Central Valley Project and State Water Project Drought Contingency Biological Monitoring Plan For Water Year 2015 and Beyond

[Working Draft]

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Contents

I. INTRODUCTION

The year 2013 was one of the driest years on record for California and California's Water Year 2014 (October 1, 2013 through September 30, 2014) continued that trend as one of the driest in decades. The dry condition in the current calendar and water years is also more pronounced as it follows three consecutive dry years throughout the state. On January 17, 2014 California Governor Jerry Brown issued a drought proclamation declaring a statewide emergency directing state resources to take all necessary actions to make water immediately available while concurrently requesting that resource managers consider modifying requirements for releases of water from reservoirs or diversion limitations so that water may be conserved in reservoirs to protect cold water supplies for salmon, maintain water supplies and improve water quality. On April 8, 2014 the U.S. Bureau of Reclamation, through collaboration the U.S. Bureau of Reclamation (USBR), California Department of Water Resources (DWR), California Department of Fish and Wildlife (CDFW), U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and the State Water Resources Control Board (State Water Board), released the Central Valley Project and State Water Project Drought Operations Plan and Operational Forecast April 1, 2014 through November 15, 2014 (DOP), which provided and requested a number of operational flexibilities to help balance the multiple water uses during a drought. Specifically these flexibilities allow water delivery to users south of Delta while still maintaining sufficient in Delta water quality and fish habitat suitability.

The DOP also proposed a number of science and monitoring actions designed to mitigate the potential negative effects of the drought and modified operations. Specifically; the DOP requires the lead agencies to develop a process to identify and implement opportunities for longer-term fish monitoring and science that would improve operational decision-making during drought as well as other year types.

This Monitoring Plan (Plan) is based on collaborative discussions between the USBR, DWR, CDFW, USFWS, and NMFS. The Plan may be modified based on evolving information which could include additional conditions through the State Water Board regulatory approvals as well as federal Endangered Species Act (ESA) and California Endangered Species Act (CESA) requirements. The Plan recognizes that California was in a consecutive 3rd year of dry conditions and assumes that these conditions will continue into Water Year (WY) 2015. Continued refinement of the Plan will be done in collaboration with the involved agencies through the Real Time Drought Operations Management Team (RTDOT) as ongoing operations, monitoring, and weather change conditions and forecasts for reservoir storage, river flow, and Sierra snowpack.

II. PURPOSE OF THE PLAN

The DOP commits Reclamation, DWR, CDFW, USFWS, and NMFS to developing, and implementing as appropriate, a multi-objective fisheries monitoring, technology improvement, and science plan to minimize, and to the extent possible, measure effects to listed species and improve understanding of biological effects associated with water operations during current and future drought conditions. This commitment includes both actions that began in WY 2014 and identification and implementation of actions to be taken in WY 2015 and beyond. This Plan relies on considerable discussion, development, implementation, and review of WY 2014 actions to define the actions needing implementation in WY 2015, should drought persist. This Plan is intended to be used as a guide which establishes the minimum research and monitoring necessary to help inform real-time operational decision making to maximize the operational flexibility of the Central Valley Project (CVP) and State Water Project (SWP) operations during drought conditions. Specifically, the purpose of the Plan is twofold:

1. The Plan describes research and monitoring actions needed to implement changes in Central Valley water operations to best protect threatened and endangered fish species while also providing additional flexibility in operations. Based on initial review of research and monitoring actions taken in WY 2014 and a determination of which of those actions will continue to be relevant in subsequent drought years, the Plan describes a series of research and monitoring actions that could be implemented to inform water operations in WY 2015.

2. The Plan is also intended to highlight the most relevant existing science as well as the most critical science needs that, if better understood, might change decisions made about how to operate the CVP and SWP during critically dry periods. There are a number of proposed actions that while not ready to be used in WY 2015 decision making, will fill important data gaps and inform future CVP and SWP operations.

Implementation:
This Plan is intended to be used to support monitoring in continued drought conditions. That is to say this Plan does not change operations described in the existing Biological Opinions, but recommends measures to be implemented concurrently with drought contingency planning and supports work that will improve the accuracy of monitoring activities. This Plan provides a suitable set of actions to inform an operational contingency plan and any subsequent drought-related Temporary Urgent Change Petitions (TUCP) filed with the SWRCB.

III.SMELT

Extreme dry periods can magnify the impacts of water project operations on the Delta and Bay ecosystems. The current drought is particularly severe which limits SWP and CVP ability to respond to the Bay and Delta ecosystems needs and also limits the water supply that can be provided to these projects' export service areas. With low summer and fall flows in the Delta, physical and biological aspects of Delta Smelt and Longfin Smelt habitat in the Delta are expected to become increasingly unsuitable for these species. An ongoing dialogue among DWR, Reclamation, CDFW, NMFS, and USFWS has resulted in general agreement that the monitoring approaches used to assess smelt distribution, abundance, and habitat need to be carefully reviewed, supplemented, and improved during WY 2015 should drought conditions persist. Enhanced research and monitoring is necessary to forecast the effects of drought water operations on these species, and to vet the potential opportunities and impacts of alternative real-time water operations proposals.

There are four elements contained within the smelt monitoring plan:

- *WY 2014 Actions*– A review of actions that were undertaken to inform Delta water operations or assess the effects of those operations in WY 2014.
- *WY 2014 Analyses* – A discussion on analyses of WY 2014 data that are currently being conducted in order to assess the effects of drought on smelt species in the Delta.
- *WY 2015 Actions* – Recommendations for the WY 2014 actions that should continue, including any adjustments to those actions, and additional actions that may be needed.
- *Other Ongoing Efforts and Recommendations for Longer-Term Monitoring and Research* – Research that is needed to better inform the balance of water exports and smelt protection required by ESA and CESA.

A. Water Year 2014 Actions

The Multi-objective Fisheries Monitoring and Science Plan included study designs to address variable gear efficiency questions in Interagency Ecological Program (IEP) monitoring efforts that target or incidentally capture Delta and Longfin Smelt. It also addressed the need for closer genetic monitoring of the Delta Smelt population. Most of the questions requiring collection of Delta Smelt were answered in full or in part using existing monitoring studies, with some temporary adjustment. In addition to the aforementioned plan, the following Delta monitoring activities were also implemented during WY 2014 (May – October).

i. Expanded IEP monitoring – Early Warning Sampling

Early Warning Sampling: Delta Smelt that migrate into the San Joaquin River increase their risk of entrainment in the southern Delta. The U.S. Fish and Wildlife Service designed and deployed a special study which was carried out at Jersey Point (SKT station 809) to address concerns that the Spring Kodiak Trawl was missing low (but operationally relevant) densities of Delta Smelt moving into the San Joaquin River. The objectives of the special study – commonly referred to as the Jersey Point Early Warning Sampling – were to provide better understanding of what environmental conditions might precede or cause increases in Delta Smelt densities at this location, obtain an accurate and precise estimate of Delta Smelt densities which could serve as an 'early warning' of potential high entrainment if water exports were sufficiently high, and to better quantify how much sampling is needed to reliably detect Delta Smelt as a function of Delta Smelt density. An analysis of Water Year 2014 early warning sampling has been prepared in a report (Polansky et al., in press) that was presented at the Delta Science Conference in October and was published in the summer issue of the IEP Newsletter, which has not been finished at this writing.

ii. Spectral Imagery of Submerged Aquatic Vegetation (SAV)

It is speculated that the extreme drought of 2014 provided optimal growing conditions for invasive SAV species, such as *Egeria densa* because low flows were expected to result in high light penetration into Delta waterways and low water velocity conditions. SAV is problematic because it changes the velocity, temperature, turbidity, and chemical characteristics of water flowing through it. In turn, those changes influence which fish species are most successful. The proliferation of SAV throughout the Delta has increased habitat suitability for largemouth bass and related sunfishes and decreased habitat suitability for most or all native fish species (Grimaldo et al. 2004; 2012; Nobriga et al. 2005; Brown and Michniuk 2007). Therefore, if extensive and extended drought increases the extent of SAV in the Delta, it is expected to reduce native fish habitat during already stressful low flow conditions. Remote sensing techniques, such as hyperspectral imagery, offer a practical and economical means to discriminate and estimate aquatic vegetation coverage over large areas across the Delta. Seasonal growth for *Egeria densa* is typically bimodal, with peaks in the spring and fall (Santos et al., 2011).

Utilizing fiscal year 2014-2015 drought funding ($500K) CDFW contracted with UC Davis to conduct a study analyzing SAV coverage in the Delta. Flights were taken over the Delta using the next generation Airborne Visible Infrared Imaging Spectrometer (AVIRIS) to capture hyperspectral images to ultimately quantify the density and distribution of SAV. The main objective of this study is to map the distribution of different types of aquatic vegetation during the peak growing season throughout the Delta. Study results should be available in June 2015.

iii. Otolith Microchemistry and Growth Rates

Fish growth rates and survival are often closely linked. Growth rates and habitat use can be determined though analysis of otolith microstructures and microchemistry. Utilizing fiscal year 2014-2015 drought funding ($340K) CDFW funded an extension of an existing Ecosystem Restoration Program grant to process and analyze otoliths from Delta Smelt collected during past and current (2011-2014) CDFW surveys Summer Townet Survey (STNS), Fall Midwater Trawl (FMWT), Spring Kodiak Trawl (SKT), gear selectivity, and salvage studies to assess rearing habitat, duration of low-salinity rearing, and growth rate. Given that 2014 was a critical drought year, this provides a unique research opportunity with a set of environmental conditions expected to be stressful for Delta Smelt, and as such, fish collected during this period should provide a "worst case scenario" case baseline set of data for growth, reproduction, and general health. 2011 provided the other extreme, a wet year with more favorable rearing conditions. This information will provide specific information regarding how previous wet conditions and current drought conditions have affected the demographics of this threatened fish species.

iv. Fish Health Analysis

Using fiscal year 2014-2015 drought funding ($230K) CDFW funded the additional collection of Delta Smelt from the 2014 August STN, the 2014 FMWT, 2014 gear selectivity and 2015 SKT that was included in the ongoing Delta Smelt fish health studies conducted at the UC Davis Fish Health Laboratory in collaboration with CDFW's Diet and Condition study (IEP) and facilitated by CDFW's IEP Field Support element. This project, concluding with SKT sampling in spring 2015, will be integrated into the fish health, reproduction, otolith growth and natal salinity history from *iii* above, and nutritional status data that resulted from the previous four years of fish collection.

v. Phytoplankton & Microcystis

Microcystis aeruginosa is a toxic cyanobacterium that has bloomed in the Delta each summer since 1999 (Lehman et al. 2005). Toxins produced by *Microcystis* bioaccumulate in the Delta food web and have been associated with poor liver condition in young striped bass and Mississippi silversides (Lehman et al. 2010). In laboratory exposures, toxins produced by *Microcystis* greatly impaired the health and survival of threadfin shad (Acuña et al. 2012) and small crustaceans commonly eaten by small fish (Ger et al. 2009a,b). The 2014 drought is expected to have decreased water quality by increasing contaminant concentrations and the concentrations of toxic byproducts generated by *Microcystis* aeruginosa. Low flows and low turbidity in the Delta increase the intensity of the blooms (Lehman et al. 2013). This lower water quality resulting from *Microcystis* blooms may similarly impair the health of Delta Smelt. In a collaborative effort between DWR and CDFW, water samples were collected by DWR and will be analyzed through an existing CDFW grant with UC Davis (augmented with fiscal year 2014-2015 drought funding, $100K) to assess phytoplankton and *Microcystis* growth. Tasks include:

- Quantifying the potential toxicity due to cyanobacteria by measuring concentrations of microcystin, saxitoxin, and anatoxin-a in the particulate organic matter.
- Identifying the origin of *Microcystis* species in the water system, the sources of organic matter and the nitrogen source for the bloom using carbon and nitrogen stable isotopes and delta 15-N of dissolved nitrate and particulate organic matter.
- Quantifying abundance of toxin producing cyanobacteria and the relative amount of *Microcystis* to total cyanobacteria in the water column using quantitative PCR (Polymerase Chain Reaction).

Additionally, analysis of this effort will determine if there has been a shift in *Microcystis* species composition during the bloom and if the drought was associated with developing a salinity tolerant *Microsystis aeruginosa* genotype.

vi. OMR Index Demonstration Project

The USFWS and NMFS Biological Opinions (BiOps) set seasonal limits on the combined flows in Old and Middle Rivers (OMR), the two primary channels leading to the south Delta water export facilities. Reclamation's OMR index demonstration project was implemented in 2014 to determine whether an OMR index that can be forecast with greater precision than the gauge data could provide a way to increase water exports while still meeting the intended OMR flow limits specified in the BiOps. Currently, compliance with those OMR flow requirements is determined through 5-day and 14-day running averages of tidally filtered gauge data, which the U.S. Geological Survey (USGS) measures directly with acoustic velocity meters. The OMR index demonstration project proposes to use statistical estimates of OMR flow in place of gauge data for operational planning. The project is based on a fixed term and was initially set for one year. This study is expected to be presented and reviewed at the BiOp annual review in November 2015.

B. Analysis of Water Year 2014

Two research thrusts that the IEP is currently pursuing for Delta Smelt are 1) improving the accuracy and precision of population size estimates, and 2) the development of mathematical life cycle models that can predict the consequences of alternative operational strategies would have on Delta Smelt. Both of these research objectives lay the groundwork for the development of predictions of drought impacts on Delta Smelt.

In the more immediate term, a team of DFW and IEP scientists convened in summer 2014 to evaluate drought impacts on Delta and Longfin Smelt using an existing qualitative (conceptual) model. This effort built on the report recently completed by the IEP's Management, Analysis, and Synthesis Team (MAST), "An updated conceptual model of Delta Smelt biology: our evolving understanding of an estuarine fish." This report provides a conceptual model of how Landscape Attributes (fixed aspects of Delta Smelt habitat, such as location with respect to the State and Federal water projects), Environmental Drivers (dynamic aspects of habitat that change seasonally and inter-annually, such as food production), and Habitat Attributes (aspects of habitat that immediately affect Delta Smelt, such as predation risk) affect vital rates of the Delta Smelt population such as growth, survival, and reproduction. The conceptual model provided a logical framework for development of predictions of drought on the Delta Smelt population, attempting to address all of the main environmental factors identified in Attachment I, Questions 1 – 9 of the DOP (e.g., salinity distribution, Delta Smelt growth rates). These questions were originally posed under the assumption that emergency temporary barriers would be installed, and thus many of the questions center around the impact of these barriers. However, it is useful to evaluate predictions for how drought conditions, regardless of barriers, are likely to affect Delta Smelt and their habitat in order to make informed decisions for drought operations should the drought persist.

To the extent that data are available, the analysis effort will evaluate each of these predictions, comparing 2013-2014 to the previous decade (2003-2012). For some variables, such as predation risk and contaminant concentrations, data are sparse or largely unavailable and it may not be possible to evaluate all predictions. However, physical environmental data, species approximate relative abundance, condition, fecundity, and food density are all largely available from IEP monitoring surveys and can be evaluated over the time period identified for analysis. These analyses for Delta Smelt are underway, with the goal of providing an oral presentation at the IEP Workshop in March of 2015 and producing a written report by the fall of 2015.

For Longfin Smelt, a newly updated conceptual model is not available. However, the analysis team working on the Delta Smelt analyses plans to develop predictions for drought effects using a similar tiered framework as the Delta Smelt conceptual model.

C. Water Year 2015 Actions

Building on the actions taken in WY 2014, and in addition to already required monitoring, below are actions that should be implemented during WY 2015 should drought conditions persist. As ongoing operations, analysis, monitoring, and weather change conditions and forecasts for reservoir storage, river flow, and Sierra snowpack, continued refinement of these actions and discussions about resource allocation and prioritization will be discussed in collaboration with the involved agencies through the RTDOT.

