

NMFS 5 Principles for what we believe an Adaptive Management Program/Framework should include:

1. Defined process that includes the full AM cycle (“plan, assess, integrate, adapt”)
2. Means to incrementally reduce uncertainty
3. Transparency, defined roles and authorities, clear collaborative decision-making that incorporates CSAMP, IEP, and five agencies into the process.
4. Certainty of occurrence via commitments to funding, agreement, and buy-in
5. Clear distinction between real-time and seasonal adjustments versus annual adjustments and multi-year studies.

Appendix C Real-Time Water Operations Charter

C.1 PURPOSE

The “Core Water Operation” serves as the foundation for meeting the requirements of D-1641 and providing for Reclamation and DWR to operate the CVP and SWP while reducing the stressors on listed species influenced by the ongoing operation of the CVP and SWP. For the Core Water Operation, Reclamation would implement activities, monitor performance, and report on compliance with the commitments in the Proposed Action. Implementing the Core Water Operation will require coordination between CDFW, DWR, FWS, NMFS, and Reclamation (collectively, the “5 Agencies”) and stakeholders. This Charter describes how the 5 Agencies and stakeholders will plan, communicate, and coordinate real-time water operations decisions on the Core Water Operation for the ROC on LTO.

C.2 BACKGROUND

Investments in science, monitoring, and decision support tools since the 2008 and 2009 BiOps provides the ability to reduce reliance on professional opinion and increase the use qualitative and quantitative models to assess risk in real-time based on the real-time monitoring of species and relevant other physical and biological factors. While Reclamation and DWR hold the responsibility for operating the CVP and SWP, many agencies and organizations assist in monitoring field conditions to provide information that assists in real-time decisions. Communication on real-time conditions and the implementation of water operations provides assurance that Reclamation and DWR are meeting the commitments within the Proposed Action.

C.3 SCOPE

Portions of the Core Water Operation rely upon real-time monitoring to inform Reclamation and DWR on how to minimize and/or avoid stressors on listed species. The Proposed Action seeks to take advantage of the expertise within the federal and state fisheries agencies in the real-time monitoring of species distribution and life-stage and to use adaptive management as a systematic approach for making and informing operational decision and reducing uncertainty for water operations and species protections in a

way that reduces the need for reinitating ESA consultations. Reclamation and DWR would then use qualitative and quantitative tools to perform risk analyses that inform operations. Actions within the Core Operation to address stressors on listed species seasonally and in real-time include, for example, Old and Middle River Flow Management, Shasta Cold Water Pool Management, and Delta Cross Channel Gate Operations.

Some elements of the Core Water Operation provide for seasonal input by the federal and state regulatory agencies on the scheduling and routing of certain flow volumes to benefit fisheries. Actions include, for example, Stanislaus pulse flows, Suisun Marsh Salinity Control Gate operation for Delta Smelt fall habitat, and restoration of rearing habitat.

The Core Water Operation in the Proposed Action provides for regulatory coordination if real-time conditions exceed the ability to anticipate how Reclamation and DWR would operate (“Outliers”). Outliers include, for example, insufficient cold water pool in Shasta Reservoir to support a winter-run Chinook salmon year class and the need for conservation measures such as trap and haul and/or hatchery production.

Reclamation and DWR must demonstrate compliance with the commitments in the Proposed Action and provide sufficient information for an evaluation of reinitiation triggers through regular monitoring and reporting. New information and changing conditions may exceed a reinitiation trigger and could require subsequent consultation. Examples of for compliance include seasonal and annual reporting.

Program Teams will implement conservation measures. These Program Teams will include representatives from agencies and stakeholders.

C.4 TERM

The term of this Charter is the duration of the ROC on LTO Biological Opinion (2030).

C.5 DELIVERABLES

One or more groups under this Charter shall be responsible for the products on the schedule identified below. Exhibits A through XX to this Charter identify the requirements for each deliverable.

