# 2019-20 Assessment of the Proposed Collaborative Science and Adaptive Management Program (CSAMP) Delta Smelt Science Plan (DSSP)

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# Executive Summary

Following receipt of the DSSP (Reed 2019) in the spring of 2019 the CSAMP Collaborative Adaptive Management Team (CAMT) initiated an assessment of the DSSP to inform decision-making around its potential adoption and implementation. This assessment, or “test”, of the DSSP was assigned to a small group of CSAMP scientists and science managers, proceeding in two general phases. In the first phase, 2019 Delta Smelt management actions and associated science activities were catalogued, and a brief review conducted of the planning processes that lead to the science activities. Generally, the assessment of biotic and abiotic responses to the actions made use of data from a mix of action-specific and ambient/ongoing activities. The mix of supporting action-specific and ambient monitoring science activities varied substantially and logically among the 2019 management actions in response to differences in the geographical and temporal scope of the actions and the action responses under evaluation. Tables 1 through 4 of this report individually provide brief summaries of the action-specific science activities associated with each of the 2019 management actions, plus off-year science activities associated with the Suisun Marsh Salinity Control Gate action, and note where ongoing ambient monitoring data will be employed in management action evaluation. In all cases the tables exhibit science covering a broad range of biotic and abiotic conditions information necessary for documenting and understanding action environmental responses.

As part of the “cataloguing” phase of the DSSP assessment a limited effort was made to identify and characterize the extent of planned Delta Smelt-related research in 2019 by reviewing program planning documents, contacting individual investigators and funding entities, and reviewing conference agendas. The studies are listed, categorized, and briefly described in Table 5 of this report.

The second phase of this limited assessment of the DSSP involved a small group of scientists and science managers participating in an informal, half-day workshop discussing science activity planning for a selected 2019 management action (the North Delta Flow (Food Web) Action). The focus of the discussion was discerning how the extant planning processes compare to those anticipated under the DSSP. Much of the workshop discussion, revolved around the challenges investigators currently face during their action science planning, and how the DSSP could potentially resolve or exacerbate these challenges. The primary product of the workshop discussion was a series of observations, included in Appendix B, intended to inform DSSP implementation. Appendix B also includes science planning-related observations made during the cataloguing of 2019 science activities.

## Summary and Recommendations

The three overarching general conclusions derived from the DSSP assessment were: 1) there already exists a high degree of compatibility between current planning efforts and those envisioned by the DSSP, 2) many aspects of the DSSP have the potential to facilitate future science planning efforts (e.g., enhanced and more systematic collaboration and communication, and potentially greater program leadership awareness of planning challenges), and 3) DSSP science activity planning process data analyses and reporting expectations may not be achievable without infusion of additional resources, or re-allocation of resources. The following six key recommendations relating to CSAMP's potential implementation of the DSSP were derived from the observations mentioned above. The recommendations have as their purpose strengthening CSAMP's science efforts in support of more effective adaptive management of urgently needed Delta Smelt management actions. The recommendations are presented in slightly greater detail in the main text of the report.

- **Recommendation 1 (consider confounding factors)**:

  Investigators developing science activity plans associated with management actions should take a holistic view, fully considering the possibility of confounding factor effects, and provide for monitoring and analysis of these effects, to the extent practical. CSAMP science plan review processes pursued by the DSSP-proposed Science Manager and Independent Science Panel should systematically evaluate the adequacy of proposed confounding factor monitoring and analysis within action-science plans.

- **Recommendation 2 (facilitate timely reporting)**:

  The proposed CSAMP Science Manager should strive to facilitate timely action-science reporting by working closely with Investigators and Action Champions to develop science reporting schedules responsive to adaptive management needs, including arranging CAMT progress updates. The Science Manager should closely track reporting progress, identify constraints on science reporting, make CAMT aware of constraints, and work with CAMT to alleviate constraints to ensure timely reporting.

- **Recommendation 3 (ensure that science supporting management actions is technically robust and adequately resourced):**

  Proposed action science should be designed and resourced to ensure, to the extent practical, that hypothesized action abiotic and biotic responses can be reliably detected. The need for rigor applies to both the technical robustness of the proposed science to address key scientific uncertainties and the strength of the logistics to accomplish the proposed science activities. Investigators proposing CSAMP science activities should directly address this objective in their proposals and plans, and the Science Manager should ensure that proposal review processes evaluate the strength and reliability of proposed detection efforts. If planned detection efforts appear to have a significant risk of inadequacy, the Investigators and Science Manager should work together, and with CAMT, to enhance the efforts and get them adequately resourced.

- **Recommendation 4 (support coordination necessary for science planning):**

  The Science Manager should coordinate with Action Champions and Investigators to identify circumstances, particularly in the case of high frequency (e.g., annual) actions, where assistance is needed with such tasks as permitting, retaining technical specialist services, and organizing/conducting stakeholder (e.g., landowner) outreach. The Science

Manager should partner with CAMT to provide this assistance, making use of CSAMP's broad representation of stakeholders.

- **Recommendation 5 (resource new methods development and implementation):**

  Investigators should actively identify and consider potential new sampling and analysis methods to address consequential uncertainties that are ineffectively addressed by extant methods. The Science Manager and CAMT should support this consideration through, for example, special study funding. The Science Manager should coordinate transparent, independent assessments (e.g., through the Independent Science Panel) of proposed new methods before they are adopted for use in informing CSAMP action adaptive management.

  Consideration of how to better resource particular action-science activities could include obtaining new funding, assessment of possible science activity efficiencies within and among management actions, and re-allocation of resources with full consideration of science information trade-offs.

- **Recommendation 6 (develop regional models):**

  The DSSP appropriately emphasizes the need for enhanced modelling to improve prediction and understanding of biotic and abiotic responses to management actions. The Science Manager should work closely with Investigators, Action Champions, modelers, and CAMT to pursue regional models (or sub-models) to improve prediction and understanding of responses to region-focused management actions.

# Introduction

In 2018 the Collaborative Adaptive Management Team (CAMT) of the Collaborative Science and Adaptive Management Program (CSAMP) commissioned Dr. Denise J. Reed of the University of New Orleans to develop a framework for planning and technical management of Delta Smelt science activities conducted under the auspices of CSAMP. The commissioning of the planning framework was a reflection of CSAMP's intent to be a trusted provider of key scientific information in support of policy makers on issues relating to current and future CVP/SWP Biological Opinions (BiOps), and more broadly to facilitate and adaptively manage actions to increase Delta Smelt resiliency and recovery. Dr. Reed's science planning document (Reed 2019), referred to here as the Delta Smelt Science Plan (DSSP), included many substantive recommendations relating to planning leadership, key unmet scientific information and tool needs, and proposed planning processes. A fundamental recommendation of the DSSP was that CSAMP adopt a 3-year science activity planning cycle accompanied by an annual supplementation process.

What is a CSAMP management action? What constitutes CSAMP? The answers to these questions have evolved over time. When the assessment effort reported here began the focus (as indicated in the DSSP title) was clearly on flow-related actions identified in the 2008 USFWS Delta Smelt Biological Opinion (2008 BiOp) (USFWS 2008). During the course of the assessment consideration was expanded to include certain non-flow actions under pursuit by CSAMP participants.

Dr. Reed submitted the completed DSSP to CAMT in March 2019. As the DSSP was nearing completion, discussions began within CSAMP regarding DSSP assessment and possible implementation. These discussions lead to development and approval of a brief document (Guidance Document, Appendix A) providing CAMT guidance to a small group of CSAMP scientists and science managers tasked with conducting a limited assessment of the DSSP. As per the Guidance Document, the assessment effort proceeded in two phases, as follows:

1) A thorough cataloguing of planned 2019 CSAMP Delta Smelt management actions (MAs), action-specific science activities, related routine ("ambient") monitoring, and relevant research efforts.
2) Selection of one of the previously planned 2019 management actions for the purpose of comparing the action's associated science activity planning processes and outcomes with those envisioned by the DSSP. The North Delta Flow (Food web) Action (NDFA) was chosen for this exercise.

Three of the 10 steps listed in the Guidance Document are not substantially addressed in this report. Step 6, which calls for the fine-scale delineation of essential steps in action-science planning, was superficially addressed during the course of Parts A & B of the assessment, and reflected in some report "observations" (e.g., Observation 18). In general, Step 6 proved beyond the achievable scope of the present assessment process, and one better pursued in the subsequent larger-scale DSSP implementation efforts. Steps 9 & 10 of the Guidance Document anticipated that the DSSP assessment effort would contribute to a decision regarding CSAMP adoption of the DSSP as a framework for MA science planning, and the possible initiation of planning under the framework in 2019-20.

In mid-2020 CSAMP did, in concept, decide to adopt the DSSP, and began to develop the processes and infrastructure to implement the framework. The pursuit of DSSP implementation has been conducted in parallel with other, related planning initiatives, including:

- A large-scale Structural Decision Making (SDM) process for identifying and prioritizing Delta Smelt-related MAs.
- Exploration of new "Decision-Support Tools" designed to predict the ecological consequences of potential Delta Smelt MAs.
- Development of a CSAMP organizational framework to facilitate Delta Smelt action and science coordination and prioritization.

CAMT and the CSAMP Policy Group (PG) received regular written and verbal reports regarding assessment effort progress and preliminary findings, plus a final report (the present document) to inform subsequent DSSP implementation and initial 3-year planning under the DSSP.

It was intended that pursuit of the steps delineated in the Guidance Document would increase familiarity with DSSP planning concepts, and led to 27 observations regarding:

- Areas where current planning processes and outcomes diverge from those envisioned by the DSSP.
- The extent and nature of current challenges in CSAMP science activity planning.
- How, and to what extent, DSSP implementation would avoid or mitigate these challenges, or exacerbate them.

The observations, which are scattered in context throughout this report, listed in Appendix B, and summarized at the end of the report, are intended to be helpful in identifying areas where adjustments may need to be made in DSSP-proposed processes, or changes made in CSAMP structure and function to accommodate Plan implementation. Although the observations were not *per se* intended to be recommendations, the six recommendations listed in the "Summary & Recommendations" sections of this report were derived from the observations.

# Part A: 2019 CSAMP Science Cataloguing

The general purpose of the 2019 CSAMP science catalogue presented in Part A is to provide context for the science planning assessment (described in Part B of the report). Part A presents a concise description of the management action-related science resulting from current planning efforts. The catalogue of 2019 CSAMP related or relevant Delta Smelt science activities provided below was largely derived from the following four sources:

1) Action-specific science activities designed and implemented to detect and understand environmental responses to MAs implemented in 2019.
2) 2019 action-specific science activities carried out in relation to MAs not implemented in 2019.
3) Ongoing ambient monitoring that either contributes directly to MA response detection, or provides a larger context for understanding responses.
4) General Delta Smelt research that provides for improved understanding of MA responses, and/or provides for action refinement.

## 2019 Management Actions

The cataloguing of 2019 CSAMP scientific activities began with the identification of planned MAs. The suite of MAs implemented in 2019 was to some degree water flow dependent. High flow conditions prevailed throughout the Central Valley during the winter-spring period of 2019 MA development, and eventually Water Year (WY) 2019 was designated “Wet”. The science activity cataloguing effort was initially focused on activities associated with flow-related MAs, but was eventually expanded to include other types of actions. The three MAs implemented in 2019 are listed below along with brief descriptions of purpose and origin. Figure 1 illustrates the approximate study/effect areas associated with each of the 2019 MAs, plus the Suisun Marsh Salinity Control Gate (SMSCG) and Roaring River Distribution System (RRDS) actions (not planned for implementation in 2019).

