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

[Working Draft]

December 12, 2014

Contents

DRAFT

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.

DRAFT

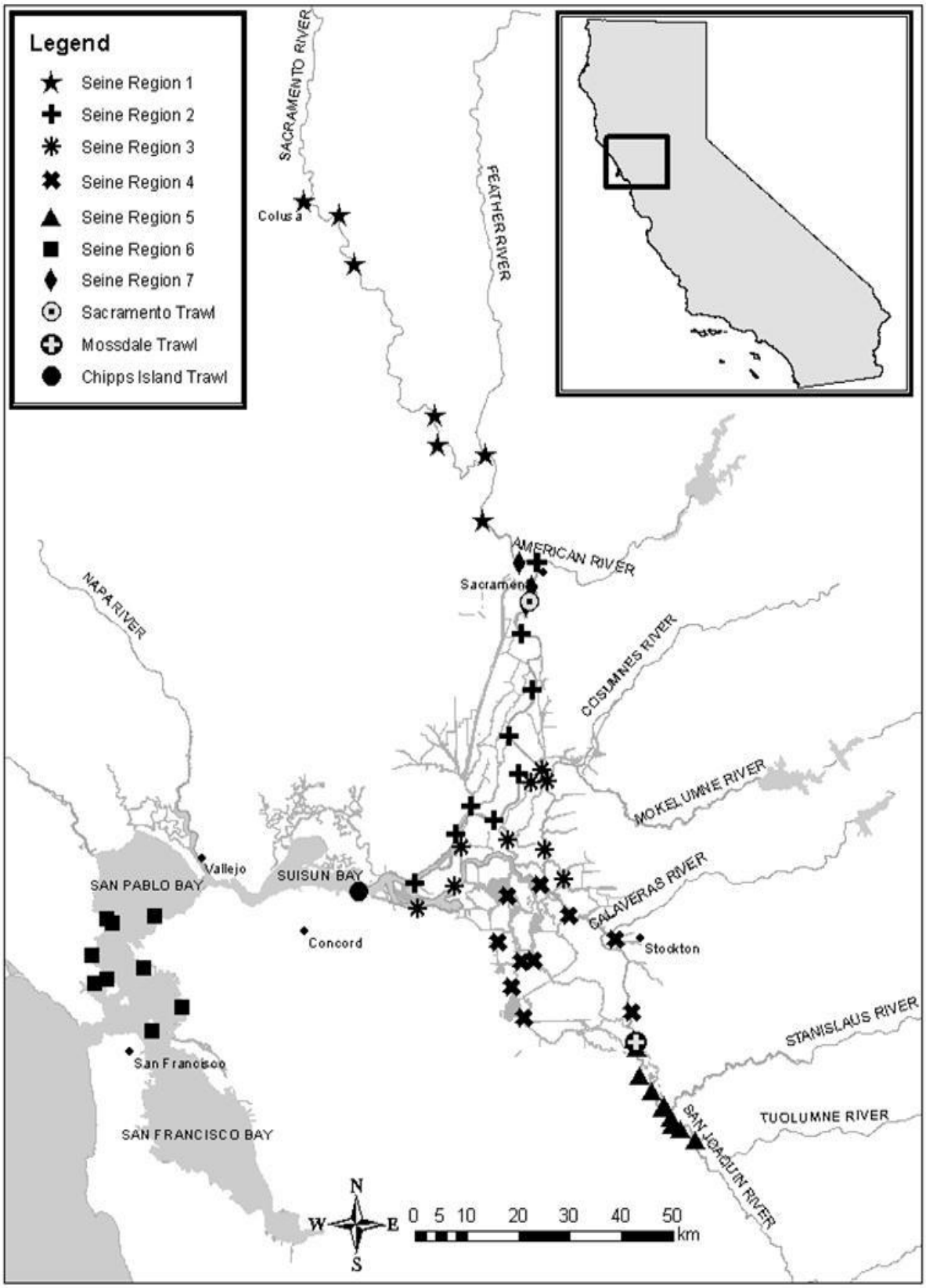
Legend
Seine Region 1
Seine Region 2
Seine Region 3
Seine Region 4
Seine Region 5
Seine Region 6
Seine Region 7
Sacramento Trawl
Mossdale Trawl
Chipps Island Trawl
SACRAMENTO RIVER
FEATHER RIVER
Colusa
AMERICAN RIVER
Sacramento
NAPA RIVER
COSUMNES RIVER
MOKELUMNE RIVER
CALAVERAS RIVER
Vallejo
SAN PABLO BAY
SUISUN BAY
Concord
Stockton
STANISLAUS RIVER
San Francisco
SAN FRANCISCO BAY
TUOLUMNE RIVER
SAN JOAQUIN RIVER
N
W
E
S
0 5 10 20 30 40 50
km

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.