Water Year 2015 Actions	Estimated Cost
Expanded IEP Monitoring – Early Warning Sampling	$527,500
Spectral Imagery of Submerged Aquatic Vegetation (SAV	$415,000
Otolith Microchemistry and Growth Rates	$140,000
Phytoplankton and Microcystis	$335,000
Enhanced Flow, Water Quality, and Barrier Monitoring	$683,500
Total Cost	**$2,503,800**

i. Expanded IEP monitoring – Early Warning Sampling - $527,500

USFWS proposes to extend the "Early Warning Sampling" approach developed in WY 2014 at Jersey Point by using an additional station at Prisoner's Point in order to better evaluate smelt movement into the interior Delta during critical migration periods. Prisoner's Point is upstream from Jersey Point and represents a greater risk of exposure to entrainment at the export facilities. The basic objective of the early warning sampling for WY 2015 is the same as WY 2014: to pilot a new source of information that may help assess whether substantial movement of Delta Smelt occurs in response to transient hydrodynamic, turbidity, and/or weather conditions. This information will be used to inform management actions in near real-time and the seasonally accumulated data will be analyzed to inform future operations management. Early Warning Sampling specifics and estimated costs for the USFWS can be found in Attachment A. Additional costs for CDFW participation in this effort is estimated at approximately $100,000.

ii. Spectral Imagery of Submerged Aquatic Vegetation (SAV) - $415,000

Similar to 2014, information should be collected on SAV coverage through the use of hyperspectral imagery throughout the Delta during the fall. This approach will also be used to evaluate the spatial distribution of WY 2015 *Microcystis* blooms. Should 2014 findings of increased floating and/or submerged aquatic vegetation occur, coordinated discussions between the state and federal fish agencies, the California Department of Boating and Waterways, and the SWRCB should take place regarding potential solutions and management applications. Efforts in 2015 are expected to have a similar budget to that of 2014.

iii. Phytoplankton & Microcystis - $100,000 (analysis) + $235,00 (DWR staff time for sample collection)

Similar to 2014, water samples will be collected for continued analysis of phytoplankton and *Microcystis* concentrations throughout the central and southern Delta. A review of 2014 preliminary data should be conducted by June 2015 to refine sample timing, frequency, methods, and locations as necessary.

iv. Otolith Microchemistry and Growth Rates - $140,000

Similar to 2014, otoliths will be collected from Delta Smelt and Longfin Smelt in order to analyze habitat use and growth rate information. Otoliths will be harvested from fish collected in CDFW surveys (e.g., STNS, FMWT, and SKT).

v. Enhanced Flow, Water Quality, and Barrier Monitoring - $683,500

WY 2014 DOP contemplated the possibility of installing physical barriers (emergency drought barriers) at Steamboat and Sutter Sloughs and West False River to reduce saltwater intrusion and protect export water quality. While this action was not undertaken during 2014, if implemented under the WY 2015, the emergency drought barriers would reduce water motion in some locations to increase it in others with an overall increase in hydraulic residence time in the affected sloughs in order to increase flow in the Sacramento River and DCC/Georgiana Slough to help meet D-1641 salinity standards in the Delta. Should WY 2015 operations call for installation of these emergency drought barriers, these effects will need to be carefully investigated through coordinated monitoring studies.

The 2014 DOP included several near term questions related to the implementation of temporary rock barriers ("drought barriers"). However, the drought barriers were not put in place in 2014 and therefore the near term questions provided in the DOP did not need to be addressed. If extreme drought conditions persist into 2015, it is likely that DWR will ask to construct and operate the drought barriers. The relevant science questions are:

a. How do low flow conditions or the combination of low flow conditions and the drought barriers affect the distribution of salinity (i.e., the low-salinity zone)?
b. How do low flow conditions or the combination of low flow conditions and the drought barriers affect water residence time and phytoplankton production in the lower Yolo Bypass, Cache Slough complex, and blocked sloughs)?
c. What effect do low flows or the combination of low flows and the drought barriers have on turbidity and water temperatures in the lower Yolo Bypass, Cache Slough complex, and blocked sloughs?
d. What effect do the drought barriers have on dissolved oxygen levels in the blocked sloughs?
e. How does the health and condition of Delta Smelt in the lower Yolo Bypass, Cache Slough complex, and blocked sloughs compare to the health and condition of Delta Smelt in the main stem Sacramento River and western Delta?
f. How are Delta Smelt distributed in the Delta in mid-summer with the barriers in place?
g. How do summer growth rates (measured in September, from otoliths) of Delta Smelt in the lower Yolo Bypass, Cache Slough complex, and blocked sloughs compare to historical growth rates from the Cache Slough complex?
h. How do low Delta flow conditions or the combination of low flow conditions and the drought barriers affect the abundance and distribution of fishes known to prey on Delta Smelt?
i. How does low flow affect the abundance and density of *Egeria densa* or other non-native aquatic vegetation in the lower Yolo Bypass, Cache Slough complex, and blocked sloughs?

Some of these questions will be answered by research elements discussed above. In order to answer the others, DWR should expand on the parameters currently monitored at existing stations and install new temporary water quality monitoring stations immediately upstream (< 1/4 mile) and downstream of each barrier to assess localized impacts (Attachment B, Tables 1 and 2) . Additional sites will also be monitored to assess barrier impacts on a broader scale. The water quality monitoring plan at each site will consist of two components: 1) continuous water quality and flow monitoring, and 2) discrete sampling for chlorophyll and nutrients. Attachment A provides the name of each monitoring station and the constituents that will be monitored, based on the temporary barriers proposed for 2014. If additional or different sites for temporary barriers are proposed for 2015, the specific monitoring plan will be revised such that it addresses specific location needs.

D. Other Ongoing Efforts and Recommendations for Longer-term Monitoring and Research

In addition to the monitoring requirements identified above, which target WY 2015 in the event of continued drought conditions, there are many other efforts currently underway that continue to refine our understanding of smelt populations in the Delta. These efforts are being developed and implemented through collaborative processes that include independent scientific peer review. As long-term efforts and future research on Delta Smelt and Longfin Smelt life history and habitat parameters continue, they should be conducted through the several collaborative processes and technical workgroups that are already in place. These groups already have the infrastructure in place to appropriately engage interested parties in the review and further development and implementation of research and monitoring needs. The primary research and monitoring effort is the Interagency Ecological Program (IEP, including the project work teams (PWT) and Management, Analysis, and Synthesis Team (MAST) efforts). Other interagency/stakeholder groups that rely on IEP data to varying degrees are the Collaborative Science and Adaptive Management Program (CSAMP), Delta Science Program (DSP), and Water Operations Management Team (WOMT).

i. Interagency Ecological Program

IEP has initiated an effort to identify near term studies and analyses (Attachment C) which are intended to supplement and improve current methods for estimating the abundance and distribution of Delta Smelt. The study objectives are designed to address concerns such as:

- Gear Selectivity - Evaluate gear selectivity and characterize the limitations of existing surveys.
    - Field sampling will be repeated seasonally in WY15 to collect information for different Delta Smelt life stages and to estimate selectivity for different IEP fish monitoring gears. Each field sampling effort will use the gear types currently targeting the particular life stage present and those gear types that target earlier and later life stages. The goal will be to seasonally sample as Delta Smelt transition from being effectively sampled by one gear (or set of gears) to another gear (or another set) to capture how relative selectivity changes with fish size (and ontogeny).

- Integration of Catch Data - Compare and integrate catch data from multiple gears.
- Vertical and Lateral Distribution - Assess factors affecting fish distribution in the water column and channel.
- Bias and Detection - Evaluate under-sampled habitats, random stations and increased effort.
- Genetics - Develop a genetics monitoring plan for population trends and dynamics.

Results are intended to help inform adjustments to ongoing monitoring that may be needed to better understand the abundance and distribution of the Delta Smelt population.

ii. USFWS Delta Smelt Life Cycle Modeling

The Delta Smelt Lifecycle Model (DSLCM) will be a decision support tool for management (a) to predict the effect of proposed management actions on the population dynamics of the federally listed Delta Smelt and (b) to assess, after-the-fact, the effects of actions that were implemented as well as the effects of historical environmental conditions. The DSLCM will be first applied to an analysis of actions aimed to minimize entrainment related mortality. Such actions could include Reasonable and Prudent Alternatives (RPAs) in the USFWS 2008 Delta Smelt Biological Opinion that are related to protecting adult Delta Smelt and protection of the larval and juvenile stages of Delta Smelt, such as controlling the range of Old and Middle River (OMR) flows just prior to and during the smelt breeding season, or variations on such RPAs. For example, the DSLCM could be used to compare the effects on the adult Delta Smelt population of OMR flows in the range of -5000 to -3000 cfs with the effects when OMR flows are in the range of -10,000 to -7000 cfs. In addition to assessing population effects of operations, other effects could include changes in the survival rates in the south and central Delta, changes in the overall Delta Smelt abundance, and changes in reproductive success

iii. Collaborative Adaptive Management Team (CAMT)

The CAMT is an element of the Collaborative Science and Adaptive Management Program (CSAMP), which was established in 2013 to support future revision of the Federal Biological opinions for the SWP and Central Valley Project. The CAMT has convened the Delta Smelt Scoping Team (DSST), which is a sub-group tasked with facilitating development of scientific investigations to address high priority uncertainties which include CVP/SWP proportional entrainment and the role of fall flows (X2) in Delta Smelt production. Through the DSST, investigative teams of scientists have been assembled to draft study plans. For example, the entrainment team’s plan includes the following elements, some of which is anticipated to be completed in 2015:

- Integrated modelling of smelt behavior, habitat (turbidity) conditions, and hydrodynamics to improve understanding Delta Smelt movement into the southern Delta and subsequent rates of entrainment at the CVP/SWP intake facilities.

- Updating the results of the Maunder and Deriso's 2011 Delta Smelt life cycle model, and testing model sensitivity to revised stock/recruitment assumptions, and covariate formulation and selection, to improve understanding of the relative importance of factors influencing Delta Smelt production.
- Exploring and implementing techniques for improving the accuracy of estimates of the proportional losses of Delta Smelt to entrainment at the CVP/SWP intake facilities.

With funding from the USBR, the DSST has engaged the Delta Science Program to provide independent review of the entrainment topic study plan and future investigation team proposals and products. Investigative teams and reviewed/approved study plans for all topic areas are expected to be in place by late 2014 or early 2015, and products available by mid-2015.

iv. Longfin Smelt Efforts

A suite of collaborative studies was recently initiated in response to CDFW's Longfin Smelt Incidental Take Permit for the SWP. The study plan includes an investigation of flow-driven variation in spawning and rearing distribution. In particular, study elements will explore the hypothesis that increased spawning in small San Francisco Bay tributaries in high precipitation years contributes to the well-established flow-production relationship for the species through tributary sampling and chemical-signature analysis of specimens collected in bay-wide surveys. The study plan also contains enhanced analysis of existing data, and possibly special field investigations, to explore potential survey biases that could distort assessment of recent population trends.

IV. ANADROMOUS FISH

A. Introduction

In water year (WY) 2014, various salmonid monitoring efforts [*e.g*., installation of temperature and dissolved oxygen (DO) probes adjacent to winter-run redds, implementation of a Delta Cross Channel (DCC) gate operations trigger matrix, and increased beach seining and trawling efforts to determine the timing and magnitude of salmonid emigration into the Delta] were implemented in order to determine the effect of the drought and operations on the salmonids, and to be able to make real-time management decisions regarding operations and protection of the listed anadromous fish species. The current drought has highlighted that we need improvements in the array of information that is collected to support management decisions pertaining to the effect of water operations from pre-spawning adult migration into the upper Sacramento River through juvenile emigration into the Pacific Ocean. These drought effects cascade between multiple cohorts such that decisions made during one cohort's emigration period are affecting a different cohort's egg incubation and rearing period, and thus immediate, seasonal, and interannual planning and evaluation tools of water operation need to be improved. This anadromous fish monitoring plan provides specifications for drought monitoring for 2015 in these areas:

i. Delta and Upstream

Most of the information regarding the relative locations of anadromous species in the Delta has relied on the Delta Juvenile Fish Monitoring Program (DJFMP), which consists of 58 beach seine sites and three boat trawling stations (figure 1), and at different times, has included additional sampling used to inform specific studies. In addition, another important source of information on juvenile salmonid emigration from the tributaries to the Delta has been derived from the operation of a number of rotary screw traps (RST) at Knights Landing (Sacramento River), Tisdale (Sacramento River), and lower American River.

In the upstream areas for 2014, NOAA's National Marine Fisheries Service (NMFS) and the California Department of Fish and Wildlife (CDFW) developed and implemented a winter-run contingency plan with increased upstream monitoring of temperature and winter-run redds. Beginning in early July, 70 loggers were deployed to measure temperature (of which 20 also measured DO) in the Sacramento River and mouths of selected tributaries between Deer Creek (RM 220, Tehama County) and Keswick Dam (RM 302). The loggers were set to record data every half-hour 24/7. Those data were then downloaded from the loggers opportunistically as human and transport resources allowed. The data can be found on the CDFW-RBFO FTP site (ftp://ftp.dfg.ca.gov/Red_Bluff_Fisheries/), which allows interested users the ability to query the data through many options, including: daily, weekly or monthly average, and minimum or maximum temperatures. This information, in coordination with monitoring of isolation pools and redd dewatering, helped managers understand and evaluate impacts associated with real-time decisions on upstream operations.

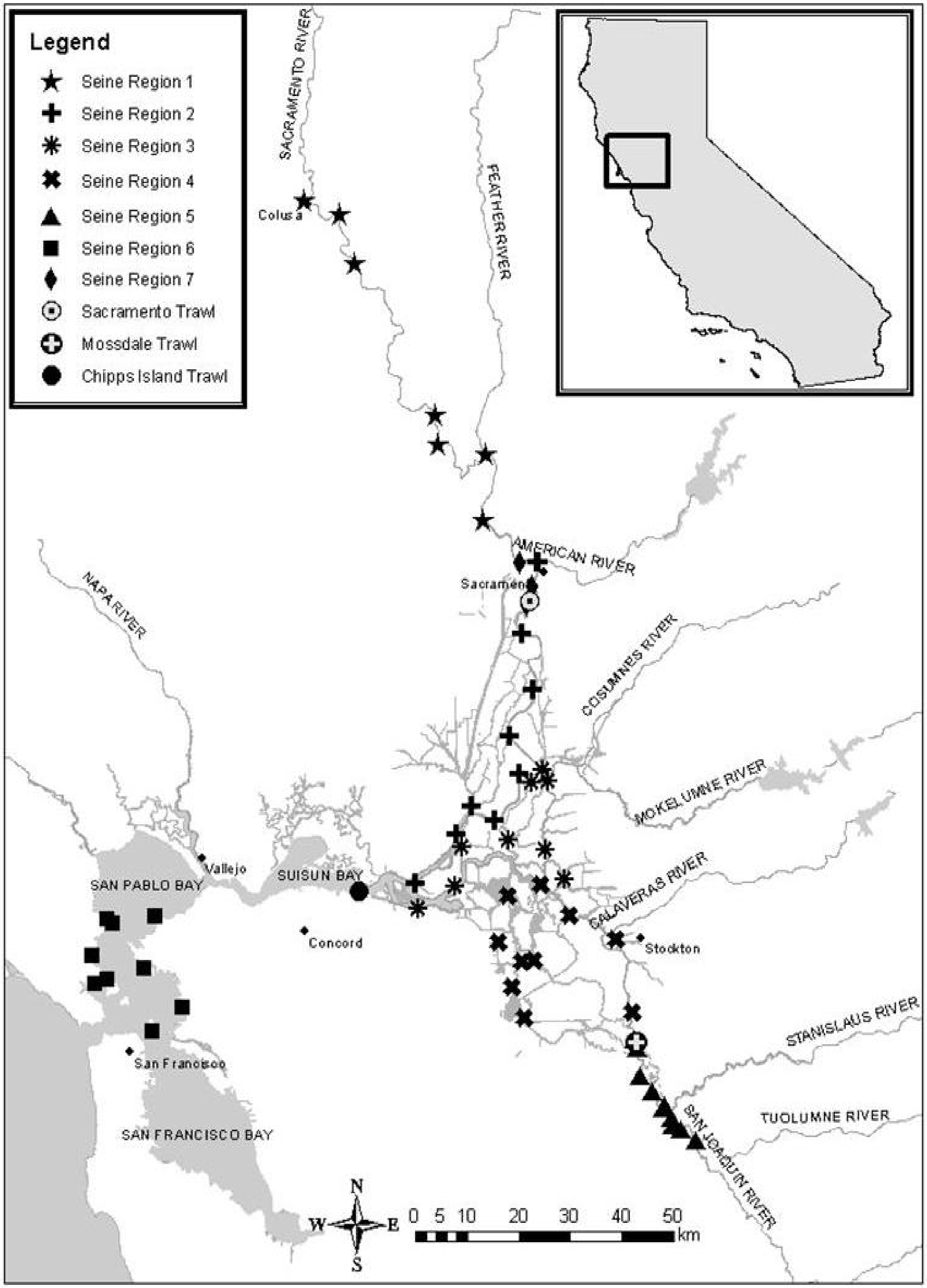
Legend
Seine Region 1
Seine Region 2
Seine Region 3
Seine Region 4
Seine Region 5
Seine Region 6
Seine Region 7
Sacramento Trawl
Mossdale Trawl
Chipps Island Trawl
SACRAMENTO RIVER
FEATHER RIVER
Colusa
AMERICAN RIVER
Sacramento
NAPA RIVER
COSUMNES RIVER
MOKELUMNE RIVER
CALAVERAS RIVER
Vallejo
SUISUN BAY
SAN PABLO BAY
Concord
Stockton
STANISLAUS RIVER
TUOLUMNE RIVER
SAN JOAQUIN RIVER
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Figure 1: Existing Delta Juvenile Fish Monitoring Program, Beach Seine and Trawl Locations