*Observation (1): Bay-Delta flow condition uncertainty presents significant challenges to annual MA planning. The DSSP’s proposed 3-year planning cycle structure, with annual supplementation, has the potential to accommodate the challenges of flow condition uncertainty by having plans and allocated resources in place to handle flow-related contingencies.*

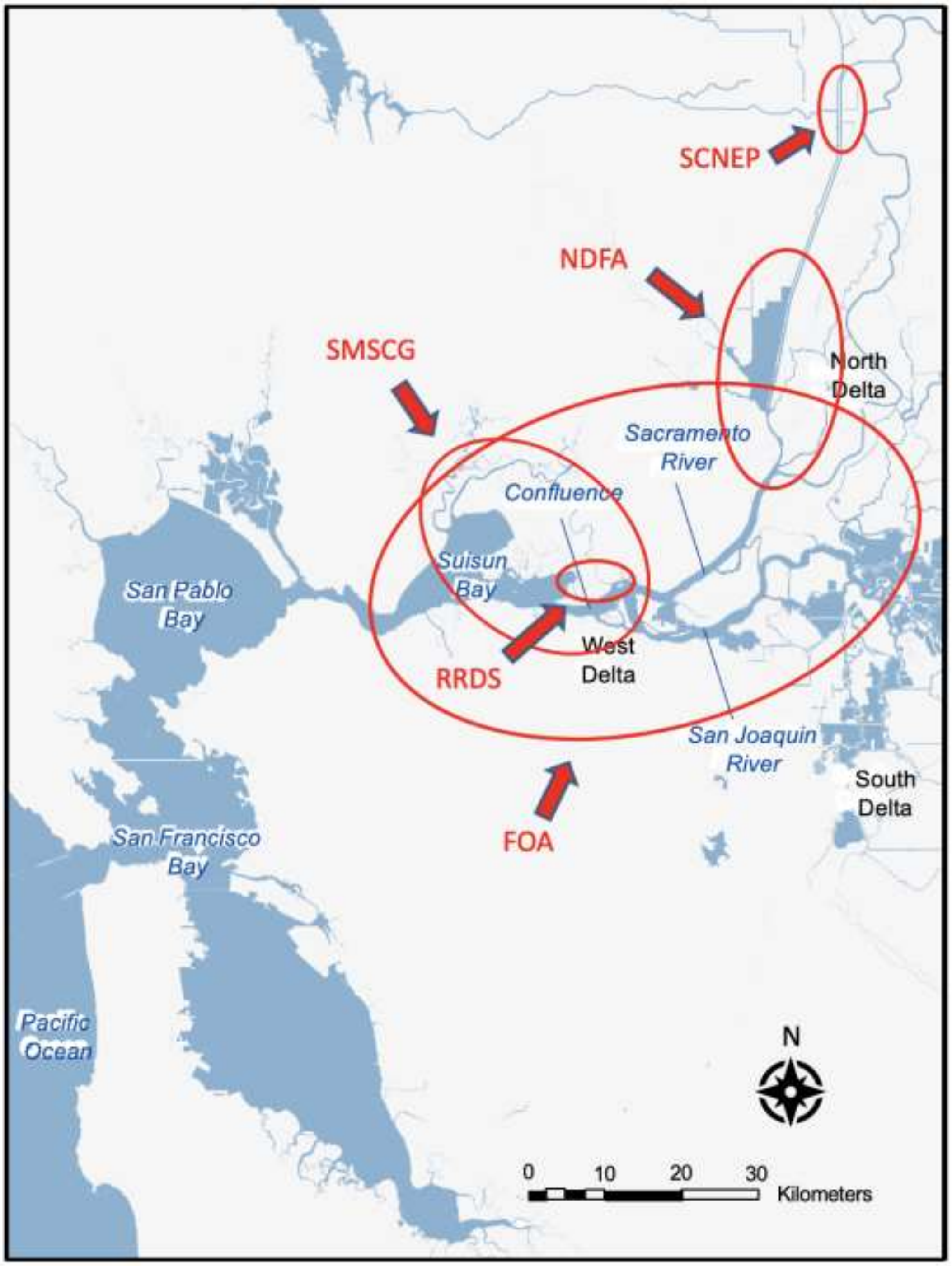


Figure 1. Locations and general study/effect areas of planned 2019 CSAMP Delta Smelt-related management actions: SCNEP = Ship Channel Nutrient Enrichment Project, NDFA = North Delta Flow Action, SMSCG = Suisun Marsh Salinity Control Gate Action, RRDS = Roaring River Distribution Action, and FOA = Fall Flow Action. Figure adapted from DWR (2019).

*Observation (2): An intended feature of the DSSP planning framework is regular communication between CSAMP leadership and the staff engaged in scientific activity planning. During 2019 staff reporting to CAMT regarding the year's anticipated MAs precipitated a CAMT discussion regarding the scope of DSSP application, and ultimately a decision to broaden the focus of scientific activity planning from just flow-related MAs to all MAs.*

*Observation (3): CSAMP Delta Smelt MAs planned for 2019 did not directly address summer habitat in the lower Sacramento River (Rio Vista to Sherman Island), an historically important rearing area for juvenile Delta Smelt.*

1) Fall Outflow Action (FOA) – The Reasonable and Prudent Alternative aspect of the 2008 BiOp includes an outflow-related action (BiOp Action 4) in some years to improve the quality and quantity of fall habitat for Delta Smelt growth and rearing. The action is intended to provide both direct and indirect benefits to rearing Delta Smelt by increasing the aerial extent and volume of fall abiotic habitat and positioning that habitat away from threats such as entrainment and exposure to harmful effects of invasive aquatic vegetation growth and toxic algae blooms.

In May of 2019 WY 2019 was designated as "Wet" as defined by the Sacramento Basin 40-30-30 Index. Given this designation, the BiOp required the water projects to provide sufficient Delta outflow to maintain X2 for both September and October no greater than 74 km. In addition, the BiOp required that following "Wet" WYs November inflows to Sacramento basin CVP/SWP reservoirs will be added to reservoir releases to provide an additional increment of Delta inflow to augment Delta outflow. Although there had been interagency discussions in early 2019 regarding modifying the BiOp fall action, in the end implementation of the action proceeded in essentially original form.

*Observation (4): Implementation of the FOA in 2019 presented two potentially significant challenges to scientific activity planning, WY designation uncertainty and ongoing discussion regarding the form of the action, which, as with any flow action, might affect sampling site number and location. Advanced planning and funding of DOP studies helped address these challenges in 2019, and the DSSP's multi-year planning framework has the potential to further alleviate annual flow condition uncertainty challenges in the future by promoting contingency planning and by staging associated resources.*

2) 2019 North Delta Flow (Food Web) Action (NDFA) – The NDFA is one of the 13 MAs identified in the 2016 Delta Smelt Resiliency Strategy (CNRA 2016). The general purpose of the action is to improve summer and early fall Delta Smelt food quality and quantity in the northwest Delta. The desired food web effect is achieved by creating modest seasonal pulsed flows of agricultural drain water and diverted Sacramento River water through the Yolo Bypass (YB) toe drain, thus creating a net-positive nutrient- and plankton-rich flow into the Cache Slough region and Sacramento River near Rio Vista.

   The 2019 flow action was planned for the period of late-August through September with a minimum total pulse flow volume of 27,000 acre-ft, which is a larger volume than deployed in previous (2016 & 2018) iterations of the action. The 2019 action was supported by a detailed monitoring and assessment workplan (DWR 2019) describing the conceptual basis and predicted outcomes of the action, associated monitoring efforts, and planned data synthesis and reporting.

   A particular challenge in planning individual NDFAs is the need for outreach to numerous agricultural landowners to obtain their cooperation in achieving the action's flow objectives, which requires coordination of land drainage operations. Developing complex drainage strategies, communicating with landowners to refine and gain support for the action, and coordinating with landowners in implementing the strategy are time consuming challenges. To the extent these outreach efforts extend beyond the Action Champion to science staff, they can impinge on science staff ability to accomplish timely analysis and reporting.

*Observation (5): A potential role for CSAMP within the envisioned DSSP planning framework and Science Manager construct is to assist action staff with stakeholder outreach (e.g., organizing outreach fora), using CSAMP member networks.*

3) Sacramento Deep Water Ship Channel Nutrient Enrichment Project, Phase 2 – The Sacramento Deep Water Ship Channel (SSC) Nutrient Enrichment Project (SCNEP) is an experimental effort to determine if nitrogen fertilization can boost plankton production in SSC waters, and an initial step in assessing the efficacy of a potential Delta Smelt management action. Specifically, the action being explored is that of adaptively managing Sacramento River flows through the SSC for the purpose of exporting enhanced phytoplankton production into the northern Delta to improve food web conditions for Delta Smelt (USBR 2019a).

The 2019 nitrogen enrichment experiment (SCNEP Phase 2) involved aerial application of calcium nitrate to a 400-meter reach of the upper SSC during two four-day periods in summer 2019. The application targeted two neap tidal periods to avoid rapid rates of dilution and dispersion due to strong tidal (spring tide) action experienced during a similar (Phase 1) experiment. The 2019 experimental nutrient application was accompanied by a robust suite of monitoring activities conducted before, during, and after fertilization, as summarized in the sections below.

*Observation (6): The evolution of the SCNEP experimental action and associated science activity from Phase 1 to Phase 2 demonstrates how comprehensive project-level monitoring and timely analysis can lead to effective action adaptive management and refined understanding of action responses.*

Monitoring and assessment of 2019 CSAMP management actions is supported by three general categories of scientific activity. In the subsections below the scientific activities supporting each of the management actions are summarized by category (i.e., action-specific, ambient (ongoing), and research).

## MA-related 2019 Science Activities

1) <u>Fall Outflow Action 2019 Science Activities</u>

- **FOA action-specific science activities**: Table 1 lists, and briefly describes, planned science activities associated with the 2019 fall outflow action. Table 1 also attempts to categorize the purposes of the reports and individual investigations in terms consistent with the DSSP framework. The Directed Outflow Project (DOP) draft technical report (USBR 2019b) provides detailed descriptions of many of the activities. The six DOP investigations listed in Table 1 cover a wide range of topics related to the health and condition of juvenile and adult Delta Smelt residing in several different regions of the upper estuary, focusing on how these health and condition factors vary geographically and seasonally under different flow regimes. Additional DOP scientific activity detail can be found in the 2019 IEP Work Plan (IEP 2018). The investigation results are intended to provide an improved mechanistic understanding of flow effects.

  In addition to the Reclamation-led DOP investigations, DWR planned a pilot deployment of hatchery-reared Delta Smelt enclosures at three Delta locations before, during, and after the 2019 FOA in order to assess smelt growth and survival responses in different regions of the Delta. Finally, two major synthesis reports, both of which were in advanced draft stage, were under review, and scheduled for completion in 2019. The two reports are the FLOAT-MAST report emphasizing Wet

Water Year 2017, and Reclamation's DOP Technical Report #1 (USBR 2019c) covering activities through 2017. The FLOAT-MAST report (FLOAT-MAST 2021) is at this writing "in press", and the final DOP report became available in December 2019. It was intended that the results of the Reclamation report be integrated into the FLOAT-MAST report.

- **FOA ambient (ongoing) monitoring support:** The FLOAT-MAST analyses and report rely primarily on the results of on-going ambient monitoring efforts, although it was intended that they incorporate any applicable available information into the synthesis. The DOP investigations are generally action-specific in nature, although the field sampling design explicitly relies upon the USFWS Enhanced Delta Smelt Monitoring (EDSM) program. Both pending DOP and FLOAT-MAST synthesis reports leveraged historical and 2017 routine survey data, and the 2019 DOP analysis utilizes status and trends monitoring data from EDSM, and the IEP's Fall Midwater Trawl Survey (FMWT), Summer Townet Survey (STN), Bay Study, and Environmental Monitoring Program (EMP).