1. Monitoring Program for Core Water Operations, Ongoing
2. December - June, Weekly and Biweekly, Real-Time Species Distribution and Life Stage
3. Monthly (and as needed), Water Operation Status
4. Monthly (and/or as needed), Specific operations for:
 - a. Old and Middle Reverse Flow Storm Events (Dec. - June)
 - b. Shasta Cold Water Pool Management (May - Oct.)
 - c. Folsom Cold Water Pool Management (May - Oct.)
 - d. Delta Smelt Fall Habitat and Suisun Marsh Salinity Control Gates (May)
5. As Needed, Coordination on Outlier Years
6. Annually, As Needed, Habitat Restoration Updates

7. Seasonal and Annual Compliance Reporting
 - a. December, Shasta Cold Water Pool Management
 - b. June, Shasta Cold Water Pool Rebuilding and Spring Pulse
 - c. September, Annual Summary of Water Supply and Fish Operations

Reclamation and DWR will continue to provide standard reporting on real-time operations, environmental conditions, and biological parameters, such as species distribution, life stage, and dynamics. These data are available daily through Reclamation and DWR websites and additional tools such as CDEC, NWIS, RWIS, SacPAS, Bay-Delta Live, and SHOWR.

This Charter provides the monitoring and water operations information that will be available as part of the Core Operation. Additional monitoring or water operations information, beyond the scope of this Charter, may be required for tracking the status and trends of species and for efforts beyond operation of the CVP and SWP.

C.6 PARTICIPANTS

Decision Making Action Agencies: Reclamation and DWR

Coordinating Regulatory Agencies: USFWS, NMFS, CDFW, SWRCB, ACOE, DSC

Coordinating Stakeholders: Public Water Agencies

C.7 DECISION MAKING

Nothing in this Charter modifies the rights and responsibilities of the Participants. Decisions shall be made consistent with the authorizing legislation and the regulations and policies under the federal and state Endangered Species Acts, as appropriate.

Reclamation and DWR shall retain sole discretion for:

- Water Operations of the CVP and SWP, including Allocations, under Reclamation Law and the State Water Project, as appropriate
- Agency Appropriations (budget requests, fund alignment, contracting, etc.)
- Section 7 Action Agency and Applicant (consultation)
- Coordination and cooperation with PWAs as required by Contracts and Agreements

CDFW, FWS, and NMFS shall retain sole discretion for:

- Consultation under Section 7 of the federal ESA and California Fish and Game Code, as appropriate and the associated Incidental Take Statements/Permits
- Agency Appropriations

State Water Resources Control Board

- Enforcement as allowable under federal and state law.

Operating Entities other than CVP and SWP shall retain sole discretion for:

- Operation of Non-CVP and Non-SWP Diversion Facilities
- Contract and/or Agreement Terms
- WIIN Act Requirements

If Reclamation determines to modify the proposed action, Reclamation will evaluate changes to one or more elements of the proposed action based on the reinitiation triggers provided by 50 CFR 402.16. These triggers include:

- (a) If the amount or extent of taking specified in the incidental take statement is exceeded;
- (b) If new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered;
- (c) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion; or
- (d) If a new species is listed or critical habitat designated that may be affected by the identified action.

Consistent with 50 CFR 402.16, the FWS and/or NMFS may also reinitiate formal consultation. Reclamation will coordinate with DWR as the “Applicant”.

Reclamation will continue to coordinate with the Delta Stewardship Council and US Army Corps of Engineers as appropriate, including venues such as the Interagency Ecological Program. Other agencies that may be involved in monitoring include the US Geological Survey.

C.8 ORGANIZATION

The organization of water operations and related species recovery in the Central Valley spans a number of overlapping programs across federal, state, and local entities as well as the public. The Core Water Operation anticipates increasing levels of coordination under efforts such as Voluntary Agreements, the Adaptive Management Framework developed under California Water Fix, and the Delta Science Plan. The Core Water Operation does not rely upon any specific structure, but is designed to support the following functions:

- Adaptation:
- Integration:
- Implementation:

Figure C.8-1 shows the different functional needs.