ii. Studies of Tagged Fish Behavior, Timing and Survival

In addition to the DJFMP, information on juvenile movement and survival has been developed through a time series of tagging studies conducted by NMFS-Southwest Fisheries Science Center (SWFSC), U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, U.S. Bureau of Reclamation (USBR), and others. These include coded-wire tag and acoustic tag studies on both the Sacramento River corridor and the San Joaquin River corridor (*e.g.*, 6-year acoustic tag studies on steelhead and acoustic tag studies pursuant to and subsequent to the Vernalis Adaptive Management Plan). Careful placement of tag receivers and the capability to load data from receivers remotely increases the likelihood that this information may be used in real time to inform water management decisions. Even if the information cannot be used in real-time, it is important to design these studies to be expressly capable of evaluating the effects of drought-related operations for the coming year. Also, there is an effort being planned to pilot using passive integrated transponder (PIT) tags in the Delta to supplement these other technologies. A coordinated effort to use tag studies to study fish behavior and survival in the Delta should be continued and is being reviewed and guided as part of the CAMT scoping of past studies and data gaps related to salmonid survival and water operations.

iii. Data Collection, Distribution, and Analyses

Data collection through the DJFMP and for most of the RSTs has been standardized and fairly routine, except for those instances (*e.g.*, WY 2014), when augmented monitoring was requested and implemented. Dissemination of the data is typically through e-mail distribution lists. Additionally, data acquisition is fairly easy to make once the data source or contact is known (Table 1). However, information alone is insufficient, and there are improvements that can be made to synthesize information in real-time for agency decision-makers regarding the distribution and abundance of fish and the risks caused by these population characteristics. Furthermore, synthesized information should continue to be disseminated to stakeholders and the public routinely via the Delta Operations for Salmon and Sturgeon (DOSS) and mulit-agency websites to improve the transparency of the real-time decision-making process. DOSS continues to improve its reporting of distribution and abundance in the Central Valley and Delta, based on the information in the following table (Table 1). During Water Year 2015, information will be distributed likely through posting on a website on a daily, weekly, and biweekly scale depending on the frequency of the survey (Table 1).

Table 1. Delta Juvenile Fish Monitoring Program Data Information.

Monitoring Site	Website/ Responsible Agency	Updating Frequency
Red Bluff Diversion Dam Screw Traps	http://www.fws.gov/redbluff/rbdd_biweekly_final.html Red Bluff Fish and Wildlife	Bi-weekly

	Office, USFWS	
Tisdale Weir Screw Traps	Not posted North Central Region- Fisheries, CDFW	Sub-weekly
Knights Landing Screw Trap	Not posted North Central Region- Fisheries, CDFW	Sub-weekly
Delta Juvenile Fish Monitoring Program (Beach Seines; Sacramento, Chipps, and Mossdale Trawls)	http://www.fws.gov/stockton/jfmp/ Stockton Fish and Wildlife Office, USFWS	Bi-weekly
SWP/CVP Fish Collection Facilities Salvage Monitoring	http://www.dfg.ca.gov/delta/apps/salvage/ CDFW Bay-Delta Region	Daily
Delta Assessment Team (Distributional, Salvage, and CWT Surrogate Monitoring)	http://www.water.ca.gov/swp/operationscontrol/calfed/calfedmonitoring.cfm OCO CALFED Operations	Weekly

For various studies, especially the acoustic tagging studies, distributions of draft and final reports often lag , sometimes for years, behind the implementation of the study and data collection, likely due to considerable workload limited to few experts that can analyze the data. Study results are often reported out in various professional conferences, for example, the Bay-Delta conference, and that may be the only citable source to the results pending a forthcoming report. These results are needed for near- and long-term planning and developing adaptive management studies to increase fish protection and operational flexibility.

B. Anadromous Fish Species Monitoring and Studies for Water Year 2015

As part of the April 8, 2014, Drought Operations Plan (DOP), NMFS and CDFW committed to co-lead an effort to review current and future monitoring needs related to drought. This review was to help identify what monitoring, studies, and efforts are necessary in 2015 in order to better evaluate the effects of the drought and operations on the listed anadromous fish species, inform real-time management decisions, and to provide a venue for transparency in data dissemination.

i. Improvements in Monitoring

NMFS and CDFW have determined that the current monitoring network has provided valuable data on the general timing, duration, and magnitude of species emigration down the Sacramento and San Joaquin Rivers into and out of the Delta. However, it is lacking in some specific monitoring locations in order to detect the effects of operations, or trigger other operations for the protection of the listed species. For WY 2015, in support of the current monitoring network, the following additional monitoring actions will be implemented to better inform real-time management decisions.

1. *Delta*

   a. *Monitoring to Support and Evaluate Old and Middle River Flow Management*

Since the issuance of NMFS' biological and conference opinion on the long-term operation of the CVP and SWP, NMFS' Old and Middle River (OMR) flow management RPA Action IV.2.3 has received much attention regarding the utility of a calendar-based onset of January 1 each year, and also the influence of OMR flow on the migration of salmonids towards and entrainment into the Federal and State fish facilities. National Research Council (2010)[1] stated that:

> "The committee concludes that the strategy of limiting net tidal flows towards the pump facilities is sound, but the support for the specific flows targets is less certain. In the near-term telemetry-based smolt migration and survival studies (*e.g.*, Perry and Skalski, 2008) should be used to improve our understanding of smolt responses to OMR flow levels. Reliance on salvage indices or the PTM results alone is not sufficient."

Therefore, additional Kodiak/midwater trawl monitoring stations will be implemented at Jersey Point and the Prisoners Point, with those locations identified in Figure 2. Although the January 1 onset of OMR flow management Action IV.2.3 is still in place, these additional monitoring stations will better inform the relationship between OMR flows and their influence on the migration of salmonids towards and entrainment into the Federal and State fish facilities for both current drought year and future operational considerations and decisions.

NMFS and CDFW initially proposed baseline sampling of 3 days per week at Jersey Point and 3 days per week at Prisoner's Point, and from December 1 through June 15, in order to establish a baseline understanding of the timing, duration, and frequency of anadromous salmonid species at those monitoring locations. This sampling frequency would provide much finer scale temporal information. With finer scale information, a clearer understanding of relative location and flux may be gained. If catch numbers increase at one station but are not reflected in the catch at the other station, this would indicate that the population fraction present at that station is moving through that station's location, but not necessarily through the other station. Conversely, if catch data rise and fall at both stations simultaneously, then fish are presently distributed uniformly in the river reach between the two stations. The direction the fish population is moving will be indicated by which station is slower to show a decrease in catch. The station that is "last" to have the catch decline should indicate the direction the fish are moving. However, reducing sampling effort during the time periods when no OMR flexibilities

[1] National Research Council. 2010. A Scientific Assessment of Alternatives for Reducing Water Management Effects on Threatened and Endangered Fishes in California's Bay-Delta. Washington D.C.: The National Academies Press. 93 pages.

are being requested or when the weather conditions indicate little or no precipitation will occur, reduces the burden of additional take of Delta smelt and other listed species that may occur during intense sampling. In addition, later on in the emigration season (May 16 through June 15), differentiation between natural origin (adipose fin present) young-of-the-year spring-run Chinook salmon and unclipped hatchery fall-run Chinook salmon (adipose fin present) becomes unreliable due to size overlap of the two runs. Recognizing the importance of reducing take, and the diminished utility of the monitoring when run differentiation will likely be difficult, the resulting baseline sampling is provided in Table 2.

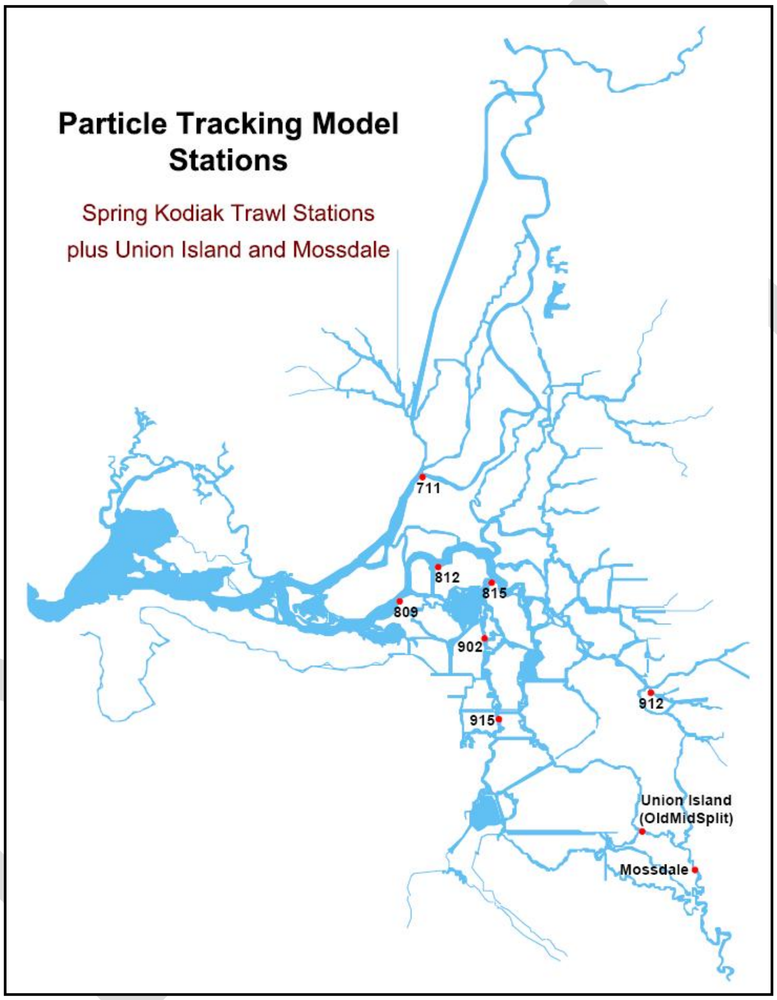

Figure 2: Location of new trawl locations in the San Joaquin River at Jersey Point (Station 809) and Prisoner's Point (Station 815).

Table 2. Summary of baseline sampling protocol. Red text indicates differences or changes compared to the Delta Smelt early warning monitoring.

Sampling location	Sampling gear	Sampling duration and frequency
San Joaquin River at Jersey Point (station 809)	Kodiak Trawl	10 min/tow, 15-20 tows/day, 1 day/week from December 15 to May 15
San Joaquin River at Prisoner's Point	Kodiak Trawl	10 min/tow, 15-20 tows/day, 1 day/week

(station 815)		from December 15 to May 15

Baseline sampling will provide species presence absence information at a weekly time scale. Although it may be impossible to confirm a negative, a catch of zero would at least indicate some lack of species presence. At a weekly time scale however, it is assumed that the single day of sampling would be representative of the entire week. The validity of this assumption should be accounted for when interpreting the data in real-time. In summary, baseline sampling will enhance the temporal resolution of other salmonid monitoring efforts in the lower San Joaquin River but will not provide a robust representation of fish flux and population distribution in real-time due to limited sample frequency, as well as other factors, such as small population size. Interpretation of these data sets will be actively discussed at DOSS and other venues. The sampling protocols at these stations for salmonids will be reviewed for 2016, based on what is learned in 2015.

Table 3 provides the triggers for increased sampling, at Jersey Point and Prisoner's Point, and their durations. Daily sampling between the two stations will provide a finer scale presence /absence and an indication of population flux through this region of the river.

Table 3. Summary of FWS and NMFS proposed triggers for increased sampling frequency. The trigger in the first row (grey) is based on expected weather conditions. Triggers in the second and third rows are based on actual conditions (flow and turbidity) and catches. Note: triggers for increased sampling at Jersey Point and Prisoner's Point are considered dependent (if triggers are met at one site, increased sampling will occur at both sites). However, triggers for resuming baseline sampling must be met at both sites.

Sampling Location	Trigger	Response
Jersey Point / Prisoner's Point	FWS: 3 days advance forecast of >50% chance of rain with expected new amounts >0.25" (in the Delta region).	Daily sampling (15-20 tows/day, alternating between sites), initiated 2 days in advance of rain event.
	NMFS: A proposed increase in exports resulting in flows within Old and Middle Rivers which produce an OMR index more negative than -5,000 cfs on a 14-day running average.	Daily sampling (15-20 tows/day, alternating between sites), initiated 2 days in advance of expected OMR Index more negative (-) than -5,000 cfs.
Jersey Point / Prisoner's Point	FWS: If actual rain amounts are not significant (only minor changes in flow and turbidity result) **AND** catches return to or decrease below baseline.	Return to baseline sampling (1 day/week at each site); otherwise continue sampling (see trigger below).
	NMFS: OMR index returns to no more negative than -5,000 cfs on a 14-day running average.	
Jersey Point / Prisoner's Point	FWS: If actual rain amounts are significant (river stage at Freeport is anticipated to exceed 20,000 cfs or turbidity at Jersey Point exceeds 10 NTU).	Return to baseline sampling after two consecutive days of catches at or below baseline at each site (4 days total, accounting for the alternating schedule).
	NMFS: OMR index returns to no more negative than -5,000 cfs on a 14-day running average.	