Table 1: Action-specific scientific activities associated with planned 2019 fall outflow action.

| Fall Outflow Action | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Scientific Activity** | **General Role** | | | **Delta Smelt Response** | | | **Habitat Response** | | | | |
| | **Prediction** | **Detection** | **Understanding** | **Pop./Dist.** | **Health** | **Vital Rates** | **WQ** | **Nutrients** | **Phyto/ Chl-a** | **Zooplankton** | **Contaminants** |
| | | | | | | | | | | | |
| DOP: DS Prey[a] | | X | | | X | | | | | | |
| DOP: DS Histology[b] | | X | | | X | | | | | | |
| DOP: DS Life History Variation[c] | | X | X | X | | | X | | | | |
| DOP: DS Growth[d] | | X | X | | | X | | | | | |
| DOP: Juv Growth[e] | | X | X | | | X | | | | | |
| DOP: Contaminant Effects[f] | | X | | | X | | | | | | X |
| DOP: X2 Report[g] | | | X | | | | X | | | X | |
| Smelt Enclosures[h] | | X | | | X | X | X | | X | X | X |
| FLOAT-MAST Rept[i] | X | | X | X | X | X | X | X | X | X | X |

a/ Assessment of summer-fall outflow effects on DS foraging (stomach fullness & prey species) using smelt collected in extant surveys.

b/ Assessment of outflow and spatial occupation effects on juvenile and adult DS gill and liver health (lesion severity & incidence).

c/ Examining annual variation in DS life history attributes by applying otolith microstructure/microchemistry techniques to extant survey specimens.

d/ Examination of the factors affecting DS growth rates in wet and dry years using otolith microstructure techniques on extant survey specimens.

e/ Evaluation of factors affecting juvenile short-term growth rates using muscle RNA-DNA ratios from extant survey caught specimens.

f/ Assessment of contaminant effects on hatchery DS exposed in the lab to waters sourced from six upper SFE regions.

g/ Completion/publication of a synthesis report on the effect of summer-fall X2 position on DS prey density and distribution.

h/ Deployment of a total of six hatchery Delta Smelt enclosures (two each at three locations) before and during fall flow action to assess growth and survival.

2) <u>North Delta Flow (Food Web) Action 2019 Science Activities</u>

The plan for monitoring and assessment of the 2019 NDFA included implementation of a suite of action-specific scientific activities, and substantial application of data obtained from on-going Bay-Delta ambient monitoring programs. The planned NDFA use of both categories of scientific activity are summarized in Table 2. Table 2 is intended to provide a general overview of science activities associated with the NDFA and their purposes. Much greater NDFA scientific activity detail can be found in the action-related monitoring and assessment workplan (DWR 2019) prepared by action staff.

- **NDFA action-specific science activities:** The suite of planned action-specific science activities designed to monitor and assess environmental responses to the NDFA are collectively referred to as the 2019 Food Web Study. Table 2 lists the individual elements of the study which are focused on documenting the water quality, nutrient, and lower trophic level responses in the YB Toe Drain, Cache Slough region, and lower Sacramento River. The planned 2019 NDFA science effort also included pilot deployment of hatchery Delta Smelt enclosures at two locations within the Toe Drain before and after the flow action, which is intended to directly provide information on action-related smelt growth and survival responses. Two of the enclosure sites associated with the FOA (Sacramento River near Rio Vista and Cache Slough) also had the potential to detect NDFA effects on smelt growth and survival. Contaminant and benthic grazing-related sampling, two factors likely to confound food web response interpretation, were also planned for 2019. There was also monitoring planned and implemented for potential undesirable MA consequences such as increased Fall-Run Chinook Salmon straying into the Tule Canal.

*Observation (7): Holistic consideration of an MA's potential physical and biological effects will identify monitoring needs un-related to Delta Smelt that are important to CSAMP decision making.*

- **NDFA ambient monitoring support:** As indicated in Table 2 the monitoring and assessment of the 2019 NDFA was primarily to be accomplished through scientific activities specific to the action. In addition to the data from action-specific activities, selected data from two ongoing ambient monitoring programs were planned for incorporation into the action effects analysis. Specifically, the October EMP benthic grabs from the Sacramento River at Rio Vista were to be incorporated into the NDFA study area clam grazing rate analysis, and continuous water quality data from four CDEC stations were intended to contribute to the analysis of action general water quality effects. Finally, it was expected that the ultimate synthesis of NDFA effects data would, as appropriate, make use of other Bay-Delta ambient monitoring efforts to provide important context to, and improved understanding of, observed action responses.

Table 2: Action-specific scientific activities associated with planned 2019 North Delta Flow Action.

| **North Delta Flow Action** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Scientific Activity** | **General Role** | | | **Delta Smelt Response** | | | **Habitat Response** | | | | |
| | **Prediction** | **Detection** | **Understanding** | **Pop./Dist.** | **Health** | **Vital Rates** | **W.Q.** | **Nutrients** | **Phyto/Chl-a** | **Zooplankton** | **Contaminants** |
| Drain Water Qual.[1] | | **X** | | | | | **X** | | | | |
| $H_2$0 Grab Samples[2] | | **X** | | | | | | **X** | **X** | **X** | **X** |
| Zooplankton[3] | | **X** | | | | | | | | | |
| Benthic Grazing[4] | | | **X** | | | | | | | | |
| Smelt Enclosures[5] | | **X** | | | **X** | **X** | | | | | |
| Analysis/Report[6] | **X** | **X** | **X** | | | | | | | | |

1/ Continuous monitoring at four action-specific stations, in addition to two long-term ambient condition stations.
2/ Bi-weekly sampling at 12 sites (Rominger Bridge in Colusa Drain → Rio Vista) to monitor water quality, nutrients, chlorophyll-*a*, and phytoplankton biomass; and five sites for contaminants.
3/ Bi-weekly zooplankton sampling conducted at nine stations from Ridge Cut Slough to Rio Vista, using 150um mesh nets (analyzed by BSA Environmental).
4/ Estimates of clam grazing rates derived from the biomass of clams collected (benthic grab samples) along a transect once in the fall, plus estimates derived from October EMP samples.
5/ Deployment of two hatchery Delta Smelt enclosures in Yolo Bypass toe drain for four weeks before and after (not during) action.
6/ Synthesized analysis and technical reporting of results to inform future action planning.

3) SSC Nutrient Enrichment Project (Phase 2) 2019 Science Activities

- **SCNEP action-specific science activities:** The proposed 2019 experimental action, aerial application of calcium nitrate fertilizer to a reach of the upper SSC, was to be accompanied by a comprehensive 8-week program of action-specific monitoring activities (Table 3) designed to improve understanding of nitrogen dynamics and environmental responses. These activities, which are described in full detail in the project Effects Analysis (USBR 2019a), were focused on documenting hydrodynamics, vertical stratification and other physical characteristics, nutrient concentrations and dispersion, and the response of the phytoplankton and zooplankton communities in the study area during the experimental period.

- **SCNEP ambient monitoring support:** Due to the high spatial and temporal intensity of SCNEP data needs, and the relatively small size and location of the project, the effects assessment does not make substantial direct use of ongoing ambient monitoring data. It is likely that the synthesis of experiment results will make use of available ambient monitoring data to provide information on the general environmental context.

*Observation (8): The utility of on-going ambient monitoring data in assessing environmental responses to MAs varies substantially among MAs, depending on the spatial and temporal scale of the actions.*

Table 3: Scientific activities associated with planned 2019 Sacramento R. Deep Water Ship Channel Nutrient Enrichment Project, Phase 2. The nutrient study/manipulation area is a 3km reach in the upper SCC, centered at Navigation Light 74.

| **SCNEP, Phase 2** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Scientific Activity** | **General Role** | | | **Delta Smelt Response** | | | **Habitat Response** | | | | | |
| | **Prediction** | **Detection** | **Understanding** | **Pop./Dist.** | **Health** | **Vital Rates** | **WQ** | **Flow** | **Nutrients** | **Phyto/Chl-a** | **Zooplankton** | **Toxics** |
| | | | | | | | | | | | | |
| D.O. & Temp.[a] | | | **X** | | | | **X** | | | | | |
| $H_2O$ Movement[b] | | | **X** | | | | | **X** | | | | |
| CTD Sensors[c] | | | **X** | | | | **X** | | | | | |
| Nitrate/Chl-*a*[d] | | **X** | **X** | | | | **X** | | | **X** | **X** | |
| Fish Community[e] | | **X** | **X** | | | | | **X** | | | | |
| Data Synthesis[f] | **X** | | **X** | | | | | | | | | |

a/ Continuous dissolved oxygen and temperature sensor monitoring at 5 manipulated reach and 2 reference sites; at 2 depths; before, during, and after fertilization.
b/ Acoustic Doppler and ADCP deployment at Navigation Light 73 (within manipulation reach) to continuously measure tidal water movement.
c/ Continuous CTD (conductivity, temperature, dissolved oxygen) sensors deployed nearshore and offshore at multiple depths at the center and both ends of the nutrient manipulation reach.
d/ Continuous measurement of Nitrate & Chlorophyll-*a* (plus BGA, turbidity, pH, fDOM, D.O., water temperature, conductivity) using buoyed multi-sensor units located on the channel ledge at the center and either end of the manipulation reach.
e/ Aquatic Habitat Sampling Platform deployment to document changes in fish CPUE before and after fertilizer application.
f/ Data analysis and hydrodynamic modeling directed at improving the understanding nutrient dynamics and related primary production responses in the SSC.

## 2019 Off-year Action Science Activities

The Suisun Marsh Salinity Control Gate Re-Operation Action (SMSCG Action) and the Roaring River Distribution System Action (RRDS Action) were not slated for implementation in 2019. However, action-specific scientific activities (described below) were to be undertaken in 2019 in connection with both actions. Both the SMSCG Action and the RRDS Action are included in the Delta Smelt Resiliency Strategy (CNRA 2016).

1) <u>2019 SMSCG Action Science activities</u> - Monitoring and assessment of the SMSCG Action is guided by a two-year (2018-2020) work plan (Sommer et al. 2018). The workplan identifies predicted action effects and describes a suite of monitoring and assessment studies to evaluate predictions. Predictions were qualitative in nature, generally based on conceptual models and data from past and present monitoring and research. The work posits 26 action-related responses across three categories (habitat, food web, and Delta Smelt) and two regions (Suisun Marsh and confluence area). The predictions are made relative to similar summer-fall hydrological circumstances without the influence of modified SMSCG operations. The multi-year, comprehensive nature of the SMSCG Action 2018-2020 work plan suggests a high degree of natural compatibility with overall DSSP proposed planning processes.

   The 2018-2020 SMSCG Action workplan lists (Action work plan, Table 2) the data sources to be used for each of the response predictions (Action work plan, Table 1). To a substantial extent the evaluation of the SMSCG Action relies on data from existing long-term (ambient) monitoring surveys, with some essential supplementation from action-specific science activities. The work plan calls for accessing/collecting the same data both in years when the action is implemented (drier years) and when it is not implemented. The purpose of the action's modified SMSCG operations is to freshen the waters of Suisun Marsh and upper Grizzly Bay to make them more favorable for Delta Smelt growth and survival. The purpose of conducting monitoring in both action implementation years (e.g. 2018) and wetter non-action years such as 2019 is to allow for the comparison of conditions created by the action to those that occur "naturally" in wetter years. Table 4 summarizes the information to be generated in all years to evaluate the SMSCG Action. Table 4 simplifies the information presented in the workplan in that it does not break down the monitoring by region within the study area.

