the sake of comparison. • Dedicated support for analysis, synthesis, and reporting of monitoring data is also needed and should be hard-wired into development of any new monitoring program.
USFWS	• The changes that are occurring in the ecosystem as a result of climate induced changes need better documentation in order to improve forecasting and development of management actions. The various monitoring programs are difficult to compare on a system-wide level.
NMFS	• We need to make sure there is sufficient action effectiveness and risk to species monitoring in place for floodplain restoration projects. Increasing access to managed floodplains and rice fields offers great potential for improved juvenile salmonid growth, but risks to adult and juvenile survival need to be monitored.
SWRCB	• Expand overall monitoring and the number of qualified parties contributing funding and create a consistent hub (One Delta One Science). • Need to grow the enterprise.
SWRCB	• Ensure the practitioners are part of the conversation.
WWD	• Flow based management decisions need support. We need to collect and analyze data to determine if there is a cause-and-effect relationship that gives rise to the flow-abundance relationships to hopefully identify the underlying biological mechanisms.
GCID	• Survival between eggs and emergence. Currently forcing Red Bluff data and carcass data. • More discussion regarding spring run JPE. JPE estimates drive operations, but there are shortcomings in RST detection. Good at catching fry, but not yearlings. Need to capture all the life stages of interest. • Consider some scenarios using the WRLCM to test sensitivities. This would help prioritize investments. Test through simulation before we implement changes to monitoring. • Allow stakeholders to participate in iTag discussions regarding acoustic telemetry array. Need more openness and collaboration, including data sharing.

Appendix 3. Questionnaire Responses and Interview Summaries Received from CSAMP Members

In April 2022, CSAMP distributed a questionnaire to its members asking four overall questions (see Box 2). Several of the overall questions included specific sub questions. Written responses were received from the following organizations:

- USBR
- USFWS
- NMFS
- CDFW
- DWR
- WWD
- MWD
- KCWA
- Coalition for a Sustainable Delta
- NGOs

CSAMP's NGO members submitted a single written response reflecting their collective input. The response did not directly address each of the four questions, but rather provided an overall perspective on the existing monitoring activity and areas for improvement.

The Coalition for a Sustainable Delta submitted a response that did not address the questions, but rather provided an alternative suggested approach for assessing the current monitoring and developing a revised monitoring framework.

CSAMP's Program Manager conducted interviews in May with those CSAMP members that did not submit written responses. The same questions developed for the written questionnaire were used for the interviews. Interviews were conducted with the following members:

- SWRCB
- GCID
- CCWD

The following pages provide the written responses received, and the interview summaries for each CSAMP member that participated.

DWR Response

1. Why do you want monitoring? What data do you currently use and for what purposes?

Environmental monitoring is fundamental to DWR core values of science driving decision-making and environmental stewardship, and it is a critical tool in adapting to emerging climate conditions. In the Delta, monitoring is critical to meeting permit compliance conditions for the State Water Project (SWP) and informing real-time operations. Beyond compliance needs, DWR values tracking the status and trends of physical conditions and biological communities in the Delta to understand ecosystem change, particularly regarding how changed could impact SWP operations and the outcomes of tidal wetland restoration projects, as well as other ecosystem services, such as drinking water.

Examples of monitoring information that are critical to real-time operations of the SWP:

- Water quality data to inform OMR management (e.g., turbidity conditions can trigger Delta Smelt protection measures)
- Presence and distribution of juvenile salmonids in tributaries, entry points to the Delta, and in fish salvage operations can trigger specific OMR management measures
- Larval smelt distribution during spring and early summer months can inform OMR management and protection measures at Barker Slough Pumping plant

Long-term monitoring information is also leveraged for effectiveness monitoring of some management actions, including:

- Summer Operation of the Suisun-Marsh Salinity Control Gates
- North Delta Fall Flow Action
- West False-River Salinity Barrier

Notably, monitoring is a critical component for adaptive management of management actions and having an adaptive management process is required for permit compliance in some cases (e.g., covered actions under the Delta Plan, ITP).

2. What are the key questions you would like to see addressed by monitoring?

Monitoring data should accurately inform real-time operations of the SWP facilities in the Delta (examples given above of information used for operations). In addition, monitoring should support answering various questions regarding environmental change and the response of the ecosystem to management actions. Some key questions include:

- What are the population trajectories for listed fishes and species of management interest (e.g., Delta Smelt, Longfin Smelt, all runs of Central Valley salmonids, Green and White Sturgeon)?
- What are the trends in key water quality components of the Delta (e.g., turbidity)?
- How does the spatial distribution and/or levels of salinity change in response to drought management actions (e.g. salinity barriers)?
- Does restoring tidal habitat result in changes to the density, composition, or distribution of planktonic organisms?

- What is the impact of Delta Smelt supplementation on overall population densities, distribution, and abundance?
- Are there indicators of new invasive species that may present management challenges or affect ecosystem services in the Delta?

a. Which do you think are being adequately addressed with current monitoring?

- Monitoring has provided valuable information on species status and trends, as well as water quality trends (e.g., trend toward increased water clarity).
- Taxonomic composition of both planktonic and fish communities is well documented.
- Long-term monitoring programs are often leveraged for effectiveness monitoring of management actions, though more work needs to be done to understand the power of these datasets to detect responses, ensure appropriate regional balance, and possibly provide for short-term, supplemental, data collection to ensure robust effectiveness monitoring.

3. Are there aspects of the monitoring enterprise that you think are working well?

In addition to the answers for Question 2a, there has been increased transparency in data transparency, QA/QC of data, and improved synthesis of data. Examples of this progress are documented in Baerwald et al., 2020, the Interagency Ecological Program's Guiding Framework for Ecological Synthesis, and in the convening of temporary synthesis working groups, such as the 2021 DSP-NCEAS partnership to understand drivers of the estuarine food web. However, there is still a need to enhance capacity for analysis and synthesis, including developing sustained capacity for reviewing and updating monitoring programs.

4. What changes would you like to see to the Monitoring Enterprise to support improved management of the Delta?

a. Are there changes to current monitoring schemes that you would suggest to better serve adaptive management decision making?

Overall, adaptive management decision-making would benefit from more sustained attention to monitoring programs and ensuring their relevance. More continuity and higher resolution in discussion at the policy-science-monitoring interface would help ensure that monitoring programs are being implemented in a way that informs decision-making. A governance structure that provides space and authority to these discussions is needed.

At a more detailed level, there are some specific areas where adjustments to monitoring schemes would be beneficial:

- Are emerging technologies and modeling tools being used to the fullest and most strategic extent possible? For example, can remote-sensing tools be deployed for multiple purposes to map ecosystem components (e.g., HABs, aquatic vegetation, turbidity)? What about modeling tools for spatial interpolation of conditions? Could strategic use of technology and tools reduce the need for on-the-ground monitoring?
- The outcomes of the special studies that were a result of the 2017 Salmon & Sturgeon Assessment of Indicators by Lifestages (SAIL) should be synthesized and evaluated

to determine whether programmatic changes to the monitoring networks for salmon and sturgeon are needed.

- Special studies are currently underway to examine the prevalence and importance of picoplankton (very tiny plankton) in the plankton composition. These studies should be evaluated and adjustments to monitoring programs made accordingly.
- Current programs for nutrients and contaminants should be evaluated at a comprehensive scale (full Bay-Delta region) to develop recommendations for ensuring appropriate spatial coverage, avoiding duplicative data collections, and assessing coverage for key constituents.

b. Are there data that are not being collected that you think should be, and why?

- There is no sustained program for monitoring coverage and species composition of aquatic vegetation, yet we know that this aspect of the ecosystem is growing and having a major effect on ecosystem function.
- A consistent program for harmful algal blooms and their toxicity needs to be implemented, with effective and timely pathways for reporting out, including the potential for an early warning system and public notifications. Ideally, a HABs monitoring program would help illuminate the drivers of bloom events.

c. Do you have suggestions for how to balance long-term data collection needs (ecosystem health and species status and trends) with monitoring to assess specific management action performance (i.e. habitat restoration, flow actions) to support adaptive management opportunities?