Using the estimated budget provided in Attachment A (Delta Smelt early warning proposal) and assuming daily sampling required by a change in operations, the additional 2 trawling locations would cost approximately $579,500/year ($3,800 for 4 staff x 30 days/month x 5 months, plus $950 for 1 data entry and lab staff x 2 days/month x 5 months). The cost is reduced because a coordinated effort has been made to maximize any efficiency gained by implementing a similar sample design to that of the proposed for Delta Smelt monitoring. The expected marginal cost of salmonid monitoring to support and evaluate Old and Middle River flow management, beyond what is proposed for Delta Smelt would be approximately $182,400.

b. Monitoring Salvage at Tracy Fish Collection Facility (CVP) and Skinner Fish Facility (SWP)

The Delta Operations for Salmon and Sturgeon (DOSS) technical advisory team, in coordination with the Smelt Working Group (SWG), has convened a subgroup to consider and make a recommendation on whether fish salvage counts at the Tracy Fish Collection Facility and Skinner Fish Facility need to be increased to a minimum 60 minutes for every 2 hours of operational time during drought years. The recommendation(s) will be submitted to the RTDOT no later than December 31, 2014. NMFS' BiOp, RPA Action IV.4.3(1) requires sampling at the fish facilities for fish salvage counts no less than 30 minutes every 2 hours (25 percent of operational time). However, during drought years, juvenile survival throughout their freshwater life history stages is expected to decrease. Likewise, salvage of salmonids at the fish facilities may also decrease, and the 30-minute salvage counts may introduce inadvertent errors in expanded salvage (*e.g*., fish may be salvaged during operations, but not during the 30-minute counts, therefore, underestimating expanded salvage and loss. Conversely, a single fish salvaged during the 30-minute count when there is no other salvage for the rest of the 2-hour time period may overestimate expanded salvage and loss). During the discussions and associated recommendations, the DOSS should:

- document potential benefits/pros (*e.g*., more accurate quantification of expanded salvage and loss) or cons (*e.g*., potential increase in incidental take and mortality) of increased sample time at the fish facilities;
- consider/propose the timing to initiate, and the duration of, the 60-minute counts, if appropriate; and
- consider the Federal and State fish facilities implementing a test to determine whether the additional 30 minutes of sampling would significantly improve daily salvage or loss estimates.

c. Enhanced Particle Tracking Model (PTM)

The NMFS-SWFSC is modifying the existing particle tracking model (PTM) module of DSM2 to develop an enhanced PTM that assigns advection and "swimming" behavior to particles as part of their effort to develop a life cycle model for Winter-run Chinook Salmon. To create a model that better characterizes the behavior of salmon, the effort has evaluated a suite of particle behaviors (*e.g*., particle moves with advection and always swims downstream vs. particle swims with downstream flow and holds station with upstream flow) and they are calibrating the model to determine which behaviors best simulate results from existing empirical datasets. By inserting a number of these particles at select Delta locations into a simulation of current and forecasted hydrology, the enhanced PTM can provide information on predicted route selection and fate of particles to inform management of various hydrodynamic effects of operations on salmonid movement.

Using the enhanced PTM for real-time operations in 2015 would provide an initial trial of the calibrated modeling and analytical efforts and techniques required for rapid response. Validation analyses of model results and WY2014 and drought-related fish tagging studies (e.g., Georgiana Slough) could inform any further refinements of the model. With increased focus and dedicated staffing at NMFS, the NMFS-SWFSC, and DWR (modeling staff), this enhanced PTM could inform operational decision making between March 1 and May 31, 2015. The goal will be to provide periodic output that can inform DOSS and the RTDOT in real-time decision making. NMFS and DWR staff will continue meetings of the interagency workgroup focused on their respective modifications to the PTM. The NMFS-SWFSC labor cost is expected to be $62,000.

2. *Upstream*

a. *Winter-Run Redd Temperature and Dissolved Oxygen Monitoring*

Each year, as a result of requirements in the State Water Control Board's Water Rights Decision 90-5 and NMFS' RPA, the Sacramento River Temperature Task Group determines a temperature compliance point on the mainstem Sacramento River that can be maintained at a daily average water temperature of 56°F throughout the winter-run egg incubation and pre-emergent fry season (to also include spring-run throughout October). In 2013, during the annual review of operations, the Independent Review Panel recommended the installation of temperature probes within winter-run redds to determine the microclimate that the eggs are exposed to. In 2014, the California Department of Fish and Wildlife (CDFW) deployed 50 temperature loggers and 20 temperature/dissolved oxygen (DO) loggers that were placed in the Sacramento River in and around winter-run spawning and rearing areas. In 2015, the temperature/DO loggers will be placed within winter-run redds and monitored.

In addition, CDFW staff have been monitoring winter-run redds for dewatering, and also pools for isolated and stranded juvenile winter-run, when Keswick releases are reduced in late summer and fall.

To continue enhanced winter-run redd monitoring, dewatering, rescues and temperature logger/DO monitoring efforts on an annual basis, additional staff and operational funding will be needed, at a cost of $500,000 per year.

b. *Recalibrate Sacramento River Temperature Forecasts*

Drought conditions during WY 2014 have highlighted the importance of correcting and calibrating the Sacramento River temperature model[2], as actual water temperatures were up to 4°F warmer than those predicted with the temperature models. The increased temperature monitoring implemented in WY 2014 offers a unique opportunity to recalibrate the Sacramento River temperature model for WY 2015 temperature control based on WY 2014 temperature information (profiles, river temps, *etc*.). NMFS and USBR have agreed to organize a series of interagency technical meetings to discuss the level of effort involved in "recalibrating" the USBR temperature model and to develop a better understanding of its use and limitations as a temperature/water operations planning tool for fisheries.

An additional topic during these early technical meetings will be the desired endpoints and objectives for further development of the NMFS-SWFSC temperature planning and evaluation model. The RAFT model and website (http://oceanview.pfeg.noaa.gov/raft/) offers an independent framework for the interagency SRTTG to consider effects on ESA-listed species under a range of forecasts and operations. This decision support tool (DST) will be further developed to include seasonal forecasts by coupling it

[2] A consistent request from the independent review panel of the NMFS BiOp has been to calibrate the long-term temperature forecasts models to reduce uncertainty.

with a reservoir model. An additional topic during later technical meetings will be presentation of model results potentially including daily to seasonal temperature and flow specific Shasta water release scenarios, cold water pool depletion timelines, probability of achieving Temperature Compliance Point (TCP) targets and optimal compliance point. The RAFT DST is fundamentally different than other temperature models in that it is available to the end-users interactively, in real time, and a final topic of the technical meetings will be to train the SRTTG as a user group of the RAFT model. This DST may be pivotal in future drought operational planning. This is a 3-year effort with an estimated cost of $450,000 to 525,000 annually.

3. Proposed Monitoring to Improve Real-Time Management Decisions

Depending on WY 2015 operations, and in anticipation that modifications to D-1641 or RPA Actions identified under the NMFS Biological Opinion may be sought, NMFS and CDFW have determined that the following monitoring, studies, and efforts may be necessary in order to better evaluate the effects of the drought and operations on the listed anadromous fish species and inform real-time management decisions. These actions shall be taken into consideration by the RTDOT when evaluating potential future modification requests.

a. Monitoring to Support and Evaluate DCC Gate Operations

The "Matrix of Triggers for Delta Cross Channel Gate Operations" (Attachment G to the DOP) should be implemented. In addition:

- Initiation of continuous 24 hour sampling at Knights Landing RST. Continuous sampling will be initiated when a flow event at Wilkins Slough occurs, which has been shown to be correlated with a peak in winter-run migration (del Rosario *et al*. 2013[3]). A flow event is defined as (1) an increase over base flow by 45% within a 5-day time period, calculated using daily flow averages, or (2) flows of 7,500 cfs and temps <13.5°C (per RPA Action IV.1.1). Increased sampling will continue indefinitely or until CVP and SWP operational flexibilities for DCC gate operations that differ from Action IV.1.1 are no longer considered.

- 3 days prior to a DCC gate opening and throughout the time that the gate is open, trawl sampling at Sherwood Harbor and Sacramento beach seine sampling will be increased to daily to improve resolution on winter-run presence and outmigration behavior.

b. Emergency Drought Barriers

During the development of the DOP the possibility of installing physical barriers (emergency drought barriers) at Steamboat and Sutter sloughs and West False River was considered as means to reduce saltwater intrusion and protect export water quality. Given the extreme nature of physically blocking these river reaches and the fact that water quality remained within tolerance levels, this action was not implemented during WY 2014. Looking forward to 2015, emergency drought barriers may again be

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[3] del Rosario, R.B., Y.J. Redler, K. Newman, P.L. Brandes, T. Sommer, K. Reece, and R. Vincik. 2013. Migration Patterns of Juvenile Winter-Run-Sized Chinook Salmon (*Oncorhynchus tshawytscha*) through the Sacramento–San Joaquin Delta. San Francisco Estuary and Watershed Science 11(1):1-22.

considered as a way of artificially increasing flow in the Sacramento River and DCC/Georgiana Slough to help meet D-1641 salinity standards in the Delta. A consequence of implementing these barriers would be reduced water motion, increase water residence time and decreased access to the identified sloughs. Through consultation on the proposed WY 2014 barriers and as part of any future installation, solar-powered monitoring instruments would be placed at appropriate locations upstream and downstream at each barrier site and would monitor parameters like dissolved oxygen, turbidity, salinity (EC), river stage, and flow velocity. Additional monitoring, including using DIDSON cameras, would be used to assess the Sutter Slough and Steamboat Slough sites for interaction with and passage of migratory fish through barrier culverts.

ii. Studies of Tagged Fish Behavior, Timing and Survival

In addition to the monitoring identified above, which target WY 2015 in the event of continued drought conditions, there are many other efforts currently underway that continue to refine our knowledge of salmonid populations in the Delta and will help to better understand fish behavior, timing, and survival. These efforts are being developed and implemented through collaborative processes that include independent scientific review. In WY 2015, attempts to refine and fund the following research and long-term efforts should continue. These efforts should be conducted through the several collaborative processes and technical workgroups already in place. These groups have the infrastructure and mechanisms in place to appropriately engage interested parties in the review and further development and implementation of these research and monitoring needs.

1. Winter-Run Acoustic Tagging Study

In 2013, the NMFS-SWFSC initiated a 3-year acoustic tagging study to determine reach survival of hatchery winter-run throughout the Sacramento River and Delta. The study will again be implemented in 2015. Real-time acoustic tag receivers are available and will be deployed at specific locations to augment other monitoring and help inform the (real-time) effects of operations and their influence on the timing and distribution of salmonids (and specifically winter-run) as they emigrate down the Sacramento River and into and through the Delta. For 2015, real-time monitoring receivers will be established at the Tisdale and Knights Landing RST locations, and future locations could include the upstream and downstream ends within the DCC and Georgiana Slough. The location of additional real-time monitoring receivers will be coordinated with NMFS and CDFW.

It is important to continue funding and implementing this study beyond 2015 in order to have additional data, and hopefully across the different water year types, to better evaluate reach survival of juvenile winter-run down the Sacramento River and into and through the Delta. Each year of the study costs an estimated $350,000 for supplies, labor, and data analysis.

2. Butte Creek Spring-run Acoustic Tagging Study

Drought survival monitoring (2014) using acoustic tags in wild-spring run Chinook salmon from Mill and Battle Creek (N=200) indicate that none of these fish survived to the ocean. Butte Creek currently supports the largest run of wild spring-run Chinook salmon in the Central Valley, with adults typically representing nearly 75% of wild spring-run salmon escapement. The dynamics of wild spring-run found in Butte Creek are different from other spring-run and fall-run populations. Thus, surrogate data from other populations may not be applicable for predicting Butte Creek spring-run responses to management conditions. For example, Butte Creek salmon have access to the Sutter Bypass floodplain in all water years, which has been suggested to be important salmon rearing habitat not consistently available for other salmon stocks. Outmigration survival estimates of the dominant Butte Creek spring-run population remains unknown. The NMFS-SWFSC proposes to leverage existing acoustic tagging infrastructure and partnerships to explicitly monitoring the survival and reach specific movement of wild Butte Creek spring-run Chinook salmon during their outmigration to the ocean.

This study is currently unfunded and estimated to cost approximately 130,000 to $160,000 per year for supplies and labor.

3. *Central Valley Salmonid Predation Studies*

CDFW has just closed a $1 million solicitation for proposals focused on research projects regarding predation on one or more fish species listed under the federal and/or California Endangered Species Acts. The geographic area of interest includes the Delta and the anadromous reaches of the Sacramento River and San Joaquin River watersheds. Results of the research will improve understanding of predator-prey relationships and be considered in adaptively managed efforts to reduce predation effects on populations of listed species and aid in their recovery.

Additionally, there is a need to clarify the relative impacts of various sources of mortality on salmon species such that management can be better informed for actions affecting water operations and for recovery planning. This need is made more urgent given current drought conditions where the causes of Central Valley salmonid mortality likely result from interactive effects of multiple variables such as habitat alterations, water diversion and introduced predatory fish species--all of which contribute to a varying degree either directly or indirectly, and in ways that will vary by location (*e.g.*, central Sacramento River vs south Delta). While large scale telemetry-based salmon survival studies enable the understanding of overall survival to the ocean and the identification of discrete regions where acoustic tags stop moving, they tend to provide limited information regarding the underlying causes of survival. An alternative approach is targeted predator research in those regions where mortality is believed to be high, in order to evaluate the degree to which predation is responsible for lost fish. These studies are complex multi-pronged approaches, many of which are being pioneered by the SWFSC through collaborative efforts including academia (University of California Santa Cruz, and University of Washington), federal (USFWS, USBR, USGS) and state agencies (DWR and CDFW). Recently the SWFSC has proposed a multi-year study to quantify the impacts of predation on special status species in the Delta, the first steps of which would employ a hydroacoustic calibration survey to validate and enhance tools currently used in a number of predation studies. This part of the larger study, to improve our understanding and survey the effects of predation on our listed species, is estimated to cost $455,000 for 2015.

4. *Central Valley Sturgeon Monitoring*

Implementation of a sturgeon monitoring program that would provide data for conservation actions and water operations is currently estimated to be $1.5 million for the first year with an annual cost of between $0.5 and $1.0 million. Utilizing fiscal year 2014-2015 drought funding ($540,000), CDFW is entering into a contractual agreement with UC researchers and NMFS-SWFSC to undertake the following monitoring and research tasks: capture, acoustically tag, and monitor the movements of juvenile sturgeon; measure environmental metrics of those areas with juvenile and adult sturgeon; estimate the number of adult green sturgeon within the Sacramento River during their spawning period of May and June; explain how physical characteristics of sturgeon riverine habitat explain occupancy; and add to the time series of the number of adults in the sDPS of green sturgeon, which will help to inform the current status of this imperiled population.

5. Central Valley Steelhead Monitoring

A Comprehensive Monitoring Plan for Steelhead in the California Central Valley (Eilers 2010) was developed to direct and consolidate monitoring efforts for steelhead in the Central Valley. The plan identifies the actions needed to fill knowledge gaps, and collect baseline information on population abundance and distribution using a statistically rigorous approach. Ultimately the goal of this monitoring plan is to provide the data necessary to assess the restoration and recovery of steelhead populations by determining the distribution, abundance, and population trends of these fish; however, due to the logistical complexity and financial restraints involved in implementing all the monitoring recommendations for the Sacramento River and San Joaquin River basins outlined in the comprehensive plan, a phased implementation plan was established: The *Implementation Plan for the Central Valley Steelhead (Oncorhynchus mykiss) Monitoring Program* (Fortier *et al*. 2014). This implementation plan is a science-based, detailed description of the procedures and methodologies for executing the monitoring programs described in the comprehensive plan. The implementation plan is focused on adult monitoring in the Sacramento River basin and includes detailed methodologies, equipment, labor, locations, and budgets. The plan outlines key monitoring elements to be implemented over a 3-year period. CDFW has secured fiscal year 2014-2015 drought funding (~$3.8 million) to implement the elements identified in Year 1, which include establishing the monitoring infrastructure and personnel costs for 2 years of monitoring (July 2015- June 2017).

6. PIT Tagging Feasibility Study

PIT tag technology has been used to monitor the migration behavior, timing, and survival of juvenile and adult salmonids throughout the western United States. In the Central Valley, coded-wire tags and acoustic technology have been used to help inform survival estimates however, the ability to obtain rigorous estimates across multiple years and a range of environmental conditions has been limited. PIT tag technology would be an instrumental addition to the salmonid assessments in the Central Valley, largely by providing performance metrics across the entire life cycle through unlimited detection life and minimized tag burden.