   The SMSCG Action study area extends from the lower Sacramento River (just above Decker Island) to the Carquinez Strait, including the confluence area, Montezuma Slough; and Honker, Suisun, and Grizzly bays. SMSCG Action monitoring extensively leverages existing survey efforts conducted in these regions, including the Summer Tow Net Survey (STN), Fall Midwater Survey (FMWT), Enhanced Delta Smelt Monitoring (EDSM), Environmental Monitoring Program (EMP), and ongoing continuous water quality monitoring (CDEC). SMSCG Action evaluations are based on data gathered during the months July through October.

Table 4: 2019 scientific activities associated with the Suisun Marsh Sanity Control Gate (SMSCG) Action.

| SMSCG Action | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Scientific Activity** | **General Role** | | | **Delta Smelt Response** | | | **Habitat Response** | | | | | |
| | **Prediction** | **Detection** | **Understanding** | **Pop./Dist.** | **Health** | **Vital Rates** | **W.Q.** | **Hydro** | **Nutrients** | **Phyto/Chl-a** | **Zooplankton** | **Pred/Prey/Comp** |
| Delta Outflow[1] | | X | | | | | | x | | | | |
| LSZ Surface Area[2] | | X | X | | | | X | X | | | | |
| Wind Speed[3] | | | X | | | | X | | | | | |
| Turbidity/Salinity[4] | | X | | | | | X | | | | | |
| N Concentration[5] | | X | | | | | | | X | | | |
| Chlorophyll-*a*[6] | | X | | | | | | | | X | | |
| Phytoplankton[7] | | X | | | | | | | | X | | |
| Zoop Biomass[8] | | X | | | | | | | | | X | |
| Clam Dynamics[9] | | | | | | | | | | | | X |
| Fish Community[10] | | X | | | | | | | | | | X |
| DS Responses[11] | | X | | X | X | X | | | | | | |
| Action Synthesis[12] | X | X | X | | | | | | | | | |

1/ Monitoring average daily net Delta outflow and the San Joaquin River contribution, data sourced from Dayflow.
2/ Modeling of low salinity zone area and hydrodynamic complexity (provided by Anchor QEA).
3/ Continuous monitoring of study area wind speed conditions, sourced from the Blacklock CDEC station north of Montezuma Slough.
4/ Discrete bi-weekly turbidity and salinity measured at study area STN and FMWT survey stations, plus 3 additional action-specific stations.
5/ Discrete monthly measurements of Ammonium, Nitrate, and Nitrite concentrations at all study area EMP stations.
6/ Continuous Chlorophyll-*a* measurement at all study area routine CDEC stations, plus one additional action-specific station in Grizzly Bay

2) <u>Roaring River Action Science Activities</u> – Planned 2019 RRDS science activity is best described as reconnaissance in nature. Project staff conducted site visits with San Francisco State University scientists to assess possible locations for zooplankton sampling.  With the assistance of CDFW, three drains along the system were identified that will allow for safe sampling of water coming out of the RRDS into the neighboring CDFW properties and Grizzly Bay (the west drain). In conjunction with the SFSU Kimmerer Lab, sampling techniques for the drains were being developed. Prior commitments likely prevented the Kimmerer Lab from initiating RRDS sampling until fall 2019. Given this timeframe, constraints were faced associated with elk and waterfowl hunting that take place over the subsequent 8 months, leaving minimal days for safe access to the system for sampling.

   Potential sampling objectives included obtaining a better understanding of the current food web resources within the system (e.g. phytoplankton and zooplankton quantity and composition) that could be available at the west drain of the RRDS versus the east drain of the RRDS. Also of interest is understanding seasonal effects (e.g. fall vs. winter vs. spring vs. summer), which would likely be both a function of season, weather conditions, and RRDS operations.

   Fall flood-up began around the week of July 8, 2019 and properties along the system began filling their managed wetlands to prepare for waterfowl season. At that time the east and west drains were fully closed, the system filled, and the CDFW, along with private landowners began pulling water from the system for waterfowl season preparations.

   Seasonal evaluations (sampling) within the RRDS would have constraints, including:

   - Elk hunting season (July 29th – September 27th) (sampling access only allowed on Mondays, no exceptions).
   - Waterfowl hunting season (October 19th – February 1) (sampling access allowed on Monday and Thursday (preferred), if needed Tuesday and Friday). Private hunting clubs that border the RRDS are allowed to hunt every day of the week, but usually adhere to the general hunt days of Saturday, Sunday, and Wednesday.
   - January through March “king tides” and excessive rainfall create the potential for severe flooding and loss of safe access along levee roads.

*Observation (9): Landscape conditions unrelated to the MA can heavily constrain conceived sampling efforts, and thus compromise the effort to meet study objectives.*

*Observation (10): Limitations in the availability and capacity of unique essential specialist resources (e.g., university or consultant staff) can complicate MA science activity planning and implementation.*

## General Delta Smelt Species and Habitat Research

Table 5 lists and generally categorizes examples of Delta Smelt-related scientific investigations underway in, or planned for, 2019 that are not directly associated with a particular MA. An earnest effort was made as part of the 2019 science cataloguing reported here to identify ongoing and planned Delta Smelt general research through review of science program planning documents and personal contacts with experienced investigators. However, the information in Table 5 should not be considered comprehensive, especially given that new research work may have been initiated since 2019.

The principal reason for identifying 2019 general smelt research in connection with this DSSP assessment is 1) to provide a sense of the degree to which present research might contribute to Delta Smelt science planning as envisioned by the DSSP, and 2) ascertain how DSSP structured science planning could potentially facilitate development and implementation of investigations that have the potential to enhance the assessment of MAs.

The DSSP emphasizes the need for adaptive management science support in the areas of MA effect prediction, detection of MA effects, and understanding the mechanisms underlying environmental and species responses to MAs. The elements of Table 5 provide numerous examples of how extant planning and execution of general Delta Smelt science provides this support, including:

- Ongoing Delta Smelt lifecycle model development to improve <u>prediction</u> of MA and ambient condition effects
- Further development, including pilot deployment of in-situ enclosures to directly <u>detect</u> Delta Smelt growth and survival responses to environmental conditions, including conditions resulting from MAs
- Evaluation of salinity and contaminant effects on Delta Smelt embryo and larval development to improve <u>understanding</u> of MA outcomes

Table 5. Examples of Delta Smelt-related research planned for, or underway, in 2019.

| **Modeling & Modeling Support** | | | |
|---|---|---|---|
| # | Element Topic/Description | Principal Investigator(s) | Affiliation |
| 1 | Continued evaluation of survey gear selectivity/efficiency to inform modeling efforts. | R. Baxter | CDF&W |
| 2 | Improvement of pelagic fish (including Delta Smelt) population estimates through refinement of gear efficiency/selectivity across multiple life stages | V. Tobias | USF&WS |
| 3 | Development of a model that provides a quantitative, empirically based decision support tool to assess Delta Smelt population dynamics, | V. Tobias | USF&WS |
| 4 | Ongoing development of a Delta Smelt life cycle model. | L. Polanski<br>W. Smith | USF&WS<br>USF&WS |

| **Sampling Methods Development** | | | |
|---|---|---|---|
| # | Element Topic/Description | Principal Investigator(s) | Affiliation |
| 1 | SmeltCam technology development and deployment in connection with vertical and lateral distribution assessment for "early warning" purposes | F. Feyrer | USGS |
| 2 | Refinement and pilot deployment of hatchery-origin smelt enclosures to assess growth and survival responses to changing field conditions | T. Sommer | CDWR |
| 3 | Development of "Aquatic Habitat Sampling Platform (AHSP)" to provide a fish community sampling method standardized across habitat types, and minimizing take of sensitive species | J. Merz | Cramer Fish Sciences |
| 4 | Development of environmental DNA sampling methods to detect and survey Delta Smelt | M. Finger | UC Davis |
| 5 | Refinement of isotope-salinity relationships for reconstruction of Bay-Delta fish, including Delta Smelt, salinity and temperature histories. | J. Hobbs | UC Davis/CDF&W |
| 6 | Improved Delta Smelt visual identification | G. Castillo | USFWS |

| CVP/SWP Entrainment Effects | | | |
|---|---|---|---|
| # | Element Topic/Description | Principal Investigator(s) | Affiliation |
| 1 | Updated and refined analysis of factors affecting entrainment (CAMT Entrainment Study 1). | L. Grimaldo<br>W. Smith | ICF<br>USF&WS |
| 2 | Characterization Delta Smelt spawning migration and distribution based on modeling of hypothesized swimming behaviors (CAMT Entrainment Study 2a). | E. Gross | Resource Management Associates Inc |
| 3 | Evaluation of proportional entrainment loss estimates derived from particle tracking and population dynamics modeling (CAMT Entrainment Study 2b) | J. Korman | Ecometric Research |
| 4 | Update and extension of historical estimates of proportional entrainment loss (CAMT Entrainment Study 3) | P. Smith | USGS (retired) |
| 5 | Determination of whole facility salvage efficiency at the TFCF using cultured smelt | R. Reyes | USBR |

| Contaminant Effects | | | |
|---|---|---|---|
| # | Element Topic/Description | Principal Investigator(s) | Affiliation |
| 1 | Comparative investigation of six commonly used pyrethroids on early stages of Delta Smelt development. | R. Connon | UC Davis |
| 2 | Evaluation of salinity & contaminant effects on embryo development and larval development and swimming performance. | R. Connon | UC Davis |
| 3 | Analysis of Delta aquatic macrophyte control (herbicide treatment) effects on Delta Smelt habitat, including vegetation, water quality, hydrodynamics, plankton and fish community. | T. Sommer | CDWR |

| Diet & Condition | | | |
|---|---|---|---|
| # | Element Topic/Description | Principal Investigator(s) | Affiliation |
| 1 | Ongoing analysis of pelagic fish, including Delta Smelt, diet composition and body condition collected in CDF&W long-term monitoring surveys. | C. Burdi | CDF&W |
| 2 | Synthesis of IEP zooplankton sample methodologies and variation in zooplankton communities across habitats | K. Kayfetz | DSP |

| Genetics | | | |
|---|---|---|---|
| # | Element Topic/Description | Principal Investigator(s) | Affiliation |
| 1 | Genetic analysis of archived Delta Smelt samples to estimate the effective population size, as well as development and implementation of a genetic monitoring plan for the wild Delta Smelt population. | M. Finger | UC Davis |
| 2 | Quantification of genetic and epigenetic variation in Delta Smelt relative to adaption to future environments. | ? | UC Davis |
| 3 | Discovering genetic loci associated with wild and early, middle, and late hatchery ancestry in FCCL Delta Smelt (pending funding). | M. Finger | UC Davis |

| Smelt Culture | | | |
|---|---|---|---|
| # | Element Topic/Description | Principal Investigator(s) | Affiliation |
| 1 | Evaluation of Delta Smelt behavioral and physiological responses to stress, predation cues, increased temperature, and salinity. | B. Davis | CDWR |
| 2 | Species and hybrid identification of FCCL wild-caught spawners. | M. Finger | UC Davis |
| 3 | Assessment of egg marking using calcein | T-C. Hung | UC Davis |

| Life History & Habitat | | | |
|---|---|---|---|
| # | Element Topic/Description | Principal Investigator(s) | Affiliation |
| 1 | Examining Delta Smelt growth and migration history based on microstructure and chemical analysis of otoliths extracted from monitoring survey specimens. | J. Hobbs | UC Davis/CDF&W |
| 2 | Assessing the relationship of turbidity and predation as it relates to growth, development and behavior (pending funding) | R. Connon | UC Davis |
| 3 | Determination of the “sprint” swimming capability (pending funding). | N Fangue | UC Davis |
| 4 | Water depth utilization under varying photo-phases, turbidity, and light intensities (pending funding). | N Fangue | UC Davis |
| 5 | Using cultured fish, determine Delta Smelt spawning behavior for the purpose of informing future spawning habitat restoration. | T-C. Hung | UC Davis |
| 6 | Spatio-temporal community patterns in early life stages of fishes and their associations with zooplankton in the upper San Francisco Estuary. | G. Castillo | USF&WS |

| | | | |
|---|---|---|---|
| 7 | Extracting better information from long-term monitoring data: Estimating occupancy and abundance of near-shore fishes in the Sacramento-San Joaquin River Delta. | B. Mahardja | CDWR |