Part of the enhanced manager-scientist dialogue should regard the need to continue monitoring to maintain a long-term record for the Bay-Delta for some parameters, given the fact that the ecosystem has changed significantly from when some environmental programs first began in the 1960s and even the 1990s. What types of data collections have methodologies that have been consistent over time, and can these be maintained? Are there other methodologies that, due to ecosystem change, cannot be carried out in the same way? When is it appropriate to develop special studies for effectiveness monitoring, and when is a sustained monitoring program needed? An explicit discussion on which parameters can realistically be carried out consistently and have similar biases over time would be worthwhile.

Generally, sustained monitoring programs will present a rich baseline data source for effectiveness monitoring and should be robust enough such that some key parameters, such as water temperature, turbidity, and fish densities for species of management interest, have existing datasets that can be leveraged to examine impacts of management actions. In some cases, the precise needs for baseline data are not known before the management actions take place (e.g., what should the hydrology be for comparison years?), and for this reason it is important that monitoring programs are already in place before new management actions are underway.

An idea to explore is maintaining a core set of stations that collectively represent that physical and biological habitat of the system and that are used to document trends over time. This core set of stations could be enhanced as needed for effectiveness monitoring

of management actions. Developing a system like this would take significant work and discussion for each parameter of interest (e.g., water quality, plankton, and fish species of interest would all need separate and devoted attention).

d. Are there examples of management actions or management issues that you think need better monitoring support?

- Adaptive management of tidal wetland restoration sites may need enhanced investigations of effective and efficient monitoring techniques for coverage of aquatic vegetation (e.g., consistent use of UAVs). There also need to be special studies for investigation of experimental control actions.
- Toxicity and prevalence of Harmful Algal Blooms specifically for drought management actions may need increased support in some years and would benefit from robust data collections when salinity barriers are not in place, for the sake of comparison.
- Dedicated support for analysis, synthesis, and reporting of monitoring data is also needed and should be hard-wired into development of any new monitoring program.

NGO Response

1. **Scope and methodology** – monitoring programs should provide a comprehensive view of the entire life cycle of Bay-Delta species that are characteristic, representative, or of special concern, and of the underlying ecosystem processes that affect species viability:

    a. species life history: generally good coverage of occurrence and distribution, but need to improve monitoring of early life history stages (e.g., larval smelt, salmon fry)

    b. ecosystem processes: generally, not well covered, need to design monitoring activities to improve understanding of processes such as trophic interactions, movement and habitat connectivity, etc.

    c. methods: need to better incorporate and apply new methods such as isotopic fingerprinting

2. **Purpose** – monitoring programs should first and foremost provide the factual basis for an accurate status and trends assessment, but also be relevant to resource management in at least two critical ways:

    a. incorporation of relevant goals and objectives: monitoring data should be relevant to assessing progress toward or attainment of scientific or policy thresholds for desired biological or ecological response

    b. adaptive management – more effort should be made to:

        i. incorporate decision trees: monitoring data should be relevant to decision triggers that catalyze new or modified management actions in response to change in status and trends and progress toward goals and objectives

        ii. incorporate conceptual models and hypothesis testing to monitoring regimes, i.e., monitoring data should be relevant to hypothesized effects associated with planned management actions

3. **Continuity** – ongoing, long-term monitoring efforts should not be discontinued or radically changed, but augmented by elements such as improved larval sampling and wider use of isotopic fingerprinting

4. **Availability and use of monitoring results** – data that has been collected but not sufficiently reviewed, analyzed or disseminated is obviously limited in utility. Adequate resources are needed to support:

    a. Results review (species identification, measurement) and QA/QC

    b. Easy access to results on website and web maintenance

    c. Analysis of results and their significance by agencies and Science Program

USFWS Response

1. Why do you want monitoring? What data do you currently use and for what purposes?

The mission of the U.S. Fish and Wildlife Service is to work with others to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people. We need monitoring data to stay on the pulse of the status of species and ecosystems and to evaluate and guide efforts to protect and enhance populations. We can't evaluate the decisions we make without scientific information. We can't write BiOps without accurate scientific information. We can't develop or contribute to the development of objective scientific tools and models without accurate and comprehensive scientific information.

The data collected by monitoring include catches of fish, effort to collect those fish, location, gear types, and specific environmental information. These data are essential for understanding movement, survival and reproduction processes of fish species in the wild. Monitoring has successfully identified multi-annual trends, seasonal changes to distributions, and some seasonal recruitment and survival processes of fish in the Bay-Delta. These data are critical to informing decision making about management topics such as water operations, delta smelt supplementation, or large-scale restoration efforts.

We have been using biological, physical, or chemical data from monitoring programs to develop, calibrate, or apply various models including population dynamics, hydrology, or water quality. The data sources we use in the modeling effort include CDFW's long-term fish monitoring programs, EDSM, EMP, USGS water data, CDEC data, fish salvage data, hydrodynamic model outputs, and bathymetric data from DWR or USGS.

2. What are the key questions you would like to see addressed by monitoring?

a. Which do you think are being adequately addressed with current monitoring?

We would like the following questions to be addressed by monitoring:

- What are the biological communities of the Bay-Delta and watersheds?
- How have these communities changed over time, why did they change, and are they continuing to change?
- What are the biomass dominant fishes in the Bay-Delta and what habitat and food web opportunities do they exploit to outcompete other less abundant fishes and invertebrates?
- What suites of mechanisms are limiting the production of delta smelt, longfin smelt and other native fishes of the Bay-Delta?
- What suites of mechanisms are limiting salmonid and sturgeon survival in the Bay-Delta?

We have done a very good job describing what species we have in the estuary's biological communities. We have gotten better over time with understanding drivers of variation in salmon survival, but there is still good work that could be done. We

have done okay with drivers of ecosystem change but the programs were not really designed to get at that kind of ecological detail and so results have varied.

3. **Are there aspects of the monitoring enterprise that you think are working well?**
   a. **If yes, please specify.**

The Bay Study is maybe the best macroscopic look at the estuary's biota. EDSM is an example of a monitoring program based on a very robust statistical sampling design, and Yolo Bypass monitoring is a good example of an effective monitoring and research hybrid program. Current CDFW monitoring programs were sufficient for monitoring delta smelt when abundance was greater, so presumably, they will be sufficient if delta smelt recover. On the other hand, the newer USFWS program, EDSM, has proven to be better for detecting delta smelt in recent years as the population plummeted. EDSM appears to work well to monitor status and trends, assess spatial distributions, and provide information for population modeling of delta smelt.

4. **What changes would you like to see to the Monitoring Enterprise to support improved management of the Delta?**
   a. **Are there changes to current monitoring schemes that you would suggest to better serve adaptive management decision making?**

One of the areas that needs to be looked into is to examine if there are overlapping or redundant monitoring programs or projects, and if yes, how to integrate them into one monitoring program to achieve the same results while saving resources and costs. For example, there are several monitoring programs related to delta smelt that are fairly similar.

The other area that needs to be discussed is how to best manage all the monitoring programs or projects in the Bay-Delta to achieve a set of common goals the science and natural resource management community desires.

   b. **Are there data that are not being collected that you think should be, and why?**

All monitoring programs, including EDSM, need to conduct auxiliary experiments to quantify gear efficiency and availability to the gear for target management species. This is a major theme of most monitoring programs, not just those in the Delta. Resolving major sources of observation error, such as size-based selectivity of nets or gear avoidance, improves the accuracy of estimates derived from monitoring data and leads to greater resolution of the variation in catches related to abundance. Quantifying gear efficiency can facilitate more accurate assessments of trends and status and more precise life cycle model estimates of population dynamics.

   c. **Do you have suggestions for how to balance long-term data collection needs (ecosystem health and species status and trends) with monitoring to assess specific management action performance (i.e. habitat restoration, flow actions) to support adaptive management opportunities?**

It is important to continue to monitor species status/trend and study species response to management actions. Modeling can play an important role in these two aspects. We can apply historical data to quantitative models to simulate long-term trends and evaluate the performance of management actions to support adaptive management opportunities.

The focus of new monitoring should be on what we don't know and still need to know. We may also refine current monitoring methods to answer new questions, and if the adjustments are done correctly, their past and future data can be used.

d. Are there examples of management actions or management issues that you think need better monitoring support?

The changes that are occurring in the ecosystem as a result of climate induced changes need better documentation in order to improve forecasting and development of management actions. The various monitoring programs are difficult to compare on a system-wide level.