Traditionally, PIT tag receivers are limited in their detection range and, for that reason, have worked best when the tagged fish are forced to pass at close range, like at a fish ladder operated at a hydroelectric dam. An impediment to establishing a system-wide PIT tag receiver network in the Central Valley has been the lack of fish detection infrastructure (*i.e.*, hydroelectric dams). However, continued innovation in receiver design and application has increased flexibility for installation of detection sites. This increased detection ability has resulted in multiple applications at streams, rivers, estuaries, and hatcheries. From fiscal year 2014-2015 drought funding, CDFW has secured $800,000 to establish a PIT tag feasibility study in the Central Valley system. CDFW is collaborating with NMFS to develop a study that balances the detection efficiencies at various locations with the ability to answer ecological and management questions. The study could be aimed at gathering the following performance metrics: smolt-to-adult survival; route selection and survival of juveniles during seaward migration; return adult route selection and spawning locations. Identifying resources to continue this infrastructure development and bolster data collection for long-term PIT tag monitoring should be considered for WY 2015 and beyond.

7. *Additional Acoustic Tagging Studies*

In addition to the fish being released as part of studies previously identified, there will be a number of acoustically-tagged fish in the system during WY 2015 which could be used to provide opportunistic information about fish presence and movement. Because of this, it is critical to support the development and maintenance of the Core Array of acoustic receivers that is currently supported by CDFW through a Ecosystem Restoration Program grant. These studies are beginning to incorporate the use of recently developed real-time acoustic tag receivers which could augment other monitoring and help identify the (real-time) effects of operations and their influence on the timing and distribution of salmonids (and specifically winter-run) as they emigrate down the Sacramento River and into and through the Delta. For example, real-time monitoring stations established at the Knights Landing RST location, or within the DCC and Georgiana Slough could provide useful information regarding the sensitivity of existing monitoring infrastructure or be used to manage risk of entrainment. NMFS will coordinate with the IEP biotelemetry PWT to ascertain the availability of acoustic tag data, the ways it could be used, and how it might be disseminated to groups like DOSS. Table 4 identifies the additional acoustic tagging studies that will be implemented in WY 2015 from which additional tracking information may be gained.

Table 4: Anadromous fish acoustic tagging studies planned for Water Year 2015

Investigator(s)	Agency	Species	Run	Type	n	Tech	Release Date	Release Location
Arnold Ammann/ Jason Hassrick	NOAA / USBR	CS	WR	Hatchery[1]	375	JSATS	early Feb, 2015	Sacramento River at Caldwell Park
Arnold Ammann/ Jason Hassrick	NOAA / USBR	CS	WR	Natural-origin[2]	200	JSATS	Jan, 2015	Red Bluff diversion dam
Josh Israel /Jason Hassrick	USBR	CS	WR & LFR	Hatchery[1,3]	150 each	Vemco 180kHz	Jan-Feb 2015	Fremont Weir
Jeremy Notch/ Arnold Ammann	NOAA	CS	LFR	Natural-origin[2]	100	JSATS	Nov, 2014	Red Bluff diversion dam
Arnold Ammann/ Ryon Kurth	NOAA / DWR	CS	SR	Hatchery[4]	300	JSATS	April, 2015	Feather River, Gridley and Byods
Steve Zeug / Bob Null	Cramer /USFWS	CS	FR	Hatchery[3]	300	JSATS	April, 2015	Battle Creek, Coleman NFH
Jeremy Notch	NOAA	CS	SR	Natural-origin[5]	200	JSATS	April-May 2015	Battle Creek and Mill Creek RST
Josh Israel / Pat Brandes	USBR / USFWS	Sh	NA			Vemco 180kHZ	Feb–April, 2015	Durham Ferry, Lower San Joaquin River
Josh Israel / Pat Brandes	USBR / USFWS	CS	FR			Vemco 180kHZ	Mid-Late April 2015	Durham Ferry, Lower San Joaquin River
Zachary Jackson	USFWS	CS	FR & SR			Vemco 180kHZ	March-May 2015	
Brian Mulvey	USCOE	CS	FR & LFR		860	Vemco 180kHZ	Nov-Mar	

Robert Chase	USBR	GS	NA		15	Vemco	Summer/ early fall	GCID – Keswick Dam
Pete Klimley/ Gabriel Singer	UC Davis	CS	SR & FR	Hatchery	400	JSATS	April 2015	Tower Bridge

[1] Livingston Stone National Fish Hatchery
[2] Red Bluff Rotary Screw Trap
[3] Coleman National Fish Hatchery
[4] Feather River Fish Hatchery
[5] Battle Creek and Mill Creek RST

iii. Data Collection, Distribution, and Analyses

1. Increasing Data Accessibility

Data, especially data utilized for real-time operations and management decisions, should be centrally located and easily accessible to all who are interested. Efforts, such as the California Fish Tracking Consortium and the California Data Exchange Center should be coordinated to house (or provide links to) all data sources. Data currently downloaded onto websites could easily link to the hub, and those data that are currently disseminated via e-mail distribution lists should be input or linked to the internet data hub. An example of an internet data hub is the Columbia River Data Access in Real Time (DART), which provides data associated with the Federal Columbia River Power System. The average annual operation costs for the DART website and database are approximately $393,000 per year. An IEP workgroup will collaborate on defining a web location for data uploads, most likely using an existing web platform for 2015.

2. Data Analysis Capacity

As provided in section II.B.7, above, there are many past and ongoing acoustic tagging studies that would help inform management of the survival and the influence of the many stressors on the various life history stages of the listed anadromous salmonid species. However, as also noted, there are often delays, sometimes up to years, in the distribution of draft and final reports because of limited capacity to analyze the data. NMFS and CDFW recommend broadening this expertise so that additional experts and organizations are able to assist in analyzing the data and produce draft and final study reports in less time and without the unnecessary delays. To address the current data analysis need, an IEP workgroup will consider the scope and potential cost of quicker analysis of acoustic tag data. An estimate of the per-year cost associated with developing this expertise at the SWFSC is approximately $100,000 to $150,000.

C. Summary Budget Table

The following table provides a summary of the budget associated with the new studies, monitoring, and efforts provided above.

Table 5: Summary budget for Anadromous fish monitoring and research

Project	Year	Cost Estimate	Funding Status

Additional trawling and beach seining when DCC gates are open, additional multiple-haul sampling at Jersey Point and Prisoner's Point for salmonids	2015	985,150	Funded
Increased Knights Landing/Tisdale Rotary Screw Trap Monitoring	2015	150,000	Funded
Increase salvage monitoring frequency	2015	TBD	Under Consideration
Enhanced particle tracking modeling	2015	62,007	Agreement Pending
Emergency barriers additional monitoring	2015	TBD	Under Consideration
Winter run acoustic tag study (Sacramento River)	2015	163,000	Funded
	2016	346,007	Agreement Pending
Spring run acoustic tag study (Butte creek)	2015	158,335	Agreement Pending
	2016	136,325	Agreement Pending
Central Valley Salmonid Predation Studies	2015	TBD	Under Consideration
Central Valley sturgeon	2015	540,00	Funded
		247,857	Agreement Pending
	2016	275,241	Agreement Pending
Central Valley steelhead	2015	3,800,000	Funded
PIT tagging feasibility study	2015	800,000	Funded
Winter run redd temperature and DO monitoring	2015	500,000	Unfunded
Recalibrate RAFT model	2015	521,054	Agreement Pending
	2016	467,992	Agreement Pending
Increasing Data Accessibility	2015	TBD	Under Consideration
	2016	393,000	Under Consideration
Data Analysis Capacity	2015	129,645	Agreement Pending
	2016	129,645	Agreement Pending

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ATTACHMENT A

Water Year 2015 Early Warning Monitoring to Detect Delta Smelt Movement

Introduction

The current drought has highlighted that we need improvements in the array of information that is collected or developed to support management decisions pertaining to the effect of projected winter/spring water operations on the Delta Smelt population.

Last year, the Service implemented a pilot monitoring effort at Jersey Point to provide an "early warning" tool to assess smelt density changes at that location. The overall intent was for the monitoring to help the Service and others ascertain whether, during weather events and freshets, substantial numbers of Delta Smelt are moving, or being moved, into areas potentially subject to entrainment. An analysis of Water Year 2014 early warning sampling has been prepared in a report (Polansky et al., in review) that will be presented at the Delta Science Conference in October.

This year, we propose to extend the multiple-haul sampling approach developed in WY 2014 and apply improved methods to evaluate "early warning" data. Multiple-haul sampling to support "early warning" will be conducted at Jersey Point and Prisoner's Point. Jersey Point sampling will be supplemented by sampling at Prisoners Point to provide smelt density information at a point that is farther upstream and more proximal to a direct route to the export pumps. The basic objective of the "early warning" sampling this year is the same as last year: to pilot a new source of information that may help assess whether substantial movement of Delta Smelt occurs in response to transient hydrodynamic, turbidity, and/or weather conditions. Because the objective is early warning, we have chosen sites that are far enough from the export pumps to detect Delta Smelt movement toward the pumps before Smelt move into areas so close to the pumps that it becomes difficult for management action to reduce entrainment.

Beyond "early warning" sampling, we also propose to pilot more intensive sampling at some Spring Kodiak Trawl stations during the normal monthly surveys. The purpose of this auxiliary sampling will be to further test our expectation that more intensive sampling at stations where we have historically observed frequent "zero" catches will produce reliable density estimates at low local density. We expect the pilot survey information to be valuable in planning for an expansion of the "early warning" survey approach in WY 2016 to potentially include modifying the existing SKT survey to provide more accurate and precise distributional information in all areas, including areas of low local density. If we achieve significant improvements in distributional assessment, that information will assist the Service, water managers, and others in calibrating the level of smelt distributional entrainment risk associated with projected Old and Middle River flow.

Working conceptual model for Delta Smelt distributional entrainment risk prediction and its uncertainties, with notes on WY 2014 pilot sampling

Delta smelt are broadly associated with turbid (low transparency) fresh and low salinity waters during juvenile rearing through adult spawning. The spatial distribution of estuary waters that meet criteria describing Delta Smelt's most frequently occupied habitat expands following winter rain storms. During these events, Delta Smelt disperse from rearing to spawning areas (Grimaldo et al. 2009; Sommer et al. 2011; Murphy and Hamilton 2013). The details of these movements differ from year to year, i.e., they are not as complete or as lengthy as anadromous fish migrations, e.g., Chinook salmon. Some Delta Smelt may migrate fair distances upstream, but others only make local movements, and during periods of high Delta outflow, some individuals may even be dispersed downstream.

The DFW Spring Kodiak Trawl Survey (SKT) develops a monthly "snapshot" of the spatial distribution of the Delta Smelt population by sampling about 40 locations once each month. This system-wide "snapshot" plays a key role in evaluation of distributional risk to Delta Smelt. It is, however, clear from as-yet unpublished analyses of these data that Delta Smelt sometimes move, or are moved, quite a lot in between surveys (Ken Newman and Leo Polansky, pers. comm.), which means that the one-month time step between surveys may be too long to reliably inform water operations managers of substantial changes in Delta Smelt distribution that could affect the interpretation of their vulnerability to entrainment.

In addition, at the space and time scale of individual trawl samples, the distribution of Delta Smelt within the volume of a channel varies and this affects their instantaneous vulnerability, or availability, to sampling gear (Bennett et al. 2002; Feyrer et al. 2013). This means that the availability of Delta Smelt to the SKT may vary even within a monthly survey due to factors like tidal phase, weather conditions, and local resuspension of sediment. Understanding variation in Delta Smelt availability to this trawl gear is an ongoing challenge that may ultimately suggest changes to survey protocols to standardize the management of these issues.

In January 2014, most Delta Smelt were rearing at or downstream of the confluence of the Sacramento and San Joaquin Rivers, making it possible that at some point during the January-March period, most of those fish would move upstream in preparation for spawning. Based on past experience, some of those fish would move into the San Joaquin River system where they could face an elevated risk of entrainment. We deployed a special survey at Jersey Point as an 'early warning system' that could provide management with a heads-up that a large entrainment event could be imminent if storms and emergency export operations transported turbid water into the south Delta.

Jersey Point monitoring occurred from February 6 – April 10, 2014; sampling occurred almost daily and usually involved 15 net tows per day distributed across three trawl lanes in the San Joaquin River channel (Polansky et al. in review). While the expectation in advance of sampling was that there would be only a sporadic observation of smelt at Jersey Point, Delta Smelt were collected on nearly every sample date and densities were usually highest in the north channel lane where water depth was shallowest (2-4 m).

The constancy of overall (all lanes) density during periods between weather events was striking, and provided an informative contrast to the Spring Kodiak Trawl, which only registered adult Delta Smelt at Jersey Point in the March and May surveys. The enhanced early warning survey's consistent catch versus the standard SKT catch showed Delta Smelt were present when the standard SKT suggested they weren't, demonstrating that the enhanced sampling provided information that was not available through the standard SKT. The results were also consistent with expectations that "zero" catches in the standard SKT may not be zeros, but sub-threshold densities that could be important to evaluation of proportional entrainment risk.

The consistent, low-density occurrence of Delta Smelt at the site was interrupted by several high-amplitude, but short-lived spikes in density in association with localized storm fronts and rain events (Polansky et al. in review). We considered two explanations for the short-lived spikes in catch we observed: (1) fish migrated very rapidly past the sampling site in association with the storms, i.e., the high frequency sampling detected schools of fish moving past Jersey Point, or (2) fish were residing in the vicinity of Jersey Point and became transiently more catchable during storms. We cannot definitively discern between these two possibilities, but the latter seems more likely because of the steady low catch of Delta Smelt throughout the sampling period. We would have expected a migration to have periods of no catch followed by periods of fish presence, possibly followed thereafter by additional period(s) of no fish catch. The SKT never detected Delta Smelt upstream of Jersey Point during its monthly monitoring surveys and there was no salvage of adult Delta Smelt reported at either the SWP or CVP fish facilities. This provides some additional evidence that Delta Smelt may not have moved up the San Joaquin River much farther than Jersey Point where water transparencies were marginal throughout the sampling period. Based on extensive analysis of the Jersey Point data, the Spring Kodiak Trawl data, and the lack of Delta Smelt salvage, we do not think that Delta Smelt moved up the San Joaquin River last winter-spring much beyond Jersey Point.

As a result of this experience, we believe the multiple-haul sampling strategy is a successful one for point-monitoring of Delta Smelt at low density. We also learned that transient changes in apparent density are likely to occur during weather events, especially during rain, or at lower light levels, and that these effects may be very pronounced. The “background” density of Delta Smelt did not substantially change over time, nor was adult salvage observed, suggesting that the observed transient spikes most likely did not represent a sustained movement of fish into the interior Delta. As such, our strategy for developing “early warning” indicators remains focused on persistent changes in local density at monitored sites. The experience also highlights the importance of carefully reviewing the standard methods used in the long-term monitoring surveys, to be sure that data are collected in a fashion that properly accounts for the strong environmental effects that storms and other events may cause.

Rationale for proposed work in WY 2015, and preview of plan for WY 2016

1. Multiple-haul sampling at Jersey Point and Prisoner’s Point. Further pilot monitoring at Jersey Point and Prisoner’s Point in WY 2015 will allow us to refine the intensive multiple-haul sampling approach begun last year, and will provide real-time information regarding potential movement of Delta Smelt into the Central and South Delta. Details are provided below. That information will supplement assessment of entrainment risk for Delta Smelt, and may help water managers identify opportunities to exercise flexibility in operations that would not be available without the real-time data.