*Observation (11): Delta Smelt MA planning and implementation currently benefits from a wide variety of general research activities emanating from many academic, agency, and stakeholder sources. The DSSP has the potential to enhance the relationship between research efforts and Delta Smelt management by focusing and prioritizing information needs, formally communicating those needs to potential investigators, coordinating funding to accomplish high priority investigations, and synchronizing MA and investigation planning and implementation.*

## Part B: DSSP Assessment

The action/science cataloguing effort ("Part A") described above involved substantial discussion with investigators and review of science planning documents, revealing much about how action and science planning is currently conducted within the CSAMP universe, and the associated challenges faced. Key observations derived from the cataloguing effort are embedded in the preceding sections of this report. As described in step 7 of the Guidance Document the second phase of DSSP assessment was intended to be a more direct effort at comparing present CSAMP planning with that envisioned by the DSSP. The limited assessment approach described below provided the opportunity to address two general topics relating to CSAMP adoption of the DSSP science planning framework. The principal topic addressed is the efficacy of DSSP envisioned science planning, and how it accommodates, or not, the present realities of CSAMP (funding protocols, available resources, action permitting, etc.). The secondary discussion facilitated by the assessment approach was that of clarifying how a current example of management action science planning by a CSAMP participant compares with the potentially more structured and collaborative approach proposed in the DSSP. Addressing these two topics, even in a limited way, provides insights into the potential planning benefits the DSSP approach could provide, the magnitude and nature of the gaps between present science planning efforts and that envisioned by the DSSP, and the challenges CSAMP will likely face in attempting to achieve the DSSP planning vision. Insights provided here in both areas are intended to facilitate CSAMP's deliberations regarding how to move forward with adoption of the DSSP science planning framework. The assessment's observations would appear to have value in considering the efficacy of both the DSSP's 3-year plan and its supplementation approaches.

The DSSP envisions the development of 3-year CSAMP associated science plans built around anticipated management actions and environmental conditions, with an annual supplementation process. The supplementation process is described on pages 47-49 of the DSSP, and with a hypothetical example described in Plan Appendix 3. Rather than consider the full array of possible actions within a year to assess the annual supplement component of the DSSP, it was decided to focus on a single 2019 management action for which science activity planning had previously been completed. The NDFA was selected because the action had well-defined and limited objectives, and because a detailed action-related monitoring and assessment (science) work plan was available. This provided for a comparison of science planning and outcomes under existing processes with those envisioned by the proposed DSSP. The existing work in planning scientific activities for this action also made the assessment efficient as investigators had already considered in detail the action and its expected effects. With DSSP implementation, contextual information would also be available from the current 3-year science plan.

The limited DSSP assessment reported here was largely accomplished through discussions held during a small, informal workshop conducted on August 9, 2019. The workshop participants were:

1) Pat Coulston (CDFW Water Branch, Senior Env. Sci., member/co-chair CSAMP DSST, former IEP Program Manager, report compiler)
2) Ted Sommer (by phone) (DWR Lead Scientist, NDFA PI & Project Sponsor)
3) Denise Reed (by phone) (University of New Orleans, DSSP author)
4) Larry Brown (U.S. Geological Survey)
5) Bruce DiGennaro (The Essex Partnership, CSAMP Program Manager)
6) Steve Culberson (Delta Stewardship Council, IEP Lead Scientist)
7) Brittany Davis (DWR EWQ&ES Branch, Env. Program Manager, NDFA PI & PM)

The workshop discussions on August 9 were generally structured around a set of pre-determined questions, but were at times “free-wheeling”. The questions, which were designed to generally reflect the supplement process as described in Appendix 3 of the DSSP, are listed below, along with summaries of related discussion. Interspersed among the summaries are key observations stemming from the discussions. Each discussion summary below attempts to briefly address the following topics:

- The purpose and value of considering the topic addressed by the question.
- How, and to what extent, are CSAMP participant investigators presently addressing the question, as illustrated by 2019 NDFA planning?
- The challenges CSAMP participant investigators encounter in addressing the question.
- How, and to what extent, might DSSP implementation facilitate addressing present challenges, or be constrained by them?

## August 9, 2019 Workshop Structured Questions and Discussion

- Question 1 – What are the potential NDFA-related scientific activities?

  This question posed within the DSSP annual supplementation process reflects the intention that science-activity planning begin with an awareness of, and consideration of, the full range of potential activities available for predicting, detecting and understanding Delta Smelt responses to management actions.

  Discussion Summary: In the case of the NDFA, its implementation in 2019 was designated as part of a comprehensive multi-year study plan. The developers of the plan were closely linked with all significant upper estuary monitoring and research efforts, including any that were considered to have value in NDFA assessment. Accessing available scientific information pertinent to the management action, and collaboration with the entities and investigators collecting that information, brings monitoring efficiency to action assessment and added expertise to facilitate mechanistic understanding of action effects. The breadth of the NDFA collaboration (5 entities, and 10 individual scientists and modelers) clearly reflects present understanding by the NDFA Principal Investigator of the importance of posing and addressing “Question 1”. At no time during the discussion was there any indication from the participants that confronting this question at the beginning of the supplementation process was anything but appropriate and effective.

Two potential science activities have been identified for inclusion in the 2019 NDFA assessment that were not available or considered for inclusion in the original multi-year study plan. The two potential activities are 1) development of biological models to integrate with hydrodynamic models to improve prediction of action-related trophic responses, and 2) the use of Delta Smelt enclosures to directly measure action effects on Delta Smelt health, growth, and survival.

*Observation (12): Robust, well-sourced science activity planning is essential to providing a strong basis for management action assessment. The level of NDFA PI awareness of the universe of CSAMP and other relevant scientific activities presently seems quite high, which may in part be because the action had been taken before under the multi-year effort. The awareness would likely be further promoted by the DSSP program timely reporting and collaboration focus.*

- Question 2 – Were the potential scientific activities undertaken during previous implementations of the NDFA? If so, what was learned?

  Two basic things can be learned from scientific activities associated with management action implementation. The first is an understanding of management action effectiveness in achieving the intended environmental and species responses. Secondly, learning will occur regarding the effectiveness of the suite of deployed scientific activities, and individual activities, in detecting and interpreting management action responses. Asking "Question 2" when considering supplementing a 3-year plan ensures that the action/science planning benefits from past experience, and avoids repeating ineffective science activities or failure to incorporate improvements.

  Discussion Summary: Scientists have been investigating the effects of summer/fall net freshwater flows through the Yolo Bypass (YB) on Bypass and downstream aquatic environments since 2011. The focus of investigation has been, and remains in 2019, flow-related food web effects and non-flow factors that have the potential to affect food web/flow dynamics. Since 2016, and including 2019, the effects of deliberate management actions have been monitored across a wide spectrum of food web related subject areas. What follows here are brief summaries of key findings from each subject area.

*Abiotic Habitat* - Flow measurements have confirmed the existence of desired positive net flows through the Yolo Bypass during summer/fall flow pulses. The 2016 and 2018 managed actions achieved average pulse-period positive net flows greater than 500 cfs. Variable increases in salinity have been observed during pulses, depending on the water source. The turbidity response has also been variable, as has nutrient concentrations. Increasing presence of aquatic weeds in the system may be acting to counter the desired phytoplankton pulse response by competing for light and nutrients.

*Observation (13): The complex and variable results of NDFA abiotic habitat condition responses to date confirm the need for comprehensive monitoring associated with each action to understand year to year differences in action outcomes, and fuel predictive models, as well as detecting action effects and inform action planning.*

*Biotic Habitat* - Measurements of Chlorophyll *a*, phytoplankton, and zooplankton during previous years' investigations indicated pulse-related biotic habitat effects in some years (2012, 2016), but not in others (2018). It has been hypothesized that the lack of a primary productivity response in 2018 may have been due to pulse flow water characteristics, in particular insufficient phytoplankton "seed", competition for nutrients from floating aquatic vegetation (FAV), contaminant levels, or more general Water Year conditions. Although productivity was not observed in 2018, transport of YB zooplankton to downstream regions was evident.

*Observation (14): Measurements of potential confounding factors, not just the main factors of interest, must be monitored in order to effectively understand management action responses.*

*Observation (15): Differential trophic level responses to the NDFA demonstrate the need for MA monitoring to be inclusive of the complete pathway of linkages necessary to facilitate understanding of management action outcomes, feed modeling efforts, and plan future actions.*

*Fish Responses* - The 2016 and 2018 managed actions were not accompanied by action-specific efforts to directly measure the effects on Delta Smelt. On-going fish surveys (e.g. FMWT) overall and in the NDFA study area tend to be insufficient for drawing conclusions about action-related effects on abundance, survival, and health, due to low catch rates, infrequent sampling, and wide spacing of stations relative to the data needs of action assessment. Understanding NDFA Delta Smelt responses is particularly difficult given the confounding seasonal effects across the before-, during- and after-action period. The ambient, ongoing monitoring (survey) efforts do confirm that Delta Smelt occur in the action area, particularly in the September-October period. The on-going fish survey data also provide fish assemblage information that can be helpful for inferring likely Delta Smelt responses. The hatchery smelt enclosure experiments planned for 2019 were an attempt to overcome the action-effect assessment constraints posed by low Delta Smelt abundance in the study area (see “Question 3”, below).

*Observation (16): The development and application of new assessment methods can be critical to advancing action-effect detection and understanding.*

- Question 3 – Have new methods/approaches become available since previous instances of NDFA implementation?

  In relation to NDFA effects monitoring the answer to this question is clearly "Yes", and new methods have been recognized by the investigators as having the potential to substantially expand and improve understanding of action effects. The four new methods with particular applicability to NDFA effects assessment are:

  - Strategically placed hatchery Delta Smelt enclosures to directly measure action-related health, growth, and survival species responses.
  - Continuous nutrient and DOC measurement to refine the understanding of action-related nutrient dynamics.
  - Vessel-based mapping of nutrients, phytoplankton, and zooplankton to examine parameter spatial gradients.
  - Improved biological modelling capable of integrating physical and chemical information to predict nutrient and food web responses.

  The first three items listed above were planned for implementation in 2019, while implementation of the fourth (actual NDFA-specific model development) awaited acquisition of necessary personnel resources and/or contractual funding. During the August 9 discussion the NDFA PI identified the lack of biological models and modelling as a major impediment to NDFA action effects prediction and understanding. Resources to develop a biological model suitable for NDFA purposes are not currently available. The DSSP management framework and increased collaboration have the potential to direct additional resources toward model development.

*Observation (17): Developing models linked to the regional objectives of management actions rather than just the actions themselves (and their monitored responses) would allow for predicting and evaluating the relative efficiency of action variants and other actions targeting the same objectives.*

The value of asking Question 3 is clearly evident to the NDFA investigators, and its inclusion in the DSSP supplementation process is generally desirable and compatible with existing CSAMP science planning. Also, implementation of the DSSP has the potential to provide some systematic rigor in posing questions about the availability and applicability (e.g. through focused workshops) of new methods to address CSAMP issues. During the August 9 discussion the following observations were made regarding the “new methods” question.