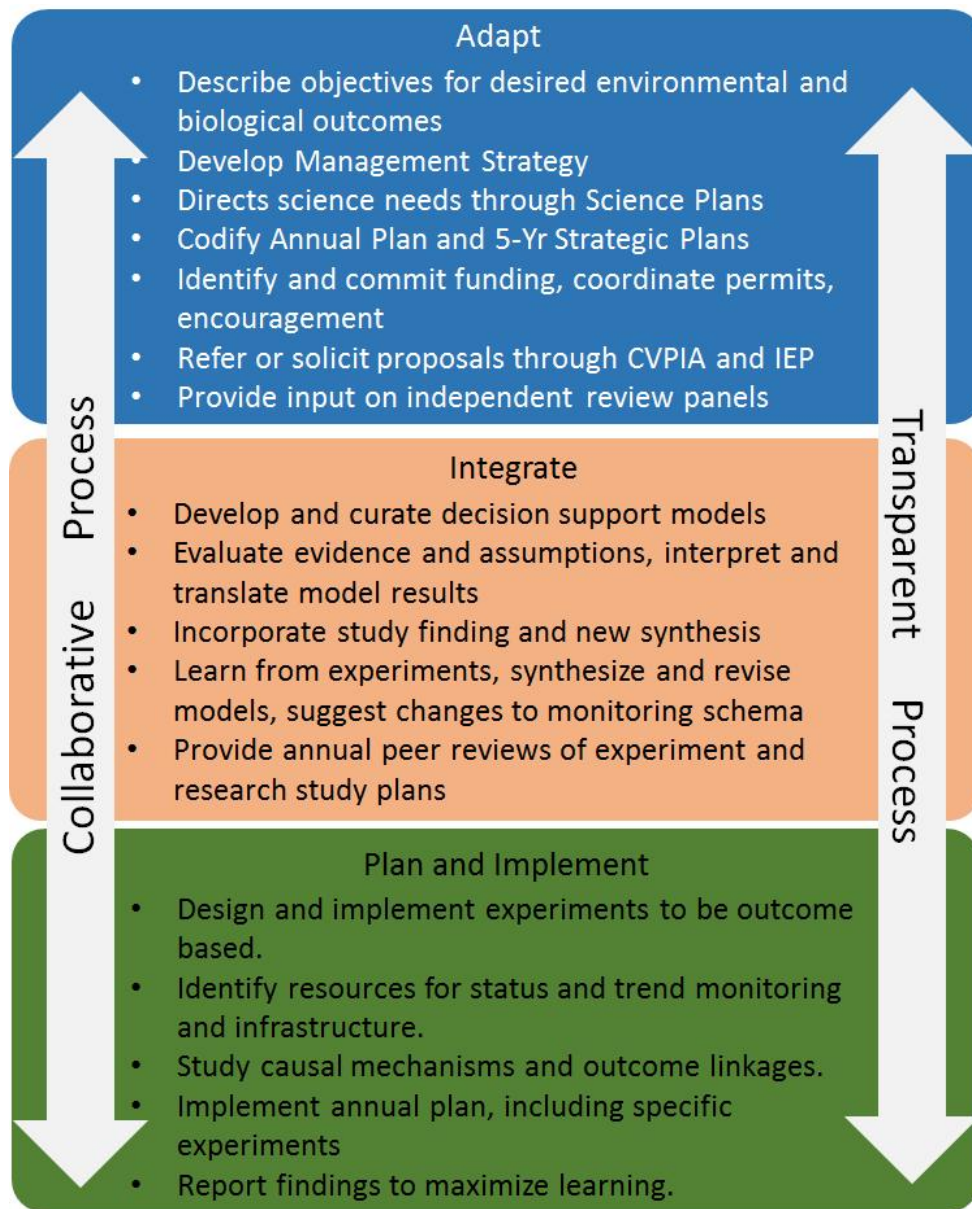


Figure C.8-1. Activities for the Implementation of Water Operations and Species Recovery

The major overarching forums where Reclamation coordinates with coordinating agencies and stakeholders include the Central Valley Project Improvement Act (focused primarily on tributary actions), Interagency Ecological Program (focused primarily on Delta actions), and the Collaborative Science and Adaptive Management Program. Each forum includes workgroups and teams for specific needs. Figure C.8-2 shows how the functions align with existing programs and activities and includes a role for Independent Review. The Core Water Operations maintains, modifies, and establishes specific workgroups and teams in consideration of existing programs and groups, but does not depend upon the existing programs and groups.