NMFS Response

Overview:
The CAMT Assessment of Long-term Monitoring Program Reviews and Objectives (Assessment) was initiated in September 2021 to understand the approaches, findings, and recommendations of previous and ongoing reviews of long-term monitoring programs (Task 1 Final Report) and to articulate the objectives of CSAMP members with respect to monitoring (Task 2). Information from the Assessment will inform future CSAMP discussions aimed at catalyzing improvements to the long-term monitoring network of the Sacramento-San Joaquin Bay-Delta.

Task 2 Questions:

1. **Why do you want monitoring? What data do you currently use and for what purposes?**

   What Data We Use Now:

   - Status of the species and status of threats to the species are data currently used by NOAA to inform federal ESA processes including section 7 consultations, progress towards meeting demographic and threats-based recovery criteria, and 5-year status reviews.
   - The CCVO Water Operations and Delta Consultations Branch uses the following monitoring (a solid overview, but not a completely comprehensive list), particularly for review/discussion at the interagency watershed-specific technical teams.
     - American River (technical team = American River Group (ARG)) – Rotary screw traps (RSTs) at Watt Avenue; seining and snorkel surveys; fall-run escapement and redd surveys; steelhead redd surveys
     - Stanislaus River (technical team = Stanislaus Watershed Team (SWT)) – Rotary screw traps (RSTs) near Oakdale and Caswell State Park; weir near Riverbank; fall-run escapement and incidental redd surveys; steelhead redd surveys; snorkel surveys
     - Delta (technical team = Salmonid Monitoring Team (SaMT)) – All Delta Juvenile Fish Monitoring Program (DJFMP) data (seines, Sacramento Trawl, Mossdale Trawl, Chipps Island Trawl); USUSFWS EDSM sampling; CDFW SKT sampling
     - Sacramento River monitoring (used a lot by SaMT to track fish heading to the Delta) – RSTs at (a) Red Bluff Diversion Dam, (b) GCID, (c)Tisdale, (d) Knights Landing, and (e) the new "Delta entry" sampling location just north of the I-5 bridge near Sacramento; carcass surveys and redd surveys.
     - Clear Creek
     - Feather River

   Why We Want Monitoring:

   - To inform NOAA's Recovery Plan demographic and threats-based recovery criteria and recovery initiatives such as reintroduction and the effectiveness of reintroduction efforts. The viable salmonid population (VSP) concept is the framework used by NOAA to assess salmon and steelhead viability and the viability of the overall salmon Evolutionary Significant Units (ESU) or steelhead Distinct Population Segments (DPS). The VSP framework identifies four key characteristics central to attaining and maintaining long term viability: abundance, productivity, spatial structure, and diversity. These four

metrics are evaluated by the Southwest Fisheries Science Center in their viability assessments conducted every five years. These metrics lie at the core of recovery criteria.

- To inform decision making regarding the impacts of water operations (both releases from dams and withdrawals at diversions) and key management actions.

From SWFSC: We do rely most heavily on adult escapement data for VSP status and trends analysis and value working towards generating quantitative abundance estimates anywhere in the enterprise where salmon are being monitored (some RSTs are providing just counts which are primarily limited to basic presence/absence) information. We are working with collaborators to generate run-specific abundance estimates at Chipps Island and have 3 funded projects with Russ Perry and others to generate trawl efficiency estimates for winter, spring and fall run. This is an important piece to help with the life cycle model to constrain freshwater from marine sources of mortality linked to management actions. The LCM as well as any salmon LCM {CVPIA SIT} needs information relating habitat improvements to fish demographic responses {productivity/survival} across the landscape.

2. What are the key questions you would like to see addressed by monitoring?

For each species:

-Where are there spawning populations?

– What is the abundance of juveniles?

– What is the outmigration timing (and life stage) of juveniles?

For each population

-What is the adult population size?;

-What is the long-term trend in population size?;

-What is the hatchery influence in the natural spawning population?;

-How diverse is the population in terms of genetic and life history diversity (e.g., run-timing diversity)?

-Freshwater and ocean survival (escapement).

-Spatial structure (Juvenile occupancy and distribution overtime).

-Effects of changing ocean conditions on salmonid populations.

-Effects of freshwater habitat conditions on salmonid populations.

-Areas of juvenile refugia.

a. Which do you think are being adequately addressed with current monitoring?

i. See 3a responses below.

ii. See Johnson et al. 2017: https://escholarship.org/uc/item/6751j957

iii. See Windell et al. 2017: https://repository.library.noaa.gov/view/noaa/15458

3. Are there aspects of the monitoring enterprise that you think are working well?

a. If yes, please specify.

- Monitoring for adult winter-, spring-, and fall-run Chinook salmon abundance has produced long-term datasets for key watersheds.
- The Red Bluff RST monitoring program has produced useful monitoring data for juvenile Chinook salmon.
- The RSTs upstream of the Delta and the DJFMP sampling in the Delta do a good job of showing timing of presence of different species/runs and lifestages.

4. What improvements or changes would you like to see to the Monitoring Enterprise to support improved management of the Delta?

a. Are there changes to current monitoring schemes that you would suggest to better serve adaptive management decision making?

- Addressing steelhead and Green Sturgeon data gaps.
- There remains significant uncertainty regarding Central Valley steelhead abundance, distribution, productivity and life history diversity (see Israel et al. 2021) as well as the contribution of the resident form of *O. mykiss* to the viability of the anadromous form (See Boughton et al. 2022).
- Addressing the steelhead knowledge gaps identified in Beakes and Phyllis (2021) and Ellrott et al. (2021) would help adaptive management decision making.
- Limited trap efficiency runs (or access to those runs) make it difficult to use RST data for estimating abundance, and even (given changes in flow-related trap efficiency) to compare between years at a given RST location.
- See Johnson et el. 2017 and Windell et al. 2017 (see links in 2a) for overview of current sampling regime and opportunities for improvement.

b. Are there data that are not being collected that you think should be, and why?

- Life cycle monitoring and life stage survival (or bottlenecks) and parentage-based tagging and expansion of our genetic tool sets.
- Steelhead - it seems as though we have very little idea as to how they are doing in the CV
  - More data on steelhead abundance, distribution, productivity, and diversity need to be collected to understand their biological status and inform management decision making. This includes evaluation of the resident form of *O. mykiss* to the viability of the anadromous form.
- CV spring-run in the San Joaquin tribs (especially the Merced). We need to start documenting presence which will help us with water districts who argue the fish are not present

c. Do you have suggestions for how to balance long-term data collection needs (ecosystem health and species status and trends) with monitoring to assess specific management action performance (i.e. habitat restoration, flow actions) to support adaptive management opportunities?

- Long term dedicated funding to perform specific monitoring, and associated adaptive management, activities. This work should inform specific management

needs crucial to operations which include data synthesis, analysis, reporting, and public portal access opportunities.
- Management action effectiveness monitoring could be required by grant funding programs, as is done in the CVPIA program.

d. Are there examples of management actions or management issues that you think need better monitoring support?

- We need to make sure there is sufficient action effectiveness and risk to species monitoring in place for floodplain restoration projects. Increasing access to managed floodplains and rice fields offers great potential for improved juvenile salmonid growth, but risks to adult and juvenile survival need to be monitored.

From SWFSC: Here are some documents where SWFSC and multi-agency technical teams have made monitoring recommendations and justifications for their value. We would want to draw heavily on multi-agency monitoring recommendations that we recently recommended for winter run, spring run, and green sturgeon. Some of these recommendations have taken hold, others still suffer from unstable funding/implementation while others have not yet been implemented.

https://escholarship.org/uc/item/6751j957 (winter run)
https://escholarship.org/uc/item/98x3435s (spring run)
https://repository.library.noaa.gov/view/noaa/15998 (green sturgeon)
https://swfsc-publications.fisheries.noaa.gov/publications/TM/SWFSC/NOAA-TM-NMFS-SWFSC-588.pdf (green sturgeon)

USBR Response

1. Why do you want monitoring? What data do you currently use and for what purposes?

Monitoring is important to Reclamation's real-time operations needs and being able to have access to current information on the physical environments (flows, temperatures) and fish abundance and distributions.

Monitoring is necessary for evaluating the status and trend of species and habitat conditions in rivers and the estuary, where the CVP operations potentially impacts these resources.