Both of these locations are in the lower San Joaquin River downstream of Old and Middle River. These sites were selected in favor of Old and Middle River sites because they are far enough from the pumps to give a warning far enough in advance of the fish reaching the pumps that effective action can be taken; also, in the event action is needed, an action that has a lower impact on project operations can be employed than what might be required if fish are detected only when they are well into Old or Middle River. Locations south of Franks Tract are close enough to the pumps that fish may be within a few days of arriving at the pumps. Moreover, detection of a wave of fishes in the Old and Middle River can be expected to indicate that additional, unobserved fish have moved into the lower San Joaquin River and other areas just downstream of the detection location, and are also in danger of entrainment.

2. Pilot multiple-haul sampling as part of the Spring Kodiak Trawl Survey. Our strategic "early warning" monitoring goal is to develop a monitoring and assessment approach that will help predict important entrainment risks. More precise entrainment risk information should help managers maximize project water deliveries while avoiding excessive entrainment of Delta Smelt. While multiple-haul sampling at Jersey Point and Prisoner's Point serve the limited objective of detecting movement of Delta Smelt toward the export pumps, understanding the full import of a density change at those sites requires knowing the proportion of the population that is in, or moving into, Central and South Delta areas vulnerable to entrainment. A doubling of smelt density in the Central Delta might represent a change from 1% to 2% of the population, or it might represent a change from 5% to 10% of the population that has entered areas potentially vulnerable to entrainment.

Understanding the scale of fish movement requires additional sampling to understand geographical distribution. As our "early warning" monitoring showed in 2014, the SKT has a relatively high detection threshold relative to what can be achieved by multiple-haul sampling. We therefore propose to work with DFW to explore opportunities to conduct pilot multiple-haul sampling at a small number of geographically dispersed SKT stations during WY 2015 to establish that the approach we have tested at Jersey Point has the same desirable reliability properties at low density when applied elsewhere. The specific details of this sampling are not provided in the present proposal, as they depend on the logistic capabilities of the SKT field crews and will need to be worked out empirically. However, we would like to target enhanced sampling at up to four stations per month, with not more than one special sampling event per day of the survey. If this "auxiliary" sampling works well, we intend to propose enhancements to the SKT in WY 2016 that will enable us to use data from that survey to more precisely scale the population-level risks of entrainment.

3. DFW Spring Kodiak Trawl Survey Initial Survey in December. The current protocol for the SKT calls for an initial monthly survey in January. Conducting the first survey in December will allow a side-by-side comparison to the Fall Midwater Trawl and provide an early distributional map based a gear with a lower detection threshold than the FMWT provides.

Study objective and study questions

Objective 1: detect *persistent changes in density* in the Lower San Joaquin River that might signal dispersal or transport of smelt from areas where entrainment risk is lower into areas where entrainment is higher. This information would provide the Service and water operations managers with an early warning that Delta Smelt are dispersing into the San Joaquin River from which they may disperse further into the southern Delta. The information would also become available to the Smelt Working Group as part of the group's risk assessment process. The information can be available on a daily or weekly (rather than monthly) basis, and the methodology substantially reduces the density detection limit (Polansky et al. in review). These features are unique among sources of distributional information that are presently available.

Objective 2: test the multiple-haul sampling approach at least one SKT station in the Northeast Delta/Cache Slough complex, one station in the lower Sacramento River, one station in the South Delta (preferably Station 902), and one station in Suisun Marsh. Careful deployment of multi-haul sampling at a variety of sites will provide crucial information on the reliability of the method, best approaches to implementing variable sampling intensity, and assessing the logistics of multiple-haul sampling in the context of the SKT Survey. These facts will inform future consideration of monitoring enhancements that might be appropriate to enable the SKT Survey to support proportional Delta Smelt entrainment assessment and projection.

Objective 3: conduct the DFW SKT in December. The normal practice has been to conduct the first SKT survey in January.

Methods

1. Multiple-haul sampling at Jersey Point and Prisoner's Point. Table 1 summarizes the proposed approach.

Table 1. Summary of proposed daily sampling protocol.

Sampling location	Sampling gear	Tows/day	Sampling focus	Lateral sampling
San Joaquin River at Jersey Point (station 809)	Kodiak Trawl	15-20	Basic approach the same as WY 2014. Focus effort on daytime flood tides, but sample other parts of tidal cycle as time allows; split the south channel and center channel effort between surface and sub-surface trawls (the north lane is too shallow to do sub-surface trawls)	Basic approach the same as WY 2014. Sample multiple trawl lanes according to the Chipps Island protocol (i.e., laterally across the channel)
San Joaquin River at Prisoner's Point (station 815)	Kodiak Trawl	15-20	THIS SITE WOULD BE ESPECIALLY IMPORTANT IF A SIGNIFICANT ENTRAINMENT CONCERN EMERGES; Focus effort on daytime flood tides, but sample other parts of tidal cycle as time allows; split the south channel and center channel effort between surface and sub-surface trawls (the north lane is too shallow to do sub-surface trawls)	Sample multiple trawl lanes according to the Chipps Island protocol (i.e., laterally across the channel)

The intensity of multiple-haul sampling at Jersey Point and Prisoner's Point will depend on the likelihood that a redistribution of smelt is about to occur, or is occurring. We propose an initial three-day sampling event at each site in the first week of December, and then weekly baseline sampling (one day at each site) that should occur until approximately April 1st, regardless of conditions. Following that event, sampling can be reduced to one day per week at each site, on consecutive days at the same tidal phase, until rain or other relevant environmental event is forecast. Depending on circumstances, it may be appropriate to sample at a higher frequency than this minimum, even absent a significant weather event.

In the event storms are imminently forecast or other events indicate heightened risk: If FMWT or December-January SKT sampling indicate that a large majority of Delta Smelt are distributed at or downstream of the Sacramento-San Joaquin river confluence, then we propose switching multiple-haul sampling to daily frequency until circumstances indicate the event is over. As we observed last winter, weather events can substantially increase local apparent density, so it is critical to our approach that we will be sampling before storms begin and continue intensive sampling well after storms (and associated significant freshets) subside, so that a before-after density comparison can be made. The Stockton FWO has the boats, nets, and personnel to conduct kodiak trawl sampling at one location per day, so the sampling would alternate between the two sites unless circumstances indicate that this approach should be departed from.

2. Multiple-haul sampling during the DFW Spring Kodiak Trawl Survey. Our intent is to work with DFW to explore opportunities to conduct episodic multiple-haul sampling at a few locations used by the SKT Survey. Since the specific details strongly depend on the logistic capabilities of the crews and other details, they will need to be developed collaboratively with DFW. We expect to propose no more than one multiple-haul sampling episode per day, and no more than four events in any one monthly survey.

3. Spring Kodiak Trawl Survey to begin in December. We propose that the first survey of the DFW Spring Kodiak Trawl Survey be conducted in early December. This will provide early distributional information using a gear that is more efficient at capturing Delta Smelt than the FMWT, while also providing a chance to compare SKT and FMWT maps.

Analytical Methods

1. Multiple-haul sampling at Jersey Point and Prisoner's Point. Since the monitoring is designed to inform real-time management, the primary products will include: (1) catch data including measurements of all ESA-listed fishes, (2) updated time series, including graphic display of Delta Smelt density at Jersey Point and Prisoner's Point, and (3) a statistical analysis of recent density changes. The basic "early warning" analysis will involve a longitudinal comparison of the data series at each site to determine whether substantial, sustained changes in density occur. During last year's initial pilot investigation, we considered a change of at least a doubling lasting for five or more days after the end of a storm event represented the minimum criteria for a substantial, sustained change. We propose to use these criteria as a starting point this year, while allowing the possibility that ongoing study will reveal other, more appropriate criteria for management.

Products of this investigation will be reviewed in conjunction with other information, including distributional information from regular trawl series, to evaluate any potential changes in distributional entrainment risk. We will also the very helpful turbidity modeling products produced by the Metropolitan Water District's engineers and their collaborators.   These products will be provided to the Delta Conditions Team and the Smelt Working Group, which will use them in accordance with the judgment of group members.

2. Multiple-haul sampling during the Spring Kodiak Trawl Survey. We wish to determine whether the result of employing this sampling approach is consistent with our experience and Jersey Point in WY 2014, and to collect basic data on the impact of implementing the approach as part of the SKT Survey. As such, we expect to examine catch data and time required to implement 3 and 6 trawl haul point sampling events involving 1-3 lateral lanes. These results are not expected to be useful for "early warning" evaluations during WY 2015.

3. Spring Kodiak Trawl Survey in December. These data are expected to inform evaluation of distributional risk by the Service, water managers, the Delta Conditions Team, and the Smelt Working Group. No special treatment of these data is proposed.

Estimated Budget:
The following budget reflects funds needed for sampling and sample processing. The bio-day rate includes all staff time, fringe, equipment, and supplies.

Project title: 2015 Smelt Movement

Bio-Day Rate (includes overhead): **$950**

Task 1: Kodiak trawl near Jersey Point and Prisoner's Point (pre-storm)

Gear/Personnel	# of Crew	Day rate	Cost/day	Days/month	Cost/month	Month	Month/year	Total
SKT (2 techs., 2 boat ops.)	4	$950	$3,800	6	$22,800	Nov. or Dec.	1	$22,800
Data Entry and Lab (1 tech.)	1	$950	$950	2	$1,900	Nov. or Dec.	1	$1,900
							Sub total:	**$24,700**

Task 2: Kodiak trawl near Jersey Point and Prisoner's Point (storm)

Gear/Personnel	# of Crew	Day rate	Cost/day	Days/month	Cost/month	Month	Month/year	Total
SKT (2 techs., 2 boat ops.)	4	$950	$3,800	25	$95,000	Jan.–April	4	$380,000
Data Entry and Lab (1 tech.)	1	$950	$950	6	$5,700	Jan.–April	4	$22,800
							Sub total:	**$402,800**
							Total:	**$427,500**

Estimated Take:

Table 2. Expected lethal take of Delta Smelt and longfin smelt for this project. All anadromous fish take is expected to be non-lethal, as denoted by an asterisk.

Fish Species	Estimated Take
Delta Smelt	500
Longfin Smelt	10
Winter run Chinook salmon	75*
Spring run Chinook salmon	50*
Steelhead	10*
Green Sturgeon	0

ATTACHMENT B

Water Quality Monitoring Sites and Constituents

Table 1. Central Delta monitoring sites and constituents (proposed stations and parameters in bold/italics)

Station Name	Continuous Data (15-minute data)	Discrete data (every other week)	CA Data Exchange Center (CDEC ID)
Three Mile Slough at San Joaquin River	Flow, stage, water velocity, water temperature, specific conductance, turbidity, and ***dissolved oxygen***	***Chlorophyll, nutrients, bromide, organic carbon***	TSL
False River	Flow, stage, water velocity, water temperature, specific conductance, turbidity, chlorophyll, and ***dissolved oxygen***	***Chlorophyll, nutrients, bromide, organic carbon***	FAL
San Joaquin River at Jersey Point	Flow, stage, water velocity, water temperature, specific conductance, turbidity, and ***dissolved oxygen***	***Chlorophyll, nutrients, bromide, organic carbon***	SJJ
Dutch Slough at Jersey Island	Flow, stage, water velocity, water temperature, specific conductance, turbidity, and ***dissolved oxygen***	***Chlorophyll, nutrients, bromide, organic carbon***	DSJ
Bethel Island near Piper Slough	Water temperature, specific conductance, ***turbidity, and dissolved oxygen***	***Chlorophyll, nutrients, bromide, organic carbon***	BET
Old River at Franks Tract near Terminous	Flow, stage, water velocity, water temperature, specific conductance, turbidity, chlorophyll, and ***dissolved oxygen***	***Chlorophyll, nutrients, bromide, organic carbon***	OSJ
Holland Cut near Bethel Island	Flow, stage, water velocity, water temperature, specific conductance, turbidity, and ***dissolved oxygen***	***Chlorophyll, nutrients, bromide, organic carbon***	HOL
Franks Tract, mid tract	***Water temperature, specific conductance, turbidity, chlorophyll, pH, and dissolved oxygen***	***Chlorophyll, nutrients, bromide, organic carbon***	***Proposed Station – Data will be telemetered***
Fisherman's Cut	***Flow, stage, water velocity, water temperature, specific conductance, turbidity, and dissolved oxygen***	***Chlorophyll, nutrients, bromide, organic carbon***	***Proposed Station – Data will be telemetered***

Table 2. North Delta – Monitoring sites and constituents (proposed stations and parameters in bold/italics)

Station Name	**Continuous (15-minute data)**	**Discrete data (every other week)**	**CA Data Exchange Center (CDEC ID)**
Sacramento River at Hood	Water temperature, specific conductance, turbidity, chlorophyll, pH, and dissolved oxygen	***Chlorophyll, nutrients, bromide, organic carbon***	SRH
Sutter Slough at Courtland	Flow, stage, water velocity***, water temperature, specific conductance, turbidity, and dissolved oxygen***	***Chlorophyll, nutrients, bromide, organic carbon***	SUT
Steamboat Slough	Flow, stage, water velocity***, water temperature, specific conductance, turbidity, and dissolved oxygen***	***Chlorophyll, nutrients, bromide, organic carbon***	SSS
Miner Slough at HWY 84	Flow, stage, water velocity, water temperature, specific conductance, turbidity, and ***dissolved oxygen***	***Chlorophyll, nutrients, bromide, organic carbon***	HWB
Liberty Island	Flow, stage, water velocity, water temperature, specific conductance, turbidity, and ***dissolved oxygen***	***Chlorophyll, nutrients, bromide, organic carbon***	LIB
Cache Slough at Ryer Island	Flow, stage, water velocity, water temperature, specific conductance, turbidity, chlorophyll, and ***dissolved oxygen***	***Chlorophyll, nutrients, bromide, organic carbon***	RYI
Steamboat Slough below Sutter Slough	Water temperature, specific conductance, ***turbidity, and dissolved oxygen***	***Chlorophyll, nutrients, bromide, organic carbon***	***Telemetry equipment will be added***
Sutter Slough – Downstream of the Barrier	***Stage, water temperature, specific conductance, turbidity, and dissolved oxygen***	***Chlorophyll, nutrients, bromide, organic carbon***	***Proposed Station – Data will be telemetered***
Steamboat Slough – Upstream of the Barrier	***Stage, water temperature, specific conductance, turbidity, and dissolved oxygen***	***Chlorophyll, nutrients, bromide, organic carbon***	***Proposed Station – Data will be telemetered***

ATTACHMENT C

Supplemental Monitoring and Quantitative Approaches for Improving the Assessment of Delta Smelt Abundance and Distribution
(Working Draft – 9/22/14)

Abstract

The following studies and analyses are intended to supplement and improve current methods for estimating the abundance and distribution of Delta Smelt in the San Francisco Estuary. The study objectives described in this draft are designed to address concerns such as:

- Gear Selectivity - Evaluate gear selectivity and characterize the limitations of existing surveys.
- Integration of catch data - Compare and integrate catch data from multiple gears.
- Vertical and Lateral Distribution - Assess factors affecting fish distribution in the water column and channel.
- Bias and Detection - Evaluate under-sampled habitats, random stations and increased effort.
- Genetics - Develop a genetics monitoring plan for population trends and dynamics.

Results from objective one and two are intended to help inform adjustments to monitoring that may be needed to improve our ability to better understand the abundance and distribution of the Delta Smelt population. Similarly, the complimentary studies proposed in objective three include random sampling, increased effort (repeat surveys), and sampling additional habitats that could be important for Delta Smelt but are not surveyed or may be inadequately surveyed. Finally, the genetics monitoring described in objective four is intended to provide complimentary information to the field studies, including population trends and measurements of genetic diversity that indicate the adaptive potential of the wild Delta Smelt population.