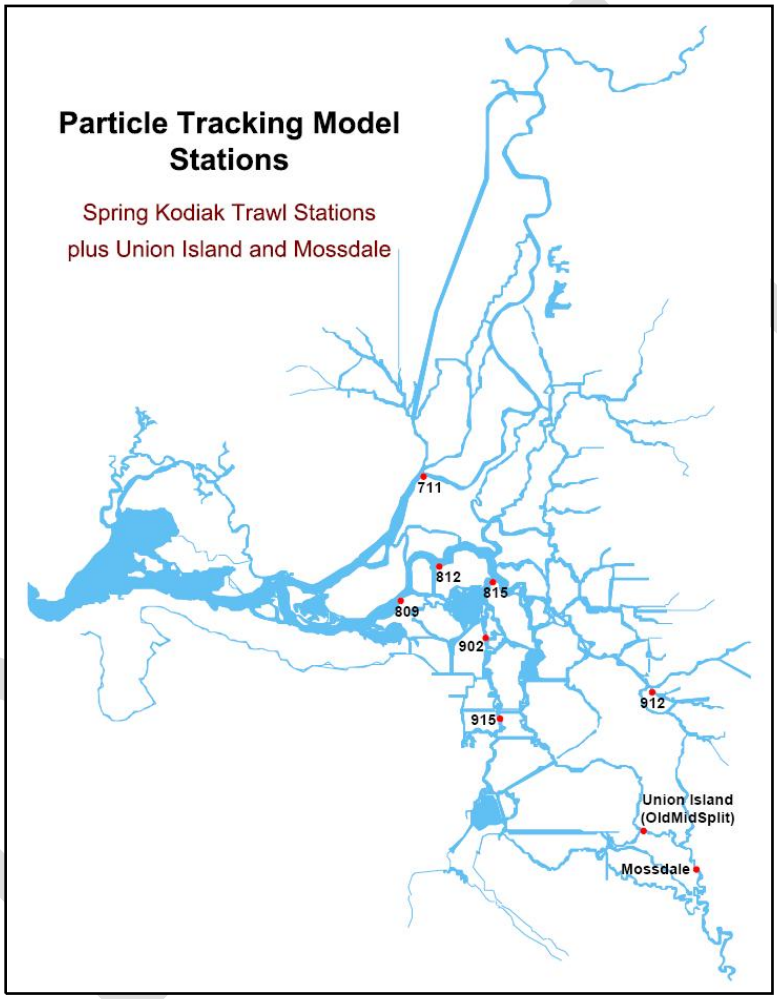

Figure 2: Location of new trawl locations in the San Joaquin River at Jersey Point (Station 809) and Prisoner's Point (Station 815).

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.

DRAFT

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

[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

DRAFT

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

DRAFT

DRAFT

V. REFERENCES CITED

Acuna, S., D.F. Deng, P. Lehman, S. Teh. 2012. Sublethal dietary effects of *Microcystis* on Sacramento splittail, *Pogonichthys macrolepidotus*. Aquatic Toxicology 110-111 (2012) 1-8.

Brown, L.R., D. Michniuk. 2007. Littoral Fish Assemblages of the Alien-dominated Sacramento – San Joaquin Delta, California, 1980 – 1983 and 2001 – 2003. Estuaries and Coasts 30: 186-200

Eilers, C., J. Bergman, R. Nielson. 2010. A Comprehensive Monitoring Plan for Steelhead in the California Central Valley. CA Department of Fish and Game, Fisheries Branch, Administrative Report Number: 2010-2

Fortier, R., J.D. Nelson, R.J. Bellmer, and R. Nielson. 2014. Implementation Plan For the Central Valley Steelhead Monitoring Program. California Department of Fish and Wildlife, Final Report July 2014, 131 pp.

Ger, K.A., S.J. Teh, C.R. Goldman. 2009a. Microcystin_LR toxicity on dominant copepods *eurytemora affinis* and *Pseudodiaptomous forbesi* of the upper San Francisco Estuary. Science of the Total Environment 407: 4852-4857.

Ger, K.A., S.J. Teh, D.V. Baxa, S. Lesmeister, C.R. Goldman. 2009b. The effects of dietary *Microcystis aeruginosa* and microcystin on the copepods of the upper San Francisco Estuary. Freshwater Biology.

Grimaldo, L.F., R.E. Miller, C.M. Peregrin, Z. Hymenson. 2012. Fish assemblages in reference and restored tidal freshwater marshes of the San Francisco estuary. San Francisco Estuary and Watershed Science.

Grimaldo, L.F., R.E. Miller, C.M. Peregrin, Z. Hymenson. 2004. Spatial and temporal distribution of ichthyoplankton in three habitat types of the Sacramento–San Joaquin Delta. In: Feyrer F., L.R. Brown, R.L. Brown, J.J. Orsi, editors. Early life history of fishes in the San Francisco Estuary and Watershed. p 81–96. Bethesda (MD): American Fisheries Society.

Lehman, P.W., G. Boyer, C. Hall, S. Waller, K. Gherts. 2005. Distribution and toxicity of a new colonial *Microcystis aerginosa* bloom in the San Francisco Bay Estuary, California. Hydrobiologia 541: 87-99.

Lehman, P.W., S.J. Teh, G. Boyer, M. Nobriga, E. Bass, C. Hogle. 2010. Initial impacts of *Microcystis* on the aquatic food web in the San Francisco Estuary. Hydrobiologia 637: 229-248.

Lehman, P. W., K. Marr, G. L. Boyer, S. Acuna, S. J. Teh. 2013. Long-term trends and causal factors associated with *Microcystis* abundance and toxicity in San Francisco Estuary and implications for climate change impacts. Hydrobiologia 718:141-158.

Nobriga, M.L., F. Feyrer, R.D. Baxter, and M. Chotkowski. 2005. Fish community ecology in an altered river delta: Spatial patterns in species composition, life history strategies and biomass. Estuaries 28:776-785.

Polansky, L., M. Nobriga, K. Newman, M. Dekar, K. Webb, and M. Chotkowski. In press. Delta Smelt movement during and extreme drought: intensive Kodiak trawling at Jersey Point. Summer 2014 Issue of the Interagency Ecological Program Newsletter. Available at: http://www.water.ca.gov/iep/products/newsletter.cfm.

Santos, M.J., L.W. Anderson, S.L. Ustin. 2011. Effects of invasive species on plant communities: an example using submersed aquatic plants at the regional scale. Biological Invasions 13: 443-457.

DRAFT