*Observation (18): Proposals to adopt new methods should be carefully evaluated so it is clearly understood what they allow us to detect and understand regarding management action effects relative to other methods.*

*Observation (19): Transparent, responsive incorporation of new approaches/methods requires timely analysis and reporting identifying unanswered questions and potential methodological solutions. A product tracking/management system established by the new CSAMP Science Manager could encourage more timely reporting of science activity results, dissemination of information to others considering the new methods, and identify where more resources should be acquired and applied to hasten science activity reporting.*

- Question 4 – Could these new methods/approaches improve understanding of NDFA effects/benefits?

  A clearly stated intention of the DSSP is to support management action decision making by promoting improved detection of Delta Smelt responses to actions, and improve understanding of underlying mechanisms. The systematic posing of Question 4 in relation to the consideration of adoption of new scientific activity methods and approaches is an obvious step in meeting this intention when considering supplementation of an existing 3-year plan.

Discussion Summary: The NDFA investigators incorporated new (and newly applied) methods into their 2019 MA monitoring and assessment plan. This was done specifically to improve understanding of NDFA effects by filling important information gaps hindering that understanding. The certainty that the new methods will contribute to effects understanding varied between methods, but there was perceived to be strong potential in each case. For example, the planned deployment of hatchery smelt enclosures, although considered a pilot effort, had the potential to provide information on NDFA and ambient condition smelt health, growth, and survival effects that are no longer obtainable through traditional field sampling methods due to low survey sample sizes.

*Observation (20): Assessment of new methods/approaches should be transparent and rigorous to ensure reasonable CSAMP confidence that the method/approach will yield results that improve mechanistic understanding of the effects of the management action in question. New methods should not be solely relied upon for key variables until tested.*

- Question 5 – What are the unresolved issues emerging from previous NDFA implementation efforts?

  Implementation of a management action can yield unexpected results that are not easily or adequately explained by associated science activities. It can also be the case that there are known scientific uncertainties that could not be addressed in previous instances of the MA due to resource limitations or the unavailability or non-existence of adequate monitoring and assessment tools. The point in asking this question during DSSP annual supplement consideration is to identify important unresolved issues that could in the current instance be potentially addressed by new, enhanced, or additional monitoring and assessment efforts.

  Discussion Summary: There were two general unresolved scientific issues lingering from previous implementation of NDFAs. The first of these was understanding the inconsistent biotic habitat response to the action, in particular the anomalous absence of a phytoplankton production response from the 2018 NDFA. The second issue is the general uncertainty regarding Delta Smelt growth and survival, and the overall study area population abundance responses, to the NDFAs.

The failure of phytoplankton to respond in 2018 as predicted suggests there are poorly understood factors constraining phytoplankton production that have not previously been adequately monitored or assessed. The NDFA investigators have identified several factors that complicate efforts to plan an effective action or reliably predict action outcomes. These factors are identified and discussed below under the “Question 6” heading.

*Observation (21): The food web responses to NDFAs appear to involve complex interactions of many abiotic and biotic factors, making predictions of responses challenging. Development of an ecological model specific to the northern Delta region has the potential to facilitate predictions, guide action planning, and create a formal structure for posing scientific questions.*

The specific intent of NDFAs is to stimulate food web production to benefit Delta Smelt. Directly detecting a Delta Smelt response to the action is challenging, because of the very low abundance of the species, and thus low levels of occurrence in samples from field surveys. In other words, it is impractical, if not impossible, to collect a sufficient number of Delta Smelt in the study area to adequately census the population or assess vital rates.

In both cases the unresolved scientific issues from previous NDFAs were clearly on the minds of the investigators as they developed plans for 2019 NDFA monitoring and assessment, which include numerous enhancements to address unresolved scientific issues. This scientific activity planning response by the NDFA investigators suggests a high level of fidelity between the approach to current CSAMP-related science planning efforts and the approach envisioned by the DSSP on the question of recognizing, tracking, and responding to unresolved issues.

- Question 6 – What are the confounding factors that could limit the success of the NDFA, and how?

  Implementation of management actions intended to benefit Delta Smelt habitat inevitably occurs in complex settings where a myriad of biotic and abiotic factors independent of the action can influence action outcomes. This is certainly the case for the intended Delta Smelt food web enhancements sought through implementation of NDFAs. This step in the annual supplementation represented by Question 6 is designed to ensure that factors that have the potential to obscure true action responses are identified and monitored, and the resulting data incorporated into the action assessment.

Discussion Summary: Since 2011 investigators have been annually observing northern Delta food web responses to summer-fall Yolo Bypass drain water pulses, including pulses in 2016 and 2018 specifically managed to produce food web benefits for Delta Smelt. Over the course of more than a decade of investigation several factors have been identified that have the potential to impact food web response, beyond just basic pulse characteristics (e.g. pulse volume and duration). The potential and observed confounding factors identified by NDFA investigators include:

- Benthic (introduced clam) grazing
- Tide cycle co-incident pulses
- Ambient water temperatures during pulses
- General Water Year flow conditions
- Pulse water nutrient levels
- Pulse water contaminant levels
- The plankton “seed” capacity of pulse source water
- Action seasonal timing
- Pulse flow routing

In the case of the 2019 pilot deployment and future routine deployments of hatchery smelt enclosures, investigators are anticipating confounding effects associated with relative hatchery fish fitness. The obvious attention NDFA investigators have given to incorporating confounding factor considerations into action monitoring and assessment suggests that CSAMP is well positioned to adopt this aspect of the DSSP framework as expressed in Box 2 of the DSSP and DSSP Appendix 3.

- Question 7 – What information/data needs to be collected to identify/understand confounding factor effects?

  Factors with the potential to confound efforts to understand abiotic and biotic management action responses can range from well documented to hypothetical. Furthermore, the effect of a confounding factor can vary with the coincident effects of other confounding factors. Given this context, the complexity of the northern Delta aquatic system, and monitoring resource (staff, vessels, funding, etc.) limitations; identifying and prioritizing the elements of a confounding factors monitoring program associated with the NDFA is inherently challenging. Designing a monitoring program extends beyond “what” to monitor, but how intensely to monitor individual elements.

Discussion Summary: The overarching objective of the NDFA is to improve the food web of the region to benefit Delta Smelt by creating and managing a summer-fall pulse of nutrient- and plankton-rich water through the Yolo Bypass and into the Cache Slough region and the lower Sacramento River. The action's monitoring and assessment work plan includes several elements (Table 2) focused on detecting the fundamental abiotic and biotic responses to the action relative to the objective. Notably, the workplan includes monitoring of factors having the potential to confound efforts to understand action-related responses.

What data needs to be collected? This seemingly simple question in the Delta management action context is invariably multi-faceted and multi-layered. Even for a basic potential confounding factor such as action-period water temperature there are a myriad aspects of water temperature that could be critical to understanding the confounding effects of water temperature. In the case of water temperature, sub-questions might include:

- What is the required data spatial intensity (for gradient detection)?
- What are the regional seasonal and daily minimums and maximums?
- How do effect-area temperature trends compare to trends in control areas?

All of the science activity elements summarized in Table 2 and described in the action work plan have the potential to individually and collectively contribute to an understanding of confounding factor effects on action responses. Two of the elements, benthic (clam) monitoring and contaminant monitoring, particularly target potential confounding factors. The planned collection of clams along the axis of the action effect area, and derivation of plankton grazing rates based on those collections, reflect a concern by the investigators that the geographical and annual variation in grazing rates could affect food web responses of managed pulses. The NDFA-related contaminant monitoring planned for 2019 and beyond is born from a concern that contaminant composition and concentration might vary from year to year due to differences in pulse water source and other factors, and variably effect action responses.

With respect to information and data needs associated with potential confounding factors, the group discussion on August 9 can roughly be placed in two categories. In one category are factors for which data and information are presently available, or routinely collected, and need to be brought into the NDFA assessment on an ongoing basis. Factors in this category include:

- The geographical extent and timing of invasive aquatic weed control measures
- The extent and timing of dredging operations
- The relative health of hatchery smelt used in enclosure experiments
- Year-to-year climate and meteorological variation
- Prior year and season biotic and abiotic conditions

The second category of data and information, of course, is that requiring new or more robust data collection efforts. This category included:

- Benthic (clam) grazing
- Study area contaminant levels
- Basic pulse source water quality

The discussion of confounding factor data and information needs during the August 9 workshop discussions, and the content of the NDFA Monitoring and Assessment Work Plan indicated that within the limits of perceived resource limitations (see Question 8 discussion, below) addressing these needs was a substantial component of 2019 NDFA science planning, and will remain so for future actions. In addition, both the August 9 discussion and the 2019 workplan acknowledged that because environmental responses to managed flow actions in the northern Delta are likely the result of complex interactions of both the specifications of the action and a plethora of potential confounding factors, proper interpretation of action outcomes will require the development and application of modelling tools. The need for this modelling component of NDFA assessment is identified in the 2019 workplan, but the modelling effort is not specifically part of the 2019 plan.

*Observation (22): Investigative teams associated with a particular MA may perceive resource limitations (staff, vessels, equipment, etc.) that can have the effect of constraining thinking about the scope and intensity of planned monitoring and assessment effort. A potential benefit of DSSP adoption is a systematic strengthening and broadening of scientific collaboration such that perceived resource limitations can be more effectively communicated and additional resources applied where collaboration priorities warrant.*

The 2019 NDFA Work Plan's focus on gathering strategically targeted data relating to potential confounding factors, and the discussion of this topic on August 9 are good evidence that CSAMP investigators, at least in the case of the NDFA, have already nominally adopted the proposed DSSP planning step relating to identifying confounding factor data needs, and agree regarding its importance.

- Question 8 – What are the potential constraints (funding, gear, staff, etc.) to mobilizing the NDFA, and how might they be overcome?

  With respect to mobilizing any management action there can be constraints associated with either, or both, of the action and its associated science activities. It is not unusual that addressing and overcoming the constraints (action and science) falls to the same individuals. An early and thorough assessment of possible action and science constraints, and application of the resources necessary to overcome them is essential to successful implementation of an action and effective monitoring and understanding responses to it.

  Discussion Summary: During the August 9 workshop several constraints with the potential to negatively impact NDFA science planning and implementation were identified by the PI and discussed by the group. The action's monitoring and assessment plan, distributed prior to the workshop, also addressed certain constraints. An annotated list of identified key constraints follows:

  - Science Activity Staffing: The monitoring and assessment program associated with the NDFA encompasses a wide range of specialized scientific activities. Each of these activities can require experimental design, logistical planning, permitting, implementation oversight, contract management, collaboration coordination, analysis, and reporting obligations. The limited current level and composition of NDFA program staffing constrains accomplishment of these obligations, particularly given the tight annual cycle of events between actions.

  - Predictive Modelling: There is not a region-specific model available to predict environmental responses to NDFA, nor was there staff or contract funding available in 2019 to develop such a model. The unavailability of a model constrains action and action science planning in several ways. For example, response uncertainty complicates decision making regarding the content and magnitude of the action. Also, absent a model there is not a clear framework for efficient integration of new information from one year to inform planning of the next year's iteration, particularly in regard to prioritizing information gaps and specifying the rigor of planned science activities.

  - Secured Funding: Funding for the action (e.g. water acquisition funding) and associated science activities is on a year-to-year basis, which can constrain and complicate planning and mobilization. Funding limitations in 2019 resulted in potentially undesirable reductions in sampling sites and frequency. Contracts with collaborators are written for three years, but funding is year-to-year. Given that annual implementation of the action is important for understanding responses under varying ambient conditions, multi-year funding is highly desirable.

- Annual CEQA Compliance: A substantial effort is required each year to obtain permits (e.g., CEQA compliance) for the action and certain related science activities (e.g., smelt enclosure "take authorization"). This effort absorbs staff time that could otherwise be devoted to timely data analysis and reporting. Longer-term action program permitting could potentially alleviate this competition for staff time.