Reclamation's specific monitoring information purposes in the Delta include:

Real-time operations:

1. Flow, Temperature, Turbidity, and Salinity at Certain Locations;
2. Salmon and Steelhead Presence and Distribution in the Delta;
3. Adult Delta Smelt Presence and Distribution;
4. Delta Smelt Initiation of Spawning;
5. Larval and Juvenile Delta Smelt Presence and Distribution; and
6. Salvage and Genetic Analysis at the Tracy Fish Collection Facility.

Status and Trend Monitoring:

1. Primary Production (Algal communities that are desirable, less desirable, or harmful)
2. Secondary Productivity (Zooplankton, Macroinvertebrates, Mollusks)
3. Juvenile Fish Abundance and Productivity
4. Community Assemblages

There are special studies which can improve the state of the science and address uncertainty in the interpretation of monitoring data. Since 2019, examples of these in the Delta include projects that have received Reclamation full or partial funding through competitive science solicitations projects:

- Synchrony of native fish movements: synthesis science towards adaptive water management in the Central Valley
- An evaluation of sublethal and latent pyrethroid toxicity across a salinity gradient in two Delta fish species
- Evaluating juvenile salmonids behavioral responses to hydrodynamic conditions in the Sacramento-San Joaquin Delta
- Improving Green Sturgeon Population and Migration Monitoring
- The Effect of climate change on the life history of spring-run Chinook salmon through time
- Understanding within- and between-basin migration in white sturgeon: a synthesis of more than 10 years of acoustic tagging data
- Regulation of controls of cold water through the temperature control device of the Shasta Dam as a means to supporting downstream fish populations
- Estimating juvenile production and run timing of spring Chinook salmon leaving the Delta

- Comparing the impact of predation on the outmigration mortality of all Central Valley salmon ecotypes relative to other habitat related covariates
- Reorienting to Recovery: Developing an inclusive, landscape scale process for Central Valley Salmonids, prioritizing actions and investments to achieve recovery and minimize community and economic impact
- Non-Invasive Environmental DNA Monitoring to Support Tidal Wetland Restoration
- From Microbes to Zooplankton, What Defines a Beneficial Wetland?
- Standard Operating Procedure for Diagnosing and Addressing Predator Detections in Salmon Telemetry Data

2. What are the key questions you would like to see addressed by monitoring?

For real-time monitoring, the key questions is:

> *"Is Reclamation implementing management actions using the physical and biological information informing the environmental and fish actions?"*

For status and trend monitoring, the key question are:

- *What algae is growing in the Delta and Suisun Bay?*
- *What eats the algae?*
- *What eats what eats the algae?*
- *What fish are in the Delta?*

It is possible that status and trend monitoring may be able to help address a small number of specific questions about management actions at a finer spatial and temporal scale. For instance:

- *Does proposed operation of the Suisun Marsh Salinity Control Gate expand the overlapping critical habitat elements of Delta Smelt and how did fish communities respond?*
- *Where do supplemental Delta Smelt migrate to outside of the release site and supplementation specific studies?*

a. Which do you think are being adequately addressed with current monitoring?

We have a firm grasp of what fish are in the Delta and what the fish eat in different Delta habitats.

3. Are there aspects of the monitoring enterprise that you think are working well?

a. If yes, please specify.

A growing number of individuals within agencies are recognizing and promoting the benefits of incorporating learning and adopting new technologies into the monitoring enterprise. Also, agencies are moving towards open and transparent data accessibility practices that will lead to greater reproducibility and the use of this information in informing water and fish management decisions.

4. What changes would you like to see to the Monitoring Enterprise to support improved management of the Delta?

a. Are there changes to current monitoring schemes that you would suggest to better serve adaptive management decision making?

Science constantly changes what we understand about the system as methods and technology advance. Making the results of monitoring schemes less reliant of specific methods and more quantitative, so innovation can occur to make results more accurate and precise over time would help decision makers feel more certain about the information they are presented. Developing monitoring that provides the results necessary to know if actions are having their predicted effect could help decision makers learn about the outcomes of the choices made.

b. Are there data that are not being collected that you think should be, and why?

How nutrients and hydrodynamics results in productivity that supports fish populations and how these rates of production vary in space and time is not well understood. Significant changes in the fish community seem to be related to changes into food web, so understanding the mechanics and drivers of the food web can reduce the uncertainty about how important these changes are to native fish.

c. Do you have suggestions for how to balance long-term data collection needs (ecosystem health and species status and trends) with monitoring to assess specific management action performance (i.e. habitat restoration, flow actions) to support adaptive management opportunities?

There will always be a need for this balance, so figuring out what this means to each agency and organization in CSAMP is the first step towards resolving it. Discussion in CSAMP alone is not likely to fully address this balance. Monitoring to assess specific management action performance and species status and trend and ecosystem health may have some overlapping, but also some independent measures. Not all measures will meet all needs, so agencies responsible for certain needs (ecosystem, species, management actions) should provide sufficient information so mutual interests and independent interests can be identified surrounding the demands of Bay-Delta monitoring.

Reclamation will focus on understanding the measures of the ecosystem and species it affects with its management actions and there is some overlap with other agencies in the Bay-Delta. However, the uses of the Bay-Delta extend beyond just Reclamation's interest and greater coordination and innovation of monitoring will be needed to meet the balance of long-term data collection and specific management action performance.

d. Are there examples of management actions or management issues that you think need better monitoring support?

See above.

CDFW Response

1. **Why do you want monitoring? What data do you currently use and for what purposes?**

   To support regulatory and management decision making. The Department relies on current survey's, trapping, and telemetry data to understand the abundance and distribution of fish species in the Delta and its tributaries, and the risks posed by water operations. This applies particularly to species listed under CESA and ESA and others which are indicators of estuarine health. Long-term trend data in conjunction with other environmental monitoring data (flow, water operations, WQ, zooplankton, and phytoplankton, and invasive) is important in understanding how species and the ecosystem respond to varying environmental conditions and water operations.

2. **What are the key questions you would like to see addressed by monitoring?**

   Understanding how specific management actions affect species of concern (Delta Smelt, Longfin Smelt, Winter Run and Spring Run Salmon).
   Of particular interest are operations of the Suisun Marsh Salinity Control Gates, North Delta Food Web enhancement, tidal marsh restoration, floodplain restoration and food supplementation from flooded rice lands, spring, summer, and fall flow actions. Additionally, the effects of extended dry conditions and the effects of invasive aquatic vegetation on habitat suitability for species of interest and the effects of contaminates on species of concern. In addition, the original needs for understanding flow management effects on the ecosystem and the mechanisms therein are still needed.

   a. **Which do you think are being adequately addressed with current monitoring?**

      Current plans for the SMSCG and north Delta food web enhancement provide the basis for evaluating the efficacy of the actions. Plans are currently being developed to address the flow actions through the Delta Coordination Team. Needs for open water sampling from the Carquinez Straight upstream to answer recruitment questions are currently being addressed as part of the Five Survey Redesign effort.

3. **Are there aspects of the monitoring enterprise that you think are working well?**

   Yes.

   a. **If yes, please specify.**

      The existing monitoring programs in the Delta provide a strong basis for understanding how the ecosystem and species respond to varying flow conditions both long- and near-term.

4. **What changes would you like to see to the Monitoring Enterprise to support improved management of the Delta?**

   A clear understanding from the stakeholder community of what information is needed to better test and evaluate the effectiveness of management actions to inform potential changes. There should be clear understanding among all stakeholders about what level of certainty is needed as part of new special studies or monitoring efforts before they are initiated. A

review of current special studies should be conducted to assess how much more sampling is needed to detect the effectiveness of actions or if the question has been addressed.

a. Are there changes to current monitoring schemes that you would suggest to better serve adaptive management decision making?

More intensive sampling in areas subject to specific management actions, including those that could be used as baseline for restoration activities. Also improving data to support the development of life cycle models. These are actions that should be integrated in conjunction with the current status and trend monitoring.

b. Are there data that are not being collected that you think should be, and why?

Contaminant and invasive plant data. Contaminants, particularly pesticides, potentially adversely affect the food web for species of interest. Toxicity testing rather than chemical analysis should be the focus. It provides a much better tool for understanding bioavailability.