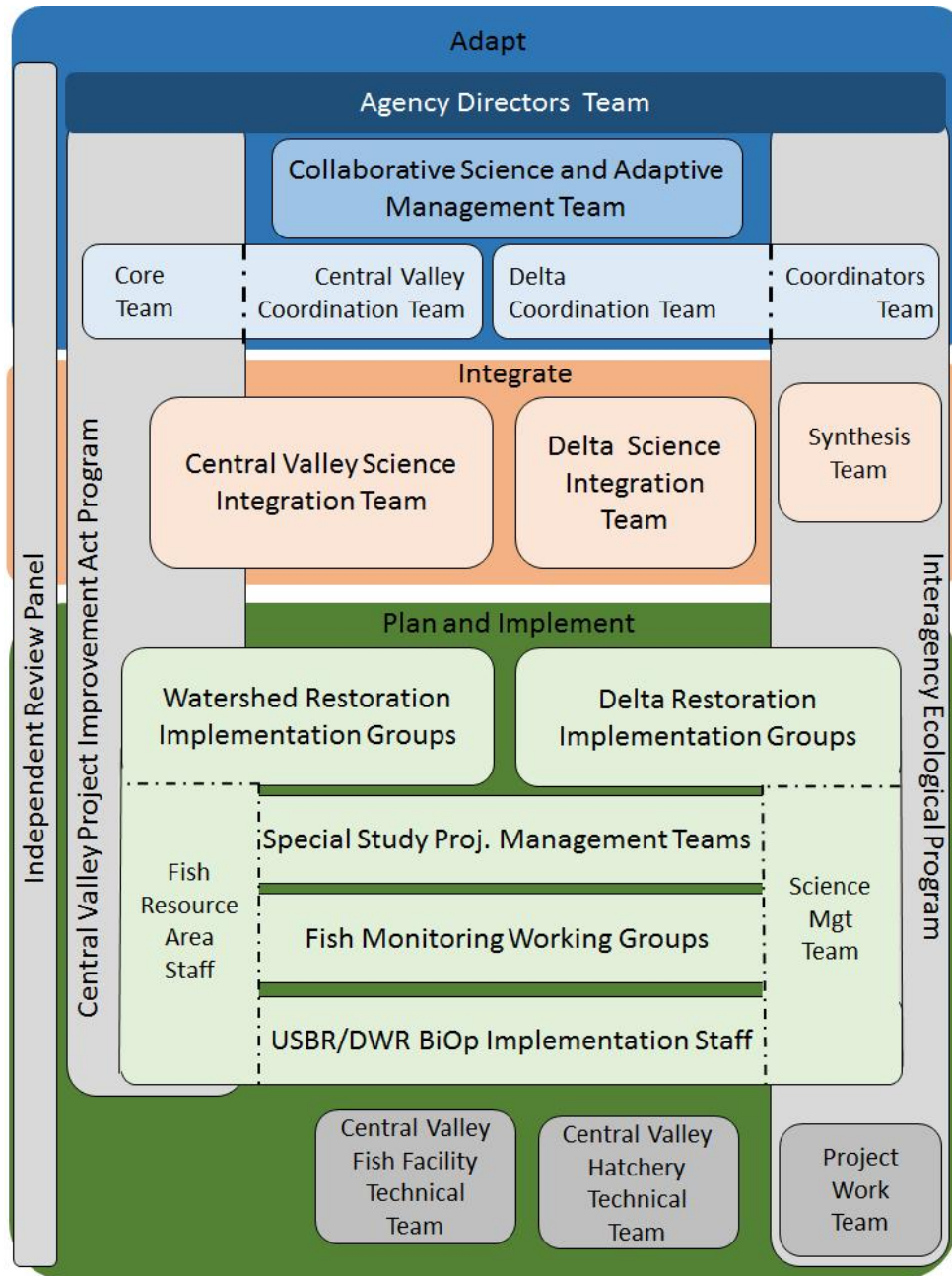


Figure C.8-2. Existing Programs and Groups within the Functions of Water Operations and Species Recovery