- Hatchery Smelt and Enclosures: The deployment of hatchery smelt enclosures was included 2019 NDFA monitoring and assessment effort to directly measure action effects on Delta Smelt. However, the method is new and considered experimental (i.e. a pilot effort). Mobilization was constrained by the challenges of building sufficient numbers of enclosures, achieving effective deployment at each of the desired sites, and enclosure maintenance (e.g., cleaning). Interpretation of the enclosure experiment is constrained by the unavoidable absence of seasonal effects control and unknowns regarding the fitness of deployed hatchery smelt.

- Insufficient Experiment-to-Experiment Planning Times: When MAs are managed as annual actions there exist fundamental time constraints that inhibit informed adaptive management. In the case of the NDFA the amount of time between the end of one year's action (October) and the beginning subsequent year planning is insufficient for completing sample processing, analysis, and full reporting.

- Source Water Funding: A key aspect of the action is the magnitude of managed flows into and through the YB toe drain. Achieving desired level and duration of flows generally requires the purchase of water from willing entities. Limited funds for water purchases constrains the magnitude of the action, and thus potentially the detection of responses.

*Observation (23): Throughout the DSSP assessment process, at various times and in various terms, the observation was made that planned science activities associated with MAs needed to be sufficiently robust to detect expected responses in order to effectively inform adaptive management of the action.*

- Basic Data to Build Models: The unavailability of a quantitative ecological model for the north Delta region is a general constraint on adaptive management of NDFAs. In particular, the absence of a model impacts the ability to size the action and to prioritize and size science activities, because the relative importance and relationship of factors influencing smelt population dynamics cannot be predicted with confidence. Development of a model has been precluded by the unavailability of appropriate staff resources, but also insufficient basic ecological process information with which to build the model.

*Observation (24): The enhanced and more structured CSAMP management action and action-science planning envisioned by the DSSP may have the potential to facilitate adoption of multi-year permitting and environmental documentation.*

It was clear from the August 9 small group discussion that planning and mobilization of the NDFA faced a variety of substantial constraints. The underlying concern associated with this conclusion is that an overly constrained action and action-specific science program create, in turn, challenges to effective adaptive management of NDFAs. Science activity planning as envisioned by the DSSP has the potential to overcome or alleviate constraints that inhibit effective adaptive management. Examples include:

- Dedicated resources for predictive model development.
- Dissemination of summary data and preliminary findings.
- Direct engagement by the DSSP’s proposed Science Program Manager with policy makers and managers to leverage resources and identify/communicate resource needs.
- Application of the DSSP’s proposed 3-year planning cycle, which calls for prioritization of candidate science activities and alignment of activities with funding sources.

- Question 9 - What resources (models, prior outcomes, expertise, etc.) are available to predict the physical and ecological effects of the NDFA?

Biotic and abiotic response to Bay-Delta management actions are typically complex, driven by multiple interacting known, suspected, and sometimes unrecognized factors. In this context investigators are likely to harbor an abundance of primary, secondary, and tertiary questions underlying scientific efforts to assess and understand responses. Investigator pursuit of questions or related hypotheses commonly run up against funding, staffing, logistical, and methodological constraints inhibiting their efforts.

An informed decision to pursue supplementation of a 3-year science plan with an additional management action and associated science activities is ideally made with a clear understanding of the predicted effects of the proposed action, and any variants. Thus, knowing the availability of predictive resources (models, information from previous action implementation, refined conceptual models, etc.) is key to scoping the action and planning the science. The 2019 NDFA Monitoring Work Plan included a comprehensive suite of action effects predictions accompanied by a variety of underlying conceptual models and observations from previous iterations of the action.

Discussion Summary: Much of the discussion during the August 9 workshop illustrated the present challenge of management action and science activity planning with limited predictive capability. DWR investigators have been observing the effects of managed and unmanaged Yolo Bypass (YB) pulse flows annually since 2011. These observations in combination with evolving conceptual models and general knowledge of the system formed the primary basis for 2019 action effects predictions. Major impediments to NDFA effects prediction included disentangling action effects from seasonal effects, and having to cope with a wide variety of confounding factors. The predictions of 2019 action responses were supported by a published paper on the effects of non-managed flows (Frantzich et al. 2018). Additional prediction support was provided by analysis of data gathered during recent managed flow actions, which was presented verbally at annual IEP workshops and other informal venues. Formal publication of the managed flow action results, which would enhance exposure and consideration of the results within the CSAMP community, has been constrained by available staff resources and the intense annual planning frequency. Most of the information gathered to date relates to flow and food web responses with very limited information on fish responses. The results from the hatchery Delta smelt enclosure experiments associated with the 2019 NDFA were expected to greatly improve future fish response predictions should predictive tools become available.

In an aquatic system as hydrodynamically complex as the northern Delta, scoping and planning of flow-related management actions and associated science activities would be greatly facilitated by the availability and use of physical and biological models able to predict action effects. The NDFA Monitoring Work Plan called for the use of hydrodynamic modeling to provide “with” and “with-out” action comparison of channel flow, conductivity, and other physical characteristics of the study area. During the August 9 workshop the PI noted that the unavailability of study area biological models as a major impediment to NDFA action effects prediction. Action operations do not presently have the resources to develop the needed biological model(s). The DSSP planning framework with its stronger focus on collaboration and information exchange has the potential to increase awareness of high priority modeling needs, and obtain and apply the necessary resources.

*Observation (25): Robust prediction of action effects requires the availability of analyses and reporting from previous iterations of the action. Where action frequency is high (e.g., annually) action planning efforts can easily constrain reporting efforts when the same staff are performing planning and reporting. This is particularly true with actions like the NDFA where planning efforts (coordination with landowners, operation permitting, etc.) are complex and intense.*

*Observation (26): The present lack of predictive models for ecological effects constrains CSAMP's ability to design monitoring around expected effects, including spatial and temporal effect gradients.*

- Question 10 – What is the temporal/spatial scale of the NDFA, including effect gradients and hotspots?

  Predicting the spatial and temporal scale of physical and biological action effects is an important step in planning science activities associated with a proposed management action, as well as planning the scope and scale of the action.

  Discussion Summary: The participants in the August 9 workshop did not take issue with the DSSP's assertion that this question be posed and addressed as part of consideration and planning of supplemental actions. However, the group did note the existence of constraints in addressing the question.

  Accurate prediction of the scale of action effects effectively informs consideration of where and when action-specific monitoring resources should be deployed, and the scope of ongoing ambient monitoring information required for action effect assessment. As discussed in the DSSP, action-effect predictions would ideally be derived from modelling efforts and results incorporating anticipated Bay-Delta conditions, including conditions affected by other planned contemporaneous management actions. One of the key recommendations of the DSSP is that CSAMP vigorously pursue improved physical and biological modelling capability to improve action-effect prediction.

Planning for the 2019 NDFA was conducted with a clear understanding of the importance of predicting the scale of the MA, but faced with the reality that adequate models and modelling resources would not be available during planning. Alternatively, 2019 NDFA planning was informed by scale-of-the-action predictions based on previous implementation of similar actions and preliminary analyses of previous monitoring. Monitoring modifications associated with the 2019 version of the action included moving the downstream limit of anticipated action affect upstream from Decker Island to Rio Vista, moving the upstream limit of monitoring from Ridge Cut Slough to Rominger Bridge in the Colusa Basin Drain to capture water quality information on the pulse flow water source, and the addition of strategically placed nutrient and phytoplankton continuous monitoring equipment. The 2019 proposed addition of continuous and vessel cruise parameter monitoring to the NDFA could assist with characterization of temporal and spatial gradients in the study area and allow for refinement of future action effect predictions.

*Observation (27): For the foreseeable future predicting the scale of action effects for the purpose of planning monitoring efforts will not be able to rely entirely on modelling. Modelling tools to predict the scale of management action physical effects (e.g., salinity and channel flows) are more available and robust than models to predict ecological effects.*

## Summary & Recommendations

We conducted a limited assessment of current CSAMP-related management action science planning relative to planning as envisioned by the 2019 Delta Smelt Science Plan. The assessment was conducted in two parts, cataloguing of science associated with 2019 management actions and a brief, but detailed, review of science activity planning for a single management action (the North Delta Flow Action). Both parts of the assessment of the assessment yielded insights into the similarities and difference between extant and DSSP-envisioned science planning, but more importantly identified constraints to extant planning efforts that potentially could be ameliorated by the DSSP planning or pose ongoing challenges for the framework's effective implementation. An example of the latter is the insufficient availability of models to plan management actions and predict their responses. The DSSP identifies model development as an early and important aspect of plan implementation.

The assessment's insights can be found in the general text of the report, but more pointedly in the "observation" boxes. All of these observations have the potential to inform DSSP implementation as it moves forward. Appendix B provides a simple list of the observations. Some of the observations were used to derive recommendations, which are listed under the sub-heading below.

Three prominent themes emerged from the assessment. First, there is strong conceptual fidelity between extant approaches to CSAMP-related science planning, and that envisioned by the DSSP. The importance of meaningful management action response prediction and careful consideration and monitoring of possible confounding factors are emphasized in the DSSP and are routine aspects of extant science planning. The DSSP's focus on developing more and improved prediction tools has great potential to assist investigators in future management action and science planning. A second theme was the recognition that constraints on management action monitoring and reporting can imperil the effective adaptive management of actions. The DSSP framework appears to have the potential to alleviate this issue through improved CSAMP internal communication (e.g., through the role of the Science Manager) to enhance awareness of CSAMP members of consequential monitoring limitations, so that limitations can be addressed in a timely way relative to adaptive management need. A third theme, related to the second, is the challenge of planning, permitting, implementing, and reporting monitoring efforts in the context of management action adaptive management when action frequency is high (i.e., annually). The DSSP planning framework appears to have the potential to address this challenge through its three-year plan structure where monitoring resources sufficient to achieve action frequency information requirements can be identified, and resources allocated, in advance. Multi-year permits and environmental review documents for CEQA and NEPA have the potential to reduce the permitting burden for annual or multi-year actions, thus freeing action staff resources for additional monitoring or the pursuit of more timely reporting of action outcomes.

## Recommendations

The DSSP can be thought of as a bold and comprehensive suite of recommendations regarding science planning in the CSAMP realm. The DSSP is clearly a well-constructed, well-sourced document containing many constructive concepts to consider as DSSP implementation proceeds. The DSSP assessment reported here did not conclude that any of the concepts presented in the DSSP be rejected. The six key recommendations listed below are in the vein of amplifying and extending certain aspects of the DSSP that are critical to the effective adaptive management of Delta Smelt management actions. The poor current state of the Delta Smelt population calls for effective management action pursued with purpose and a sense of urgency.

- **Recommendation 1 (consider confounding factors)**:

  As noted in the DSSP, detecting and understanding confounding factor effects on management action performance is essential for evaluating and adaptively managing actions. Investigators developing science activity plans associated with management actions should take a holistic view, fully considering the possibility of confounding factor effects, and provide for monitoring and analysis of these effects, to the extent practical. CSAMP science plan review processes pursued by the DSSP-proposed Science Manager and Independent Science Panel should systematically evaluate the adequacy of proposed confounding factor monitoring and analysis within action-science plans.

- **Recommendation 2 (facilitate timely reporting)**:

  Effective adaptive management of Delta Smelt management actions requires timely reporting of action-associated science activity outcomes. The proposed CSAMP Science Manager should strive to facilitate timely action-science reporting by working closely with Investigators and Action Champions to develop science reporting schedules responsive to adaptive management needs, including arranging CAMT progress updates. The Science Manager should closely track reporting progress, identify constraints on science reporting, make CAMT aware of constraints, and work with CAMT to alleviate constraints to ensure timely reporting.