Invasive aquatic plants are changing the structure of the Delta in a way that is reducing its suitability for species of management interest. There needs to be a better understanding of how those changes affect species of interest and how to effectively manage invasive aquatic plants through current methods and potential habitat manipulation.

Consideration should be given to assessing mature fish abundance and distribution. Most of the current monitoring is for 4-6" fish, which is a very small portion of the food web. Better understanding of mature fish would help address predation effects.

c. Do you have suggestions for how to balance long-term data collection needs (ecosystem health and species status and trends) with real-time monitoring and special studies to assess specific management action performance (i.e. habitat restoration, flow actions) to support adaptive management opportunities?

There are different reasons for why each of these types of work are conducted. It is important to recognize that good monitoring programs should have a core that addresses both long-term and real-time needs, augmented with special studies that address specific, shorter-term management questions and research topics. Currently monitoring plans are in place or being developed for the existing management actions identified in the BiOp's and ITP. Suggestions on how to feasibly improve what is being implemented or planned are welcome along with ideas on additional investigations.

Special studies in general need to incorporate an evaluation step to assess whether or not the specific question being investigated has been answered and investigation terminated. Many of special studies start as a short-term question but then the data ends up getting used for something else that is deemed important, so it becomes long-term monitoring even though it has a different purpose from it's origin (e.g., zooplankton collection added to CDFW surveys, are they now for general food web information and no longer DS diet?).

d. **Are there examples of management actions or management issues that you think need better monitoring support?** No

KCWA Response

1. Why do you want monitoring?

Monitoring is needed to evaluate conditions in the system, status of the species, and the effectiveness of management actions as they relate to compliance with the permits for operation of the State Water Project (SWP). Monitoring is necessary to know if certain permit conditions have been met. Management actions required by the permits, such as the North Delta flow action intended to generate food to benefit Delta Smelt, must be evaluated to see if they work and under what conditions. Refining our understanding, via monitoring, is the only way to design actions that will benefit the species.

Consistent to Reynolds et al., we also recognize the importance of status and trends monitoring (necessary to understand the system over time), as well as effectiveness monitoring (necessary to understand the outcomes of actions). Monitoring in an adaptive management context helps to assess outcomes of multiple actions or actions with a high degree of uncertainty, which is the case in an estuarine system. Within the permits we also have threshold monitoring that determines changes to operations, such as triggers for OMR protections. We recognize the importance of each of these types of monitoring in assessing compliance with our regulatory obligations. We would like to ensure that this monitoring reflects the best available science and is done efficiently, without unnecessary overlap or repetition, and relevant to current management needs.

What data do you currently use and for what purposes?

The Kern County Water Agency (KCWA) and the State Water Contractors use data to know if we are complying with regulatory obligations related to operation of the SWP, to evaluate the impacts of project operations on the ecosystem, and to assess whether management actions are having the intended effects. We also use data to determine if there are science gaps that are important for our understanding of the system.

2. What are the key questions you would like to see addressed by monitoring?

Key questions would be related to hypotheses stemming from management actions, are they working? For example, related to the effectiveness of: spring pulse flows in the Sacramento River, predator management/aquatic weed control, Delta Smelt Summer-Fall Habitat action (called out in RPM5), operations of Suisun Marsh Salinity Control Gates, Old and Middle River flow management and triggers, etc. As it stands, evaluation of the effectiveness of many management actions is done by leveraging existing status and trends monitoring rather than by targeted monitoring specific to evaluating the intended biological outcomes of the management action and informing adaptive management.

a. Which do you think are being adequately addressed with current monitoring?

Consistent monitoring of the same parameters for general trends. While this is helpful, it is not targeted.

3. **Are there aspects of the monitoring enterprise that you think are working well?**
   a. **If yes, please specify.**
   The monitoring associated with the Fish Restoration Program (FRP) was designed in an adaptive management framework to understand the benefits of tidal marsh restoration required under ESA and CESA permits for operation of the SWP. The framework also allows for the methods to be replicated by others as other habitat restoration projects are constructed. We anticipate this monitoring will provide important data and information on how restoration benefits species and ecosystem processes, which can in turn inform future restoration efforts, including how restoration design can maximize benefits and minimize unintended outcomes such as occupation by invasive species.

4. **What changes would you like to see to the Monitoring Enterprise to support improved management of the Delta?**
   a. **Are there changes to current monitoring schemes that you would suggest to better serve adaptive management decision making?**
   In order for monitoring to be conducted under an adaptive management approach it should be related to fully articulated management decisions (the problem) and regulatory conditions (objectives), it should address uncertainties about how the system could respond to management over time and space with the intention to reduce uncertainties while learning and refining said management actions. Hypotheses related to the management decisions should be framed so that the appropriate study design can be developed to test those hypotheses. Although there are elements of adaptive management in place, oftentimes the agencies have relied on existing IEP monitoring surveys to assess the effectiveness of actions. Such monitoring wasn't designed for the actions. We applaud the desire for efficiency, but these surveys come up short in being able to address uncertainties enough to move to subsequent phases of adaptive management.

   b. **Are there data that are not being collected that you think should be, and why?**
   Data are often collected within the channels, so data on shallow/littoral habitats is needed. In addition, within channels, monitoring could be conducted in light of complex factors that can confound results, including hydrodynamics and fish behavior (e.g., diurnal positioning close to river bottom). More information on routing and survival of salmonids via telemetry data is needed.

   c. **Do you have suggestions for how to balance long-term data collection needs (ecosystem health and species status and trends) with monitoring to assess specific management action performance (i.e. habitat restoration, flow actions) to support adaptive management opportunities?**
   Conducting monitoring in an adaptive management approach can balance status and trends monitoring with effectiveness monitoring.

   d. **Are there examples of management actions or management issues that you think need better monitoring support?**
   Technical details should be addressed by the PWA technical experts in conjunction with other scientists from CSAMP, as proposed by comments by The Coalition for a Sustainable Delta.

MWD Response

1. Why do you want monitoring? What data do you currently use and for what purposes?

- We want monitoring to inform adequate protections for aquatic resources (e.g. standards set in federal and state permits, and pre-season take limits, such as the winter run JPE).
- We want monitoring to document risk of take within season in a manner that allows change in operations to minimize take.
- We want monitoring to inform whether there is a biological response to an action. (e.g. response in the distribution or abundance of Delta smelt to the Suisun Marsh Salinity Control Gate Action).

2. What are the key questions you would like to see addressed by monitoring?

Rather than asking for the "key questions" or "management questions" or "questions of management relevance", we suggest thinking of this in terms of "what decisions that you make are adequately informed by the monitoring and/or are sensitive to uncertainty that could be reduced with monitoring data?"

We would like to see monitoring designed to inform decisions related to the responses to question #1, including the following examples:

- Monitoring that informs the abundance and distribution of listed fish species, including the extent of species distribution and habitat use during their life cycle.
- Monitoring that can inform real time operation of the water project facilities.
- Monitoring that can provide information on the biological response to management actions that are being implemented to meet Biological Opinion and Incidental Take Permit requirements, and can inform decisions in an adaptive management framework.

a. Which do you think are being adequately addressed with current monitoring?

Suggest rephrasing this question to "What decisions do you make that are adequately informed by the current monitoring? What decisions that affect your organization are adequately informed with current monitoring?

One example would be the network of real time monitoring stations for salinity and the modeling tools that use the monitoring data to assess potential changes in salinity resulting from management actions.

3. Are there aspects of the monitoring enterprise that you think are working well?

a. If yes, please specify.

This seems similar to the previous question. If the monitoring is "adequately" informing decisions, then one could say it is working well.

4. What changes would you like to see to the Monitoring Enterprise to support improved management of the Delta?

a. Are there changes to current monitoring schemes that you would suggest to better serve adaptive management decision making?

Design monitoring for today's management decisions. Current management decisions are constrained by using monitoring designed for past management decisions. (e.g. FMWT designed for juvenile striped bass).

Design monitoring to address the full range of habitats used by a species, to inform species abundance and distribution.

b. Are there data that are not being collected that you think should be, and why?

Based on the Structured Decision Making efforts it seems clear that we need to know how zooplankton respond to actions and how listed species respond to changes in zooplankton throughout the SF Estuary. Prey continues to show up as a significant factor in multivariate analyses.