Consistent with the Proposed Action, Reclamation and DWR propose to convene Watershed Monitoring Workgroups for each of the Upper Sacramento, American, Delta, and Stanislaus watersheds (“Watershed Monitoring Workgroups”). Each of the Watershed Monitoring Workgroups will be responsible for real-time synthesis of fisheries monitoring information and providing recommendations on scheduling specific volumes of water as specified in the Proposed Action. The Delta Monitoring Workgroup shall be responsible for integrating species information across watersheds, including Delta Smelt and Winter-run Chinook, and other salmonids and sturgeon. In addition to Delta Watershed Monitoring Workgroup, the program may include a Smelt Monitoring and Salmonid Monitoring Teams. The Watershed Monitoring

Workgroups will include technical representatives from federal and state agencies and stakeholders and will provide information to Reclamation and DWR on species abundance, species distribution, life stage transitions, and relevant physical parameters.

A Water Operations Management Team (WOMT) comprised of agency managers will coordinate on overall water operations to oversee the implementation of various real-time provisions. The WOMT shall be responsible for overseeing the Watershed Monitoring Workgroups and elevating disagreements to the Directors of the 5 agencies where necessary.

- Directors
- WOMT
- Watershed Monitoring Workgroups
 - Sacramento River Temperature Task Group
 - American River Group
 - Stanislaus Operating Group
 - Delta Monitoring Workgroup
 - Smelt Monitoring Team
 - Salmon Monitoring Team
 - Program Teams

The WOMT shall coordinate the preparation of seasonal and annual reporting in coordination with the Watershed Monitoring Teams

C.9 PROCESS

The coordinated operation of the CVP requires the following functions for the Core Water Operation.

- Monitoring (Exhibit A)
 - Real-Time Physical and Biological Parameters (Species Distribution and Life-Stage)
 - Long-Term Proposed Action Performance Monitoring
- Water Operation Decisions
 - Projections based on Forecasts and Real-Time Reporting
 - Scheduling Recommendations for Specific Blocks of Water
 - Outlier Conditions and Coordination
- Seasonal Reporting
 - Fall Cold Water Pool Management and Winter- and Fall-run Redd Dewatering
 - Spring Pulse and Shasta Storage Rebuilding
- Annual Reporting and Evaluation of Reinitiation Triggers
- Targeted Consultation, if Required

In October, Reclamation will coordinate with Sacramento River Settlement Contractors (SRSCs) to lower peak diversions for rice decomposition by spreading diversions over a longer time period. Reclamation will and evaluate winter-run redd dewatering in the current year against the probability of sufficient cold water in the subsequent year based on end of September Shasta storage. Reclamation and DWR will also manage for fall Delta Smelt habitat. By the end of December, Reclamation will post a seasonal report on Shasta Cold Water Pool Management.

In December and/or January, the onset of Old and Middle River Reverse Flow Management begins depending on the real-time distribution of species. Reclamation and DWR will manage exports to limit entrainment and to take advantage of storm flows. Reclamation will post a risk analysis for each time Reclamation increases exports to capture peak storm flows. If conditions fall within the bounds of the Proposed Action, Reclamation and DWR will increase exports. If conditions exceed the criteria in the Proposed Action and Reclamation and DWR desire to increase exports, Reclamation and DWR will seek technical assistance from CDFW, FWS, and NMFS.

In February, consistent with contracts and agreements, Reclamation will create and post a projection of water operations using, at minimum, a 90% forecast to determine whether a Shasta-Critical year is in effect and make an initial allocation. The projection will include, at minimum, the likelihood of a spring pulse flow on the Sacramento River and the likelihood for each tier of Shasta cold water pool management based on potential storage levels. If the projection identifies a Tier 4 year, Reclamation will coordinate and seek technical assistance from NMFS and coordinate with CDFW and FWS. In each March, April, and May, Reclamation will update and post the projection.

Starting in April and no later than the end of May, depending upon when stratification of Shasta Reservoir occurs, Reclamation shall post a seasonal report on the refill of Shasta and prepare a Shasta Cold Water Pool Management Plan in coordination with the Sacramento River Temperature Task Group. The Shasta Cold Water Pool Management Plan will include the projected Shasta cold water pool management tier at the 90% confidence level. If the projection identifies a Tier 4 year, Reclamation will seek technical assistance from NMFS and coordinate with CDFW and FWS.