- **Recommendation 3 (ensure that science supporting management actions is technically robust and adequately resourced):**

  Efficient, effective, and confident adaptive management of Delta Smelt management actions requires that associated science activities rigorously address uncertainties regarding abiotic and biotic responses to the action. Proposed action science should be designed and resourced to ensure, to the extent practical, that hypothesized action abiotic and biotic responses can be reliably detected. The need for rigor applies to both the technical robustness of the proposed science to address key scientific uncertainties and the strength of the logistics to accomplish the proposed science activities. Investigators proposing CSAMP science activities should directly address this objective in their proposals and plans, and the Science Manager should ensure that proposal review processes evaluate the strength and reliability of proposed detection efforts. If planned detection efforts appear to have a significant risk of inadequacy, the Investigators and

Science Manager should work together, and with CAMT, to enhance the efforts and get them adequately resourced.

- **Recommendation 4 (support coordination necessary for science planning):**

  Multi-year management actions can pose difficult challenges for action-science investigators as they attempt to report on the outcomes of one year's results while planning the next. The Science Manager should coordinate with Action Champions and Investigators to identify circumstances, particularly in the case of high frequency (e.g., annual) actions, where assistance is needed with such tasks as permitting, retaining technical specialist services, and organizing/conducting stakeholder (e.g., landowner) outreach. The Science Manager should partner with CAMT to provide this assistance, making use of CSAMP's broad representation of stakeholders.

- **Recommendation 5 (resource new methods development and implementation):**

  Given the much-diminished size of the Delta Smelt population and the plethora of potential factors challenging its viability, Investigators should actively identify and consider potential new sampling and analysis methods to address consequential uncertainties that are ineffectively addressed by extant methods. The Science Manager and CAMT should support this consideration through, for example, special study funding. The Science Manager should coordinate transparent, independent assessments (e.g., through the independent science panel) of proposed new methods before they are adopted for use in informing CSAMP action adaptive management.

- **Recommendation 6 (develop regional models):**

  The DSSP appropriately emphasizes the need for enhanced modelling to improve prediction and understanding of biotic and abiotic responses to management actions. The Science Manager should work closely with Investigators, Action Champions, modelers, and CAMT to pursue regional models (or sub-models) to improve prediction and understanding of responses to region-focused management actions.

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All references can be found at https://www.baydeltalive.com/CSAMP/smelt_work/delta-smelt-technical-studies

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# Appendices

## Appendix A: CSAMP Guidance for Initial Implementation of the Delta Smelt Science Plan

In late February 2019 CSAMP received the final version of a commissioned overarching plan (Plan) providing a framework for ongoing assessment of the effects of ambient environmental conditions and flow-related management actions for Delta Smelt. Implementation of the Plan was addressed by CSAMP during March meetings of the Policy Group (PG), Collaborative Adaptive Management Team (CAMT), and Delta Smelt Scoping Team (DSST), with the PG requesting development of guidance to be employed by a small ad hoc team enlisted to test aspects of the Plan in 2019, and facilitate initial implementation. The key elements of this guidance, largely the result of discussions within and between the CAMT and DSST, are provided below.

The Plan envisions the serial development and implementation of 3-year science plans with an annual supplementation process. Three-year plan development is intended to occur in the last few months of the year preceding plan implementation (see Plan Table 9). The final Plan became available in early 2019, such that management action and science planning for 2019 had largely been completed, and implementation initiated through extant processes. Given this temporal context, the "testing" approach delineated below seeks to accomplish: 1) a cataloguing and characterization of planned 2019 flow-related management actions and associated science (items 1-5, below), 2) an abbreviated testing of Plan concepts and processes (items 6-7, below), and 3) Summarizing and reporting what was learned through review and testing efforts using Plan communication approaches (items 8-10, below). It is intended that by implementing the measures described below CSAMP will be assessing and gaining familiarity with Plan concepts, and positioning the program to effectively produce the first 3-year plan (2020-2022) in fall 2019.

**Guidance**

1. Identify planned 2019 flow-related actions and associated predictions/hypotheses. (April)
2. Review the various extant Bay-Delta science program planning documents, and consult with Action Champions, experts and investigators, to catalog planned 2019 Delta Smelt-related ambient condition and flow action-related research, monitoring and assessment efforts at the program and sampling element levels. (April)
3. Categorize the science elements identified in the cataloguing effort above based on whether their purpose is prediction, detection, and/or understanding. (April)
4. Further categorize the elements as ambient condition and/or flow action directed. (April)
5. Identify and list by element the expected 2019 data, analysis, and report products. (April)

6. Develop an interim set of practical and essential steps to predicting, detecting, and understanding Delta Smelt responses that can be integrated with and flesh-out planning processes (e.g. Plan Appendix 3). (May-June)
7. Select one of the 2019 flow actions, retroactively apply the Plan science planning process, and compare planning process outcomes for the two approaches. (May-June)
8. Communicate 2019 Delta Smelt ambient condition and flow action-related activity progress and preliminary results to CAMT and the PG with monthly verbal and written updates. (May -> Nov)
9. Begin 3-year (2020-2022) plan development, as per Plan Figure 5 and related text. (September)
10. Using a fall 2019 focused workshop or active solicitation, followed quickly by a summary report, the test period team and new 3-year plan team will document key 2019 ambient condition and flow action-related science and Plan process outcomes to inform future planning. (Nov.)

*/Reed, Denise J. 2019.Science Plan to assess the effects of ambient environmental conditions and flow-related management actions on Delta Smelt. March 2019. 59 pages, w/3 appendices

## Appendix B: Consolidated List of Assessment Observations

Observation (1): Bay-Delta flow condition uncertainty presents significant challenges to annual MA planning. The DSSP's proposed 3-year planning cycle structure, with annual supplementation, has the potential to accommodate the challenges of flow condition uncertainty by having plans and allocated resources in place to handle flow-related contingencies.

Observation (2): An intended feature of the DSSP planning framework is regular communication between CSAMP leadership and the staff engaged in scientific activity planning. During 2019 staff reporting to CAMT regarding the year's anticipated MAs precipitated a CAMT discussion regarding the scope of DSSP application, and ultimately a decision to broaden the focus of scientific activity planning from just flow-related MAs to all MAs.

Observation (3): CSAMP Delta Smelt MAs planned for 2019 did not directly address summer habitat in the lower Sacramento River (Rio Vista to Sherman Island), an historically important rearing area for juvenile Delta Smelt.

Observation (4): Implementation of the FOA in 2019 presented two potentially significant challenges to scientific activity planning, WY designation uncertainty and ongoing discussion regarding the form of the action, which, as with any flow action, might affect sampling site number and location. Advanced planning and funding of DOP studies helped address these challenges in 2019, and the DSSP's multi-year planning framework has the potential to further alleviate annual flow condition uncertainty challenges in the future by promoting contingency planning and by staging associated resources.

Observation (5): A potential role for CSAMP within the envisioned DSSP planning framework and Science Manager construct is to assist action staff with stakeholder outreach (e.g., organizing outreach fora), using CSAMP member networks.

Observation (6): The evolution of the SCNEP experimental action and associated science activity from Phase 1 to Phase 2 demonstrates how comprehensive project-level monitoring and timely analysis can lead to effective action adaptive management and refined understanding of action responses.

Observation (7): Holistic consideration of an MA's potential physical and biological effects will identify monitoring needs un-related to Delta Smelt that are important to CSAMP decision making.

Observation (8): The utility of on-going ambient monitoring data in assessing environmental responses to MAs varies substantially among MAs, depending on the spatial and temporal scale of the actions.

Observation (9): Landscape conditions unrelated to the MA can heavily constrain conceived sampling efforts, and thus compromise the effort to meet study objectives.

Observation (10): Limitations in the availability and capacity of unique essential specialist resources (e.g., university or consultant staff) can complicate MA science activity planning and implementation.

Observation (11): Delta Smelt MA planning and implementation currently benefits from a wide variety of general research activities emanating from many academic, agency, and stakeholder sources. The DSSP has the potential to enhance the relationship between research efforts and Delta Smelt management by focusing and prioritizing information needs, formally communicating those needs to potential investigators, coordinating funding to accomplish high priority investigations, and synchronizing MA and investigation planning and implementation.

Observation (12): Robust, well-sourced science activity planning is essential to providing a strong basis for management action assessment. The level of NDFA PI awareness of the universe of CSAMP and other relevant scientific activities presently seems quite high, which may in part be because the action had been taken before under the multi-year effort. The awareness would likely be further promoted by the DSSP program timely reporting and collaboration focus.

Observation (13): The complex and variable results of NDFA abiotic habitat condition responses to date confirm the need for comprehensive monitoring associated with each action to understand year to year differences in action outcomes, and fuel predictive models, as well as detecting action effects and inform action planning.

Observation (14): Measurements of potential confounding factors, not just the main factors of interest, must be monitored in order to effectively understand management action responses.

Observation (15): Differential trophic level responses to the NDFA demonstrate the need for MA monitoring to be inclusive of the complete pathway of linkages necessary to facilitate understanding of management action outcomes, feed modeling efforts, and plan future actions.

Observation (16): The development and application of new assessment methods can be critical to advancing action-effect detection and understanding.

Observation (17): Developing models linked to the regional objectives of management actions rather than just the actions themselves (and their monitored responses) would allow for predicting and evaluating the relative efficiency of action variants and other actions targeting the same objectives.

Observation (18): Proposals to adopt new methods should be carefully evaluated so it is clearly understood what they allow us to detect and understand regarding management action effects relative to other methods.

Observation (19): Transparent, responsive incorporation of new approaches/methods requires timely analysis and reporting identifying unanswered questions and potential methodological solutions. A product tracking/management system established by the new CSAMP Science Manager could encourage more timely reporting of science activity results, dissemination of information to others considering the new methods, and identify where more resources should be acquired and applied to hasten science activity reporting.

Observation (20): Assessment of new methods/approaches should be transparent and rigorous to ensure reasonable CSAMP confidence that the method/approach will yield results that improve mechanistic understanding of the effects of the management action in question. New methods should not be solely relied upon for key variables until tested.

Observation (21): The food web responses to NDFAs appear to involve complex interactions of many abiotic and biotic factors, making predictions of responses challenging. Development of an ecological model specific to the northern Delta region has the potential to facilitate predictions, guide action planning, and create a formal structure for posing scientific questions.

Observation (22): Investigative teams associated with a particular MA may perceive resource limitations (staff, vessels, equipment, etc.) that can have the effect of constraining thinking about the scope and intensity of planned monitoring and assessment effort. A potential benefit of DSSP adoption is a systematic strengthening and broadening of scientific collaboration such that perceived resource limitations can be more effectively communicated and additional resources applied where collaboration priorities warrant.

Observation (23): Throughout the DSSP assessment process, at various times and in various terms, the observation was made that planned science activities associated with MAs needed to be sufficiently robust to detect expected responses in order to effectively inform adaptive management of the action.

Observation (24): The enhanced and more structured CSAMP management action and action-science planning envisioned by the DSSP may have the potential to facilitate adoption of multi-year permitting and environmental documentation.

Observation (25): Robust prediction of action effects requires the availability of analyses and reporting from previous iterations of the action. Where action frequency is high (e.g., annually) action planning efforts can easily constrain reporting efforts when the same staff are performing planning and reporting. This is particularly true with actions like the NDFA where planning efforts (coordination with landowners, operation permitting, etc.) are complex and intense.

Observation (26): The present lack of predictive models for ecological effects constrains CSAMP's ability to design monitoring around expected effects, including spatial and temporal effect gradients.

Observation (27): For the foreseeable future predicting the scale of action effects for the purpose of planning monitoring efforts will not be able to rely entirely on modelling. Modelling tools to predict the scale of management action physical effects (e.g., salinity and channel flows) are more available and robust than models to predict ecological effects.