Incorporate innovative monitoring strategies where appropriate to better address management decisions, such as use of monitoring strategies that reduce take (e.g., Smelt Cam and eDNA), and use of real time monitoring stations and high frequency monitoring on boat cruises (e.g., USGS).

c. Do you have suggestions for how to balance long-term data collection needs (ecosystem health and species status and trends) with monitoring to assess specific management action performance (i.e. habitat restoration, flow actions) to support adaptive management opportunities?

Quantify the Value of Information (VOI) of continuing to collect long-term data. Continuing monitoring simply because it is a long-term data set is falling victim to the sunk-cost fallacy. If there is value to adding to the data set, state it explicitly, and quantify its value relative to the management decision it is meant to inform.

d. Are there examples of management actions or management issues that you think need better monitoring support?

Actions that will impact zooplankton, aquatic weeds, and contaminants need better monitoring support as they are frequently stated as important yet there is little monitoring being leveraged or the monitoring is not at the appropriate scale in the case of zooplankton. For example, actions that are expected to occur over a few days to a week have monitoring at a temporal scale far larger such as once a month or every other week.

WWD Response

1. **Why do you want monitoring? What data do you currently use and for what purposes?**

   Accurate and sufficient monitoring is important to understand and track species responses to factors that affect their viability, including hydrologic, habitat, and biologic conditions. My team and I track survival, abundance (JPE, etc), entrainment and similar metrics; however, the scientists rely on a broader set of data that are necessary to understand and analyze the effects of actions on and changes of species over time.

2. **What are the key questions you would like to see addressed by monitoring?**

   Many of the current restraints placed on operations of the Central Valley Project and State Water Project are in fact experiments; based on an analysis of data regulatory agencies impose actions that they believe will have an effect on species. The key question I would like monitoring to address is whether these actions are having the hypothesized effect on species abundance, survival, or viability. Can the actions be modified to reduce water supply reductions, without increasing impacts on species?

   a. **Which do you think are being adequately addressed with current monitoring?**

      There are physical parameters, especially for steelhead and chinook, that are adequately covered by current monitoring programs, such as flow, entrainment, and temperature.

3. **Are there aspects of the monitoring enterprise that you think are working well?**

   a. **If yes, please specify.**

      Abundance indices provide useful information on population trends and distribution monitoring provides useful information for use in real-time operations.

4. **What changes would you like to see to the Monitoring Enterprise to support improved management of the Delta?**

   a. **Are there changes to current monitoring schemes that you would suggest to better serve adaptive management decision making?** Changes are needed to improve monitoring of species abundance. Methods used to collect data need to be tailored to the species for which data are being collected. In addition, more comprehensive monitoring related to biological conditions that affect species would be valuable to inform key policy decisions. However, most of the improvements are needed in data collection and syntheses.

   b. **Are there data that are not being collected that you think should be, and why?** Monitoring needs to be improved to support and improve the various species life cycle models. As historic patters shift, e.g., as the spatial distribution of smelt changes, we need to adapt our monitoring programs to capture those changes.

c. Do you have suggestions for how to balance long-term data collection needs (ecosystem health and species status and trends) with monitoring to assess specific management action performance (i.e. habitat restoration, flow actions) to support adaptive management opportunities?

The balance should come from available funding and the source of the funding. Funding from the projects (operators, pwas, etc) should be prioritized for monitoring to assess management action performance and to support adaptive management. Public funding or funding from other sources can be used to support the long-term data collection needs. Additionally, this needs to be balanced with the usefulness of the information- data is only as good as its analysis. We need to improve our ability to analyze the data collected and incorporate that data into decision making.

d. Are there examples of management actions or management issues that you think need better monitoring support?

Flow based management decisions need support. We need to collect and analyze data to determine if there is a cause-and-effect relationship that gives rise to the flow-abundance relationships to hopefully identify the underlying biological mechanisms.

GCID Interview Summary

1. **Why do you want monitoring? What data do you currently use and for what purposes?**
   - Depends on the question we're interested in answering.
   - To know how are the species doing. Assess whether populations are increasing or decreasing.
   - To detect a response by species or life stage to management action or environmental perturbation.
   - Information on species status helps inform decisions on what actions to take (e.g. ops, restoration).
   - Concerned that the monitoring data may not have the necessary accuracy or resolution to answer certain questions, such as responses to specific management actions (eg. presence/absence vs abundance). Should have confidence intervals.

2. **What are the key questions you would like to see addressed by monitoring?**
   - Characteristics of winter run population (eg. egg to fry survival)
   - What are the effects of management actions such as spring pulses?
   - Need a better understanding of the metrics we are trying to meet, then match monitoring to that. Need to think about our goal. Look at conceptual models, then rebuild monitoring and actions.
   - We are currently trying to use existing monitoring to fit metrics (not measuring eggs or survival).
   - Mark recapture data would be useful.

   a. **Which do you think are being adequately addressed with current monitoring?**
      - Existing monitoring (eg. Carcass surveys, Red Bluff juvenile monitoring screw traps data) are good for assessing broad scale increases or decreases,
      - We are measuring production at Red Bluff, which is ok for a rough metric of how many juveniles are produced, but it's not sufficient for generating egg to fry survival estimates.

3. **Are there aspects of the monitoring enterprise that you think are working well?**

   a. **If yes, please specify**.
      - Programs working well for their original intention, but not beyond that.
      - Salvage facilities – specific to goal
      - RST – know what they are doing, but needs more work.

4. **What changes would you like to see to the Monitoring Enterprise to support improved management of the Delta?**

   a. **Are there changes to current monitoring schemes that you would suggest to better serve adaptive management decision making?**
      - Better accountability – not getting annual reports, documentation. CI's, how the data should be applied.

- Better integration. Monitoring is currently being funded and maintained by different parties under different contracts. How can we trust the data? Challenges.
- Monitoring JPA
- Chipps Island data being used for purposes it wasn't designed for. Not a production estimate for fish leaving the Delta. Rethink.
- Genetics framework. Evolving. How can it be applied to a larger watershed framework? What fish are making it? Where did the fish go? Better understand whats going on.
- Use current system to grab genetic samples. Not just what run. Where did it come from? Genetics library. Wild vs hatchery?
- Need an apriori assessment of whether the technique will work for the action,
- Lots of opportunity to use the fish collected. Where did they come from, when, what were the conditions they experienced?

b. Are there data that are not being collected that you think should be, and why?

- Capture efficiency. Link info to abundance estimate. RSTs
- Not looking for zero % error. Build the efficiencies in. Acknowledge it. Not being critical.
- Openness to change, improvement.
- Consider different techniques.
- Red Bluff and Stan are looking at efficiencies, but not Battle, Clear, Butte, etc.
- Info is not disseminated.
- River channel movement adds challenge.
- Limited testing.
- Disconnect between those collecting data and those wanting to use the data. May not be aware of issues regarding data use.

c. Do you have suggestions for how to balance long-term data collection needs (ecosystem health and species status and trends) with monitoring to assess specific management action performance (i.e. habitat restoration, flow actions) to support adaptive management opportunities?

- Really depends on the question, which drives scale. For example, long term doesn't require fine scale changes that require more accuracy.
- Current programs are designed for long term.
- Rethink scale for assessing management actions.
- Do we have monitoring/resolution to test specific hypotheses? Don't force the data.
- Is the monitoring tied to the actions?
- Have the conversations.

d. Are there examples of management actions or management issues that you think need better monitoring support?

- Survival between eggs and emergence. Forcing Red Bluff data and carcass data.
- JPE. Expect same issues with spring run that we're having with winter run. Need to be discussing. Shortcomings in data – RST detection, percent error. JPE drives ops, but data isn't sufficient.

- Fish entering the Delta. Efficiency estimates so we know abundance. Good at catching fry, but not yearlings. Need to capture all the life stages of interest.
- OMR corridor. No monitoring for salmonids.
- What monitoring is driving LCMs? Is the data accurate? Are we discussing this? Consider some scenarios. Test sensitivity. Help prioritize investments. Test through simulation before we implement changes to monitoring.
- AT array, iTag. Insular. Stakeholders can't participate. Need more openness and collaboration, including the data.

CCWD Interview Summary

1. **Why do you want monitoring? What data do you currently use and for what purposes?**

   CCWD is not currently using Delta fish survey monitoring data. No longer required to monitor facilities due to proven effectiveness.