Purpose

The IEP currently conducts several monitoring programs that are used to estimate the relative abundance and distribution of the Delta Smelt population in the San Francisco Estuary. The study concepts proposed here are intended to complement the currently implemented methods primarily by quantifying gear selectivity. Therefore, these proposed studies are expected to enable for the first time, quantitative comparisons of Delta Smelt density across the current surveys. The field study concepts articulated in this proposal are coupled to a commitment to intensive data analysis and the development and implementation of appropriate changes to monitoring methods that can better inform management decisions and conservation measures. Ultimately, the proposed studies and data analyses are intended to improve our ability to estimate the abundance and distribution of Delta Smelt in the San Francisco Estuary.

Background

Many of the IEP surveys were designed and initiated several decades ago with the intent of catching juvenile Striped Bass and Chinook Salmon, but some of these have frequent incidental captures of Delta Smelt (e.g., Fall Midwater Trawl, Summer Tow-net Survey, Chipps Island Trawl, Fish salvage facilities). In addition, the IEP has existing surveys that were explicitly designed to monitor the relative abundance and distribution of Delta Smelt (e.g., 20mm and Spring Kodiak Trawl). As a result of the IEP's intensive monitoring, Delta Smelt are collected every month of the year at nearly all life stages (except eggs) throughout much of the spatial territory that they are likely to occupy. These surveys provide much of the data that informs our decisions and our evaluations of the effectiveness of management actions. However, some stakeholders have expressed concerns over both known and potential biases that may affect the interpretation of monitoring data. The Service is proposing a suite of studies to (a) increase the objective evaluation of existing data sets, and (b) guide potential changes to IEP's Delta Smelt monitoring programs. Below are concepts for special studies and other investigations we have identified as important for more accurately and precisely estimating the relative abundance and distribution of Delta Smelt, for the ongoing development of the USFWS life cycle model, and for future biological opinions and the BDFWO monitoring survey review (Laca et al. effort). Increases in sampling effort are anticipated to result in an increase in Delta Smelt take. Therefore, study implementation will likely be phased to strike a balance between the generation of new information and higher incidental take. All budget estimates provided are approximate total costs. Yearly funding needs will depend on development of specific study plans and the phased implementation during the proposed 3–5 year study period.

Goal

Improve understanding of Delta Smelt abundance and distribution.

Objectives

The proposed concepts listed below address the following objectives:

1. Quantify factors affecting the relative gear selectivity for IEP surveys that provide abundance and distribution data for Delta Smelt. Important correlates include ontogenetic stage (size and growth), net dimensions, deployment methods, and environmental variables such as turbidity, temperature, flow, and tide.
2. Determine the vertical and lateral distribution of pelagic life stages of Delta Smelt over a range of potential environmental drivers, including tidal effects.
3. As appropriate, develop potential adjustments to current monitoring strategies to account for findings in #1 and #2 above, as well as other recent studies in this area, in order to support more efficient protective measures for Delta Smelt. This objective includes development of reliable population size estimation, and any adjustments that might be needed to ongoing monitoring to reduce sources of bias and ensure appropriate spatial and temporal coverage.
4. Provide insight into population trends, changes in effective population size, geographic and annual changes in population dynamics and genetic diversity loss that may reduce the adaptive potential of the wild Delta Smelt population. This is intended to improve our understanding of the Delta Smelt population by complementing the field data and modeling analyses.

Methods

A concern about the current fish monitoring programs, particularly as they apply to Delta Smelt, is how representative the sample catches are of the entire Delta Smelt population and how one might use sample catch data to make inferences about the entire population. For example, the sample average density of Delta Smelt in the January 2004 Spring Kodiak Trawl survey (based on 39 samples) was 0.001453 Delta Smelt per cubic meter. Is that density an unbiased estimate of the average Delta Smelt density in the total water volume inhabited by or occupied by Delta Smelt and how could that sample density be used to estimate the number of Delta Smelt?

The answers to these questions are a function of several factors which can be split into two categories, those involving Delta Smelt and those involving the particular fishing gear. To make inferences about the total Delta Smelt population, we need to know the total volume of water occupied by Delta Smelt, and we would like to know something about the variation in Delta Smelt densities laterally and vertically in the water occupied. In statistical parlance we need to bound the sample frame, in other words, to specify the areal extent and the depths occupied by Delta Smelt. For example for the Delta Smelt Life Cycle Model (DSLCM), we have specified the areal extent to be from western San Pablo Bay eastward across Suisun Bay and Marsh, up the Sacramento River a few miles south of the city of Sacramento, and across the south and central Delta and along the San Joaquin River to Mossdale. The depth occupied has not been specified, but 4m is a tentative value. The density of Delta Smelt varies laterally and vertically (and by time of year and life stage) and this has an effect on interpretation of catches made by fishing gear.

How fishing gear is deployed and its ability to catch a fish available to the gear, i.e., fish that are present in the water swept by the gear, affect the quality of the sample fish density values, i.e., number of fish per unit volume of water sampled. The ability to catch fish that are available to the gear is called ``contact selectivity’’ and mathematical models take fish size, e.g., length, as input and produce estimates of the probability of capture to quantify contact selectivity. Of equal importance is the nature of the volume of water sampled. If Delta Smelt densities were homogenous laterally and vertically, then any volume sampled would yield an unbiased estimate. On the other hand, if any volume of water could be randomly sampled, at any depth and at any lateral location in the specified Delta Smelt habitat, then an average density taken from a collection of samples would yield an unbiased estimate of density. However, the Delta Smelt density is highly heterogeneous, and the volume of water that can be sampled, or is typically sampled, is not a completely random volume, i.e., gear deployment is necessarily constrained to sample particular volumes. For example, Kodiak trawl gear used in the Spring Kodiak Trawl survey samples the top portion of the water column; e.g., the volume sampled is a 10m wide swath of the top 3m extending 100m in length (imagine a 10 x 100 x 3 cuboid). The gear used by the 20mm Survey makes an oblique tow; imagine a cylinder with diameter 3m and length 100m oriented at a diagonal from 10m depth to the surface.

Objectives 1, 2, and 3 below pertain to the above factors. Objective 1 focuses on making between gear comparisons in contact selectivity and fitting mathematical models for different gear types. Such comparisons and model fitting are complicated by questions about variation in fish densities and Objective 2 is directed at gaining understanding about heterogeneity in density. Objective 3 looks at sample selection bias and sample precision issues. Selection bias is systematic exclusion of portions of the sample frame; a simple example of selection bias in a study of the heights of a population of adult humans would be to only sample females. In particular, one component of Objective 3 examines the spatial extent of Delta Smelt habitat (the problem of bounding the sample frame) and another investigates how representative the spatially-fixed (not randomly chosen) sample locations are of the specified Delta Smelt habitat. A third part of Objective 3 focuses on the precision question by examining the effect of increasing survey effort (sample size).

Gear Selectivity Studies (Objective 1)

Gear selectivity evaluations are needed to integrate catch data from multiple surveys to estimate abundance and ultimately to model population dynamics for Delta Smelt and other species of management concern. Data from simultaneous, adjacent deployment of IEP survey gears during the tidal cycle will permit the estimation of selection curves relating the relative capture probability of Delta Smelt of a given size across gears. The selection curves will be modeled statistically following Millar and Fryer (1999). The sampling design and analytical approaches for the single location and multiple gear evaluations (described below) was approved by IEP in 2012. Sampling efforts in the fall (juvenile to sub-adult) and spring (larvae to juveniles) were successful and data collection and model development are ongoing.

Multiple Gears (Single Location, Task 1.1): Field sampling will be repeated seasonally to collect information for different Delta Smelt life stages and to estimate selectivity for different IEP fish monitoring gears (Table 1). Each field sampling effort will use the gear types currently targeting the particular life stage present and those gear types that target earlier and later life stages. The goal will be to seasonally sample as Delta Smelt transition from being effectively sampled by one gear (or set of gears) to another gear (or another set) to capture how relative selectivity changes with fish size (and ontogeny). For each gear and tow, we will identify and measure all fishes to the nearest mm fork length for juveniles through mature adults. Larvae will be identified and measured in the lab to the nearest 0.1 mm total length. Within each sampling period, proposed monthly effort will entail two days of field work. Sampling will stop when take is exceeded or if sufficient data are obtained for robust modeling.

Gear deployment will follow the protocols used by the respective agencies, except that tow durations will be 10 min (see Honey et al. 2004 for survey and gear descriptions). During each field day, we will deploy gears with the following frequency by tide: 6 flood tows, 6 ebb tow and 1-2 tows on each slack water (14 replicate tows per day). Field work will be planned for daylight hours over a three-day period (sampling on days 1 and 3) when flood and ebb tides occur primarily during daylight hours. Data will be checked, processed and evaluated for sufficiency prior to further sampling.

Table 1. Target Delta Smelt life stages and the gears, time period, and sampling effort proposed to determine relative efficiencies of standard fish monitoring survey gears. Note: TNS = Summer Townet Survey, FMWT = Fall Midwater Trawl, OT = Bay Study Otter Trawl, SKT = Spring Kodiak Trawl, CMWT = Chipps Island Midwater Trawl, SLS = Smelt Larva Survey, 20mm = 20mm Survey.

Life stage(s)	**Gears deployed**	**Months sampled**	**Sampling effort**
Juvenile to Sub-Adult	TNS, FMWT, OT, SKT, CMWT, Beach seine	August through October	2 days / month
Pre-Spawning Adults	FMWT, SKT, OT, CMWT, Beach seine	December through January	2 days / month
Spawning Adults	FMWT, SKT, OT, CMWT, Beach seine	March through April	2 days / month
Larvae to Juveniles	SLS, 20mm, TNS, Beach seine	April through June	2 days / month

We will select sampling locations based on relatively high local densities of Delta Smelt detected during routine fish monitoring. The most likely sampling range for juveniles to sub-adults will be in the lower Sacramento River between Chipps Island and Decker Island; sampling for spawning adults and larvae and juveniles may take place in the Sacramento Deep Water Ship Channel; however, the channel width may be insufficient to simultaneously deploy all gears targeting adults. Depending on the number of gears, GPS coordinates for 3–5 trawl lanes will be established and provided to boat operators. For each tow, vessels towing each gear type will be randomly assigned to a trawl lane. Following IEP protocols, we will deploy beach seines in the vicinity of the trawl lanes if suitable shallow habitat is available during the juvenile through adult periods (Table 1).

<u>Shadow Trawling (Spring Kodiak Trawl and Fall Midwater Trawl at Multiple Locations, Task 1.2):</u> In January and February 2015 when surveys 1 and 2 of the Spring Kodiak Trawl (SKT) Survey occur, the midwater trawl gear used in the Fall Midwater Trawl (FMWT) Survey will be co-deployed with the Kodiak trawl gear at a subset of the SKT Survey's 40 sample locations (stations). A stratified random sampling procedure will be used to select the subset where strata are defined in terms of expected Delta Smelt densities, with higher density strata being sampled more intensively than low density strata. The relationship between the catch numbers and catch lengths for these spatially-temporally paired data will be analyzed and algorithms will be constructed for calibrating midwater trawl catches to roughly equate to what corresponding Kodiak trawl catches were. The algorithms will possibly be functions of environmental conditions and/or spatial locations.

The primary objective of the co-deployment is to be able to calibrate historical Spring Midwater Trawl data collected during the months of January, February, and/or March and the years 1968-1974, 1977-1979, 1991-2001 to estimate hypothetical Kodiak trawl catches for the same time periods. The Kodiak trawl replaced the midwater trawl in January 2002 but no side-by-side evaluations took place. The nature of the relationship between Delta Smelt catches made by Kodiak trawl and midwater trawl gear when Delta Smelt lengths average 62mm, 64mm, and 66mm during January through March, respectively, is unknown as is how the relationship might vary as a function of environmental conditions. Such a calibration of historical Spring Midwater Trawl catches would ease interpretation of the time series of Delta Smelt catches for the winter months since 1968 and provide additional information for fitting the Delta Smelt Life Cycle Model.

Vertical and Lateral Distribution Studies (Objective 2)

Understanding how environmental variables influence the vertical and lateral distribution of Delta Smelt is critical to ensure that samples from IEP surveys are comparable and representative of the Delta Smelt population. In addition, IEP surveys sample the water column and channel habitats in different ways and provide a depth-integrated (for oblique tows) and time-integrated (tow duration) snapshot of catch. Although a separate gear selectivity evaluation element of this greater effort will provide some insight into the vertical and lateral distributions of Delta Smelt, availability (presence) and avoidance (present but not captured) are confounded and difficult to separate in the study design. In contrast, SmeltCam technology replaces the cod-end of towed gears with video cameras and thus provides instantaneous depth- and channel-specific catch data with reduced lethal take.

A working conceptual model that Delta Smelt are not randomly distributed in the water column can be ascertained from previous studies (Bennett et al. 2002; Feyrer et al. 2013; Bennett and Burau, unpublished). However, those studies focused on larval, pre-adult and adult Delta Smelt and application across other size ranges of fish, gear types and seasons requires further evaluation. The proposed work is needed to establish the effectiveness of the SmeltCam under various conditions for different life stages of Delta Smelt, and to better understand the vertical and lateral distribution of Delta Smelt.

The overall goals of this element (Task 2.1) include determining the factors influencing the vertical and lateral distribution of Delta Smelt, and the continued evaluation and application of SmeltCam technology for studies of Delta Smelt and other fishes. Specific objectives include the following: (1) quantifying key aspects of Delta Smelt vertical and lateral distribution for juvenile (sampling gear = townet), pre-adult (sampling gear = midwater trawl) and adult (sampling gear = Kodiak trawl) life stages in freshwater and low salinity zone habitats, (2) evaluations of the suitability of SmeltCam technology for the same life stages and sampling gears, and (3) determining the identification accuracy of SmeltCam, including developing robust identification protocols with QA/QC procedures. The collection of studies in this element represent a collaborative effort among IEP agencies, Sureworks LLC, and MWD/SFCWA. Field sampling will be accomplished with vessels and crews from CDFW, USFWS, and USBR. SmeltCam operations and image processing will be done by Sureworks LLC. Data analysis and reporting will be a collaborative effort that is led by USGS. The results of this work will be published in at least one journal manuscript and presented at one or more conferences/workshops.

The first year of the overall project is organized around a group of nine related studies collectively designed to examine the vertical and lateral distribution of juvenile, pre-adult, and adult Delta Smelt in freshwater and low salinity zone habitats while also evaluating the utility of the SmeltCam (Table 2). Note that there are two completed studies (Feyrer et al. 2013 and the 2014 USFWS early warning sampling) which represent two of the nine studies that will collectively address the overall objective and are in gray text in the table. The remaining seven studies will be conducted between approximately September 2014 and August 2015, and are listed in chronological order in the table. As noted in the table, some of studies will include a gear efficiency element where a closed codend will be attached to the back of the SmeltCam and fish observed by the SmeltCam will be compared to those collected in the closed cod end. Sampling for the gear efficiency element will be conducted in areas where Delta Smelt and other special status fish species are not expected to occur in attempt to avoid take.

Table 2. Status and description of SmeltCam studies.