   CCDW does use physical and water quality monitoring data on flows and salinity.

   Support use of data for status and trends, managing SWP and CVP operations, specific project effectiveness monitoring and assessing progress toward achieving SWP and CVP goals and permit terms.

   Hard to find Delta Smelt, therefore most actions are triggered by physical parameters.

2. **What are the key questions you would like to see addressed by monitoring?**

   CCDW is not an exporter. Key questions tend to be related to exports (e.g. I:E)

   Monitoring should be used to address status and trends, effectiveness, flows, etc. (see above)

   a. **Which do you think are being adequately addressed with current monitoring?**

      NA

3. **Are there aspects of the monitoring enterprise that you think are working well?**

   a. **If yes, please specify.**

      EDSM redesign has been good.

      AT arrays are also good in terms of how they have been redesigned. The implementation of more tag studies has also been good.

      Good question for those on the boats. Check with the field crews. What do they think we should be doing more or less of?

4. **What changes would you like to see to the Monitoring Enterprise to support improved management of the Delta?**

   a. **Are there changes to current monitoring schemes that you would suggest to better serve adaptive management decision making?**

      Need to design the AM first, then design the monitoring.

      All AM projects became prescribed conditions of the ITP. No decision to make.

      SMSCG could have been a good AM project, but it became a permit requirement with specific constraints

   b. **Are there data that are not being collected that you think should be, and why?**

      Water quality data. HAB is a big issue with barrier in place.

More continuous monitoring stations to monitor fluxes would be helpful to see how HABs are moving around. USGS is installing multiple sensors to assess.

Surrogate species. Can we do some monitoring to address? What are we doing to address criticisms regarding the use of surrogate fish?

c. Do you have suggestions for how to balance long-term data collection needs (ecosystem health and species status and trends) with monitoring to assess specific management action performance (i.e. habitat restoration, flow actions) to support adaptive management opportunities?

Status and trends monitoring is really important, but we should be looking for more public funds to pay for it (eg. FMWT, STN).

Can we subsample tows to free up $/boats/people for special studies?

d. Are there examples of management actions or management issues that you think need better monitoring support?

Food web actions – do two actions in a given year (Sac action in the summer through Yolo and a fall ag drainage). Currently constrained by band width.

Waiting for DWSC to be at an implementation stage – baseline monitoring?

Could use more baseline monitoring – e.g. Fall Outflow, regardless of whether it's an action year or not.

Previous FLOAT conversations *regarding baseline – check with Fred.*

Other CCWD Comments:

Consider a reserve account for monitoring using state surplus funds.

Monitoring is key to understanding climate change.

Should we consider changing the timing of some monitoring to account for the impacts of climate change?

Should the scope of existing fish surveys be shift given climate change (e.g. sample more upstream). Should we also consider adjusting the timing of seasonal sampling given changes in climate (i.e. what is "fall"). Spawning is occurring out of season.

What do changing temps mean to fish? We are seeing unusually warm Jan's and Feb's.

More temperature sensors have been added in the Delta to look at climate change, but is its comprehensive enough?

Would like to study temperature and hydrodynamics, including the effects of residence time, and potential relation to HABs.

SWRCB Interview Summary

Big Picture Comments

- Ensure we're asking the right question and analyzing the data, but ensure it's done thoughtfully so we don't lose cohesiveness and trends over time.
- Don't strip data collection to do more analysis, because you lose information.
- Need more entities at the table to do the monitoring and analyses.
- Bring other water right holders into the fold. More comprehensive approach.
- Monitoring needs to be robust and reliable to gain the trust of regulated entities, stakeholders, NGOs and agencies.
- More monitoring and a better system for conducting and better participation.
- Pressure to redo monitoring, but need to be cautious and maintain long-term data sets.

1. Why do you want monitoring? What data do you currently use and for what purposes?

Required by 1641 and 1485 to assess compliance. Tied to permits.

Important to understand status and trends from tributaries through the Delta, and understand how management actions are affecting species.

Most requirements are put on CVP and SWP related to WQCP.

Need to address impacts that may occur from implementation.

Currently rely on data collected by CDFW and USFWS (IEP data).

2. What are the key questions you would like to see addressed by monitoring?

a. Which do you think are being adequately addressed with current monitoring?

Three are questions in the permit that represent the minimum needed.

Need more related to water quality and protection of beneficial uses.

See **scientific basis reports** prepared in 2018.

3. Are there aspects of the monitoring enterprise that you think are working well?

a. If yes, please specify.

Struggle with boat maintenance, but agencies share resources, collaborate and help each other out. Out there every month.

Not a lot of folks that have the skills, including boat operations.

Getting better at automating data and availability

Better data management.

4. What changes would you like to see to the Monitoring Enterprise to support improved management of the Delta?

a. Are there changes to current monitoring schemes that you would suggest to better serve adaptive management decision making?

See Independent Science Advisory panel report on Biological Goals

Any changes should be reinforced with a strong scientific basis and design relative to status and trends and adaptive management – within 1-3 years does it work

Want to see them well supported.

Ecological focus, not just ESA

b. Are there data that are not being collected that you think should be, and why?

c. Do you have suggestions for how to balance long-term data collection needs (ecosystem health and species status and trends) with monitoring to assess specific management action performance (i.e. habitat restoration, flow actions) to support adaptive management opportunities?

Expand allocation of responsibilities for programs and plans

d. Are there examples of management actions or management issues that you think need better monitoring support?

Status and trends data needs to be conducted in an unbiased way. Have a firewall between those doing the data collection and those funding it.

Board leans heavily on the data to support decisions. Need qualified science that's unbiased. Program that supports next phase of WQCP needs to have a broader base of funding and geographic scope.

Expand overall monitoring and the number of qualified parties contributing and broadening funding and creating a consistent hub (One Delta One Science).

Bring SFEI into the discussion. Get agency scientists more engage.

VA process will involve a lot of analyses to bring to the Board, including improvements to monitoring over time to address milestones

Functioning sustainable ecosystem, not just ESA.

What's the impact of flow? How do we protect the watersheds?

Will need to grow the enterprise.

Will have to be a collaborative enterprise. Need to ensure the practitioners are there.

Deserving of a significant enterprise.

Ok to talk about who will fund, but it shouldn't be a lowest common denominator.

Coalition for a Sustainable Delta Response

Advancing the "reimagining" of fish monitoring in the Delta and adjacent waters

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DRAFT 03/30/2022

In the summer of 2021, CAMT convened a review of Delta fish monitoring with the intention of catalyzing improvements in long-term monitoring and in developing targeted monitoring[1] for assessing effectiveness of prescribed management actions intended to benefit listed species. Past and ongoing monitoring in the Delta has provided a baseline of conservation-relevant ecological data; however, the Delta Independent Science Board's Monitoring Enterprise Review revealed a need to better align monitoring with the information needs of resource managers. In addition to the Delta ISB, the problem of a "monitoring-management disconnect" was affirmed by findings of the Task 1 CAMT monitoring assessment. Although previous monitoring reviews addressed in Task 1 have evaluated and identified improvements to existing monitoring programs, none were explicitly tasked to consider if new or different approaches to monitoring are needed to assess the status and trends of fish populations with the degree of accuracy necessary to inform policy or guide management, or to reliably ascertain the effectiveness of directed management actions. Recognizing these challenges, the Delta ISB recommended that Delta monitoring be "reimagined" to meet "priority needs that are of fundamental importance to decision-makers and adaptive management across the Delta."

Task 2 of the CSAMP/CAMT monitoring review called for assessing and documenting the objectives that should be served by Delta fish monitoring. However, discussions within CAMT indicate that participants do no share agreement on why a re-evaluation of Delta fish monitoring is advisable, or how such a re-evaluation should occur. Where agreement exists is in recognition that when multiple fish species and life stages, complex habitats, environmental stressors, and management actions are considered simultaneously, the number and variety of possible monitoring objectives is daunting. So then is the task of evaluating information needs.