Study	Life Stage	Net	Year	Month	Habitat	Vertical distribution	Lateral distribution	SmeltCam gear efficiency	Notes
completed	Sub adult	midwater trawl	2012	November	FW	X	X		Feyrer et al. (2013)
completed	Adult	kodiak trawl	2014	February-April	FW		X		2014 USFWS early warning sampling
SA1 (sub-adult 1)	Sub adult	midwater trawl	2014	September	FW	X		X	Thermal stratification
SA2 (sub-adult 2)	Sub adult	midwater trawl	2014	November	FW	X		X	Abiotic/biotic habitat drivers
SA3 (sub-adult-3)	Sub adult	midwater trawl	2014	December	LSZ	X	X		
A1 (adult 1)	Adult	kodiak trawl	2015	January	LSZ		X		
A2 (adult 2)	Adult	kodiak trawl	2015	February	FW		X	X	
J1 (juvenile 1)	Juvenile	townet	2015	July	FW	X	X	X	
J2 (juvenile 2)	Juvenile	townet	2015	August	LSZ	X	X	X	

This work will also include an effort to standardize the level of confidence and accuracy of fish identifications generated by the SmeltCam. Automated species identification by the SmeltCam is presently achieved through a support vector machine (SVM). Training the SVM algorithm to identify fish species is an ongoing exercise and involves using positively identified images and metadata. While the algorithm works relatively well, it is continually being improved. Hence for these studies, each image obtained during sampling will be reviewed by humans to ensure accurate species identification. Previous work (Feyrer et al. 2013) provided a relatively subjective human-assigned level of confidence for each species identification. This study will improve upon Feyrer et al. (2013) by establishing a specific protocol for species identifications made by human reviewers, including oversight from expert staff routinely engaged in fish identification during IEP surveys.

For planning the second year of implementation, timing, techniques and methods will be guided by and based upon the analysis and synthesis of data collected in year one of the study. For example, technological advancements are anticipated in 2015 and the seven studies (SA1–J2) may be repeated between approximately September 2015 and August 2016. Though we anticipate further and continued use of the SmeltCam technology, actual recommendations will be determined in the fall of 2015.

<u>Develop Appropriate Adjustments to Monitoring Programs (Objective 3)</u>

New information developed by us and others may indicate that current monitoring efforts could be improved. Objectives #1 and #2 are intended to explore whether existing sampling gears and strategies are still appropriate to address management information needs for Delta Smelt. After quantifying the monitoring shortcomings, translating those findings into improved monitoring protocols will require careful assessment of the specific issues that need to be addressed, modeling and testing of potential solutions, and implementation of study design modifications. This work will also require careful assessment of the data needs of the Delta Smelt life cycle modeling efforts that are underway, especially the Newman et al. effort. Close collaboration with life cycle modelers will help ensure that any monitoring adjustments that are developed are crafted to reduce prediction error and in other ways improve the usefulness of the life cycle models. The financial support summarized in Task 3.1 in the attached budget is intended to provide a strong and direct link between the monitoring investigations described in this proposal and the ongoing life cycle modeling. The following sampling elements describe some of the issues that may be investigated.

<u>Random Sampling (FMWT, Task 3.2):</u> The 100-plus locations (stations) that the Fall Midwater Trawl Survey samples four times each fall (once per month from September through December) were not randomly selected locations on a map (nor are the oblique tow volumes sampled at each location completely sampling of the water "column" at each location—but that issue is not addressed here). To determine whether or not there is any selection bias in terms of the areal locations chosen, coincident

with the time that samples are taken by the FMWT survey, midwater trawls tows will also be made at a random sample of locations and differences in the resulting catch sample densities of Delta Smelt will be made. Stratified random samples will be taken, strata being months and spatial regions. Sample sizes will vary between strata with sample allocation possibly being proportional to predicted densities and/or total Delta Smelt abundance in the region, i.e., dense regions get more samples than sparse regions. Depending on the selection bias results of the FMWT, random sampling may be conducted for other gears targeting Delta Smelt (not represented in the budget).

Increased Survey Effort (Task 3.3): Infrequent sampling and sparse data may also result in increased variability and reduced precision. Catch data are often highly variable and patchy in space and time and repeated sampling is critical for obtaining a representative sample of the population. Currently, the FMWT and SKT are conducted monthly over an eight- and five-day sampling period, respectively. Doubling these efforts to sampling twice per month will, if appropriate, be attempted from December through May targeting regions of high importance to Delta Smelt and regions with high uncertainty of catch data. The additional sampling may be conducted at the long-term fixed sites or by stratified random sampling depending on preliminary results. Adjusting sampling regimes or gears to reduce detection limits may also be important, and will be considered in this work.

Spatial Coverage (Task 3.4): Geographically appropriate sampling is important for making inferences regarding habitat use, overall abundance, and population dynamics. Bias may result if regions or habitat types that could be important for Delta Smelt are not surveyed or are inadequately surveyed. Currently, IEP surveys have limited coverage in several regions, including the Cache Slough Complex and the Sacramento Deep Water Ship Channel. Increasing the frequency of the USFWS beach seine (year round) and larval trawl survey (February through July) at Liberty Island, as appropriate, will facilitate the parameterization of Delta Smelt occupancy models. Sampling other shallow-water habitats in the Cache Slough Complex may require the deployment of alternative gears if depths are not sufficient for surface trawling. In addition, more sites are needed in the Sacramento Deep Water Ship Channel to improve spatial resolution of the IEP surveys for all life stages of Delta Smelt.

Genetic Monitoring of the Delta Smelt Wild Population (Objective 5)

Genetic monitoring of the threatened Delta Smelt population is crucial for developing effective conservation and recovery actions. Simply gaining an accurate census size for a cryptic species such as the Delta Smelt is difficult without concerted targeted efforts. Despite targeted efforts, accurate and precise abundance estimates are very difficult at low population sizes. Genetic monitoring can provide insight into population trends and reveal both geographic and annual changes in population dynamics that cannot be gained from field sampling alone. In addition, long-term genetic monitoring can detect genetic diversity loss that may reduce the adaptive potential of the Delta Smelt population indicating that a captive population may be critical. Fisch et al. (2011) conducted a genetic assessment of the wild Delta Smelt population to assess temporal and geographic structure, genetic bottlenecks, and effective population size (N_e). They found both significant declines in N_e and evidence of genetic bottlenecks in addition to weak geographic structure, and suggested continued genetic monitoring of the species.

The Genomic Variation Lab (GVL) of UC Davis has developed the tools for both genetic monitoring of the wild population and the genetic management of the captive Delta Smelt population since 2006 (Lindberg et al. 2013, Fisch et al. 2009, 2011, 2013). Initially we used 12-16 microsatellite loci, but current technology provides more powerful, efficient, and high throughput genetic data with single nucleotide polymorphism (SNP) markers. Another advantage of SNPs is that they are standardized across platforms, and therefore repeatable, making temporal comparisons more feasible than with microsatellites. The GVL has identified thousands of Delta Smelt SNP markers using the RADseq method (Lew et al. unpublished data), and developed a panel of 96 SNPs specifically designed for assessing population structure and diversity. This panel can be used on our EP1™ System (Fluidigm Corporation) for fast, high-throughput monitoring. While fewer SNPs can be used, Morin et al. (2009) suggests a minimum of 80 SNPs is needed for sufficient statistical power to examine genetic structure and diversity.

This study (Task 5.1) would build upon the work of Fisch et al. (2011) to develop and design a yearly monitoring program to consistently monitor genetic diversity trends and N_e of Delta Smelt and provide information to managers for the conservation of this species. Results and analysis from each year will be cumulative and compiled into an annual report for managers.

Attachment C – Budget

Project title: Delta smelt monitoring											
Bio-Day Rate:		$950									

Objective 1 (Gear Selectivity Studies)

Task 1.1: Continue side-by-side fishing gear comparison studies

Gear/Personnel	# of Crew	Days per shift	Day Rate	Cost per shift	Shift per month[1]	Cost per month	Months sampled	Month per year	Project Cost	Funding needed 2015	2016
CMWT (2 techs., 1 boat op.)	3	1.5	$950	$4,275	2	$8,550	Aug.–Oct., Dec.–Jan., Mar.–Apr.	7	$59,850		
FMWT (2 techs., 1 boat op.)	3	1.5	$950	$4,275	2	$8,550	Aug.–Oct., Dec.–Jan., Mar.–Apr.	7	$59,850		
OT (3 techs., 1 boat op.)	4	1.5	$950	$5,700	2	$11,400	Aug.–Oct., Dec.–Jan., Mar.–Apr.	7	$79,800		
SKT (2 techs., 2 boat ops.)	4	1.5	$950	$5,700	2	$11,400	Aug.–Oct., Dec.–Jan., Mar.–Apr.	7	$79,800		
SLS (2 techs., 1 boat op.)	3	1.5	$950	$4,275	2	$8,550	Apr.–Jun.	3	$25,650		
TNS (2 techs., 1 boat op.)	3	1.5	$950	$4,275	2	$8,550	Apr.–Jun.	3	$25,650		
20mm (2 techs., 1 boat op.)	3	1.5	$950	$4,275	2	$8,550	Apr.–Jun.	3	$25,650		
Beach Seine (2 techs.)	2	1.5	$950	$2,850	2	$5,700	Aug.–Oct., Dec.–Jan., Mar.–Apr., Apr.–Jun.	10	$57,000		
Data Entry and Lab (4 techs.)	4	1	$950	$3,800	2	$7,600	Aug.–Oct., Dec.–Jan., Mar.–Apr., Apr.–Jun.	10	$76,000		
								Sub total[2]:	$489,250	$0	$0

[1]Assumes 2 sites (or repeat sampling at 1 site) and 1 siter per day = 2 x 12-hr shifts

[2]Funding secured

Task 1.2: Co-deployment of SKT and FMWT during both surveys (shadow trawling)

Gear/Personnel	# of Crew	Days per shift	Day Rate	Cost per shift	Shift per month[1]	Cost per month	Months sampled	Month per year	Project Cost	Funding needed 2015	2016
FMWT (2 techs., 1 boat op.)	3	1	$950	$2,850	4	$11,400	Jan.–Feb.	2	$22,800		
SKT (2 techs., 2 boat ops.)	4	1	$950	$3,800	4	$15,200	Jan.–Feb.	2	$30,400		
Data Entry and Lab (2 tech.)	2	1	$950	$1,900	4	$7,600	Jan.–Feb.	2	$15,200		
Data Analysis (Statistician)	NA	NA	NA	NA	NA	NA	NA	NA	$25,000		
Data Analysis (Modeler)	NA	NA	NA	NA	NA	NA	NA	NA	$25,000		
								Sub total:	$118,400	$118,400	$0

[1]Assumes 40 sites (10 sites per region) and 10 sites per day = 4 x 8-hr shifts

Objective 2 (Vertical and Lateral Distribution Studies)

Task 2.1: Continue SmeltCam studies

Gear/Personnel	# of Crew	Days per shift	Day Rate	Cost per shift	Shift per month[1]	Cost per month	Months sampled	Month per year	Project Cost[3]	Funding needed 2015	2016
FMWT/TNS (2 techs., 1 boat op.)	3	1	$950	$2,850	5	$14,250	Sep., Nov., Dec., Jan., Feb., Jul.–Aug.	7	$199,500	$99,750	$99,750
USGS labor, travel, supplies	NA	NA	NA	NA	NA	NA	NA	NA	$629,688	$314,844	$314,844
Sureworks LLC labor, travel[2]	NA	NA	NA	NA	NA	NA	NA	NA	$370,000	$0	$185,000
								Sub total:	$1,199,188	$414,594	$599,594

[1]Assumes 5-day sampling period = 5 x 8-hr shift

[2]Funding secured in 2015 (MWD/SFCWA)

[3]Two-year study period (Sep. 2014–Aug. 2015; Sep. 2015–Aug. 2016)

Objective 3 (Develop Adjustments to Monitoring Programs)

Task 3.1: Development of monitoring strategies and support for life cycle model

Gear/Personnel	# of Crew	Days per shift	Day Rate	Cost per shift	Shift per month	Cost per month	Months sampled	Month per year	Project Cost[1]	Funding needed 2015	2016
Statistician/modelers	1	1	$935	$935	15	$14,025	NA	12	$336,600	$168,300	$168,300
Biologist	1	1	$935	$935	15	$14,025	NA	12	$336,600	$168,300	$168,300
Technical support	1	1	$935	$935	6	$5,610	NA	12	$134,640	$67,320	$67,320
								Sub total:	$807,840	$403,920	$403,920

[1]Task will be implemented in 2015 and 2016

Task 3.2: Conduct stratified random sampling during FMWT

Gear/Personnel	# of Crew	Days per shift	Day Rate	Cost per shift	Shift per month[1]	Cost per month	Months sampled	Month per year	Project Cost	Funding needed 2015	2016
FMWT (2 techs., 1 boat op.)	3	1	$950	$2,850	8	$22,800	Sept.–Dec.	4	$91,200		
Data Entry and Lab (1 tech.)	1	1	$950	$950	2	$1,900	Sept.–Dec.	4	$7,600		
Data Analysis (Statistician)	NA	NA	NA	NA	NA	NA	NA	NA	$25,000		
Data Analysis (Modeler)	NA	NA	NA	NA	NA	NA	NA	NA	$25,000		
								Sub total:	$148,800	$148,800	$0

[1]Assumes 80 sites (allocated by region) and 10 sites per day = 8 x 8-hr shifts

Task 3.3: Increase FMWT and SKT sampling frequency during late winter and early spring

Gear/Personnel	# of Crew	Days per shift[1]	Day Rate	Cost per shift	Shift per month[1]	Cost per month	Months sampled	Month per year	Project Cost	Funding needed 2015	2016
FMWT (2 techs., 1 boat op.)	3	1	$950	$2,850	3	$8,550	Dec.	1	$8,550		
SKT (2 techs., 2 boat ops.)	4	1	$950	$3,800	3	$11,400	Jan.–May	5	$57,000		
Data Entry and Lab (1 tech.)	1	1	$950	$950	3	$2,850	Dec.–May	6	$17,100		
Data Analysis (Statistician)	NA	NA	NA	NA	NA	NA	NA	NA	$25,000		
Data Analysis (Modeler)	NA	NA	NA	NA	NA	NA	NA	NA	$25,000		
								Sub total:	$132,650	$0	$132,650

[1]Assumes 30 sites (10 sites per region or strata) and 10 sites per day = 3 x 8-hr shift

Task 3.4: Survey potential Delta Smelt habitat under sampled by existing surveys

Gear/Personnel	# of Crew	Days per shift	Day Rate	Cost per shift	Shift per month[2]	Cost per month	Months sampled	Month per year	Project Cost	Funding needed 2015	2016
LVT[1] (2 techs., 1 boat op.)	3	1	$950	$2,850	6	$17,100	Apr.–Jun.	3	$51,300		
SKT (2 techs., 2 boat ops.)	4	1	$950	$3,800	6	$22,800	Aug.–Oct., Dec.–Jan., Mar.–Apr.	7	$159,600		
Data Entry and Lab (1 tech)	1	1	$950	$950	6	$5,700	Aug.–Oct., Dec.–Jan., Mar.–Apr., Apr.–Jun.	10	$57,000		
Data Analysis (Statistician)	NA	NA	NA	NA	NA	NA	NA	NA	$25,000		
Data Analysis (Modeler)	NA	NA	NA	NA	NA	NA	NA	NA	$25,000		
								Sub total:	$317,900	$0	$317,900

[1]Larval trawl from USFWS Liberty Island survey (suitable for shallow habitat)

[2]Assumes 6 regions (Cache Slough Complex, Sacramento Deep Water Ship Channel etc.) and 1 region per day = 6 x 8-hr shifts

Objective 4 (Genetics Monitoring)

Task 4.1: Develop yearly program to monitor genetic diversity and effective population size

Gear/Personnel	Year 1	Year 2							Project Cost	Funding needed 2015	2016
Project Scientist	$39,446	$19,723	.	.	.	.	.	.	$59,169		
Lab Technician	$13,999	$7,000	.	.	.	.	.	.	$20,999		
Materials (1200 samples)	$28,000	$14,000	.	.	.	.	.	.	$42,000		
Indirect Cost (17.5%)	$14,253	$7,127	.	.	.	.	.	.	$21,380		
								Sub total:	$143,547	$95,698	$47,849

		Funding needed 2015	2016
Grand total:**	$3,357,575	$1,181,412	$1,501,913

****Grand total indludes tasks that are funded (Task 1.1, side-by-side trawling) or partially funded (Task 2.1, SmeltCam/Sureworks). Therefore, yearly funding needed in 2015 and 2016 is less than total project costs.**