This document attempts to provide a narrower, more tractable framework for initiating the process of reimagining Delta fish monitoring. Three key monitoring topics are identified – 1) status and trends monitoring, 2) habitat integrity and function, and 3) documentation and assessment of management actions. Each topic identifies issue areas that require expert input, including questions intended to elucidate important monitoring information needs. Preliminarily, it is envisioned that these issues and questions would be addressed by technical experts in a workshop setting facilitated by a subject-area expert. For this

[1] Where "targeted monitoring" is defined by its integration into conservation practice, with monitoring design and implementation based on a priori hypotheses and associated models of system responses to management (Nichols and Williams. 2007. *Monitoring for conservation. TRENDS in Ecology and Evolution. Vol. 21*:12).

approach to be successful, it will be essential that participants focus on discussing the issues and questions as framed – the discrete purpose is to identify information needs that must be met to advance conservation planning and meet obligations for management of the imperiled species of the Delta. Whether the information needs that are identified in the workshops can be met using available survey and monitoring methods and funding, and how existing monitoring programs can contribute to meeting current and future information needs will be determined subsequently.

1. Status and trends monitoring

The purpose of status and trends monitoring is to determine population size to a useful degree of certainty and to document changes in abundance and spatial distribution of fishes of concern in the Delta over time. Rigorously designed, unbiased status and trends monitoring can identify changes in population size, can inform quantitative population viability assessments, can contribute to risk assessment, and thereby guide conservation planning efforts. However, status and trend monitoring typically lacks a priori hypotheses and specific objectives relating to the decision criteria that must accompany proscribed management actions, therefore cannot discern cause-and-effect relationships between populations and management actions.

Workshop discussion on status and trends monitoring will focus on five fishes of management concern species (or species-life stages) occurring in the Delta -- Chinook salmon, steelhead, delta smelt, longfin smelt, and striped bass.

Workshop activity: Without referring to or relying on a specific sampling method (existing or future) and/or environmental indicator, workshop participants should identify the specific population metric(s) that would most effectively and efficiently inform status and trends-based assessments. Experts will consider sampling issues including accuracy/precision, and temporal, spatial, and sampling design considerations relevant to the species-life stage and to the population metric selected, anticipating that status and trends data on listed and other fish species will be mobilized to inform adaptive management of those species and trigger policy decisions more generally. Where there may be uncertainty or disagreement about the feasibility of achieving agreement on a population metric, panelists will identify a second population metric that is more likely to be achievable.

2. Habitat function

Habitat is a species-specific concept. Each species has a distinct landscape area that it occupies and specific resources and resource conditions that it requires for its survival and persistence. The habitat of a species can be occupied or unoccupied at any point in time. Habitat can vary in quality or conditions as measured by the growth and survival of the individuals that reside there. Unsuitable environmental conditions may occur across all or portions of a species' habitat making certain resources unavailable or just marginally acceptable. A species may experience population losses or individuals may move to landscape areas with better conditions, or both may occur. Unsuitable conditions may be

short-lived, for example during a winter cold snap, or they may last for long periods, like during an extended drought that may last for years. Whether unsuitable for short or long periods, environmental conditions can again become suitable allowing a local or regional population to rebound in numbers and move back into habitat that was temporarily unoccupied, or both.

Habitat includes both physical resources and biological resources; combined they provide the environmental elements necessary for the survival, persistence, and recovery of a species. Habitat quality varies with dynamic environmental conditions across the landscape and through time.

Understanding the location and extent of habitat that support species of concern and the availability of that habitat over time is essential to directing conservation efforts and contributing to species recovery.

Workshop activity: With this background in mind, workshop participants will define and describe up to five aquatic habitat strata (types or categories) that occur in the Delta, including strata that may be consistently or only intermittently occupied by Delta fish species of management concern. Panelists will identify key physical or biological attributes within habitat strata that are likely to influence the occupancy, survival, or growth of fish residing there.

Panelists will use the (five) habitat strata to populate the table below. Assume it is the season when each species/life stage is most likely to be present in the Delta and that key physical/biological attributes are suitable. These strata may at various times and varying abiotic conditions be surveyed, contributing to thorough sampling across the full ranges of targeted species.

Panelists will place a "1" in cells where the species/life stage is expected to occur frequently, place a "2" in cells where the species/life stage is expected to occur infrequently, or leave cells blank where the species/life stage is expected to be very rare or absent.

	Habitat strata				
Species/life stages	A	B	C	D	E
Rearing juvenile salmon					
Rearing juvenile LFS					
Rearing juvenile striped bass					

3. Management actions

A large and diverse number of management actions have been enacted, are prescribed, or are being considered with the general intent of providing benefits or protections to threatened and endangered fish species. Under the programmatic adaptive management approach proscribed in the ITP, management actions must be evaluated to determine if they should continue, be modified, or be discontinued in favor of alternatives. This process requires that each directed management action include clearly articulated objectives and decision criteria, where the objectives are specific, observable outcomes from the management action.

Workshop activity: The purpose of this workshop exercise will be to identify species/life stage specific objectives and performance measures for two mitigation and minimization measures associated water project operations actions in the Delta. Results from this exercise can serve as model approaches for other management actions implemented under the ITP and re-consulted Biological Opinion.

Old and Middle River (OMR) flows

Existing regulations (California's Incidental Take Permit and Federal Agencies' Biological Opinions) include complex standards for how negative OMR flows are allowed to be and when. Reducing the magnitude of negative OMR flows from -5,000cfs to -2,500cfs when listed fish species are thought to be at increased risk, or when a triggering event occurs, provides an example of a common OMR management action. For juvenile salmon entering from the North Delta and for adult longfin smelt expert panelists will: 1) identify the primary objective of this OMR flow action, 2) linked to the objective, specify one or more measurable, expected outcome(s) from the action and attending performance measure(s), and 3) describe an experiment or data-collection effort that would allow the effectiveness of the action to be evaluated.

Fall X2 Action

According to the USUSFWS (2008) the objective of the Fall X2 Action is to "Improve fall habitat for delta smelt by managing of X2 through increasing Delta outflow during fall when the preceding water year was wetter than normal. This will help return ecological conditions of the estuary to that which occurred in the late 1990s when smelt populations were much larger. Flows provided by this action are expected to provide direct and indirect benefits to delta smelt. Both the direct and indirect benefits to delta smelt are considered equally important to minimize adverse effects." In its incidental take permit, CDFW (2019) expanded the management action to a Summer-Fall Action. For simplicity, we focus here on the fall outflow action (the Fall X2 Action). However, the intended benefits of CDFW's proposed action are worth noting: The delta smelt (DS) "summer-fall habitat action, (Summer-Fall Action) is intended to benefit DS food supply and habitat, thereby contributing to the recruitment, growth, and survival of DS."

For juvenile/sub-adult delta smelt and for juvenile/subadult longfin smelt, the expert panel will 1) identify the most important biological objective of the Fall X2 Action, 2) link it to the objective and specify one or more measurable expected outcomes (performance measures)

from the action, and 3) describe an experiment or data-collection effort that would allow the effectiveness of the action to be evaluated.

Concluding observations

An approach to advancing the monitoring reimaging process recommended in the draft ISB monitoring review is a necessary bridging activity from CAMTs Task 1 reporting to initiation of formal deliberative design/redesign of monitoring to meet the information needs of resource managers and the regulated communities that rely on Central Valley and Delta water resources. Whether viewed as an actionable Task 2 component or the initial action kicking off a monitoring-design process under Task 3, the process-informing workshops described above are timely. The enabling information and expertise required are available among the resource agencies and independent scientists. . The task is essential and pressing. It needs not await further polling of the opinions and surmise of the resource agencies and other institutions.

[1] Please direct comments or questions to bcavallo@fishsciences.net or 530.613.8459

Appendix 4. List of Acronyms

CAMT Collaborative Adaptive Management Team
CDFW California Department of Fish and Wildlife
CCWD Contra Costa Water District
CSAMP Collaborative Science and Adaptive Management Program
CVP Central Valley Project
DSP Delta Science Program
DWR California Department of Water Resources
GCID Glenn Colusa Irrigation District
ISB Delta Independent Science Board
KCWA Kern County Water Authority
MWD Metropolitan Water District of Southern Californa
NGOs Non-Governmental Organizations
NMFS National Marine Fisheries Service (Also NOAA Fisheries)
NRDC Natural Resources Defense Council
SWP State Water Project
SWRCB State Water Resources Control Board
TBI The Bay Institute
TNC The Nature Conservancy
USBR United States Bureau of Reclamation (Also BOR)
USFWS United States Fish and Wildlife Service
WWD Westlands Water District