Starting in April, and no later than the end of May, depending upon stratification of Folsom Reservoir, Reclamation shall prepare a Folsom Cold Water Pool Management Plan in coordination with the American River Group. If the Folsom Cold Water Pool Management Plan is unable to meet a daily average water temperature of 65°F or lower at Watt Avenue Bridge from May 15 through October 31, Reclamation will use the ARG and elevate to WOMT.

In each month, through October, Reclamation will update and post the Shasta Cold Water Pool Management Plan.

In May, Reclamation and DWR shall coordinate a plan for the Operation of the Suisun Marsh Salinity Control Gates to create habitat for Delta Smelt and/or off-ramp flows if conditions do not warrant habitat for Delta Smelt.

By the end of September, Reclamation shall post an annual report that covers the prior fall/winter seasonal operation, spring operation, and summer conditions. The annual report will include a determination on whether there is new information on the effects of the Proposed Action or a desire to modified the Proposed Action that warrants targeted reinitiation on one or more components of the Proposed Action.

C.10 DISPUTE RESOLUTION

In the event of a dispute within any of the groups, the groups will elevate the dispute to the WOMT for resolution. In the event the WOMT cannot resolve the dispute, the WOMT will elevate to the Directors.

C.11 AMENDMENTS

Reclamation, in coordination with DWR, may amend this Charter at any time and will provide at minimum 2 weeks' notice. Amendments may trigger reinitiation of consultation consistent with 50 CFR 402.16.

C.12 DEPENDENCIES

The Proposed Action coordinates actions within the following forums that are beyond the sole control of Reclamation and DWR.

- CVPIA Fish Resource Area Programs - Monitoring, restoration, and special studies
- Interagency Ecological Program - Permitting and Coordination for Physical and Biological Monitoring
- Collaborative Science and Adaptive Management Program - Synthesis

In the event the above groups are unwilling or unable to provide for the commitments in the Proposed Action, Reclamation and DWR will confer with CDFW, FWS, and NMFS on alternative implementation paths.

C.13 SIGNATURES

[Need commitments by fish agencies if Reclamation and DWR are to rely upon CDFW, FWS, and NMFS for reporting, otherwise, Reclamation and DWR must establish the needed information from elsewhere]

Exhibit A - Monitoring Program for Core Operations

Monitoring Program for Core CVP and SWP Operation

This monitoring program for the Core Water Operation of the CVP and SWP identifies the information required for:

- Real-time water operations,
- Demonstrating compliance with Core Water Operation commitments in the Proposed Action, and
- Evaluating re-initiation triggers.

Additional monitoring to determine status and trends of species and understanding ecosystem interactions may occur through other processes, such as Voluntary Agreements and/or existing water quality permits, are listed, but are not explicitly relied upon for the Core of the Proposed Action. Reclamation and DWR may accomplish the monitoring through agreements with other agencies, partnerships with local water users, and/or contracts with private entities.

This Core Monitoring Program considers the information developed by the Salmon and Sturgeon Assessment of Indicators by Lifestage (SAIL) Program (Johnson et al. 2017) and the Enhanced Delta Smelt Monitoring (EDSM) Program (cite). This Core Monitoring Program focuses on the functions met by the different efforts and use the current technologies as examples that meet the functions. Additionally, the Core Monitoring provides support for the necessary studies to develop annual incidental take limits. Monitoring methodologies may change as technology advances or research supports better protocols.

Core Water Operations

Core water operations include Shasta and Folsom Cold Water Pool Management, Delta Cross Channel Gate Operations, Old and Middle River Reverse Flow Management, and Delta Smelt Fall Habitat.

Physical information for real-time operations includes:

- Delta Flow, Temperature, Turbidity, and Salinity Stations
- Tributary Flow and Temperature Stations
- Folsom Reservoir Temperature Profiles
- Shasta Reservoir Temperature Profiles

Biological information required for real-time operations includes:

- Chinook Salmon
 - Redd Timing and Location: Provides the spatial and temporal risk of mortality for the different flow and temperature regimes as well as the potential for dewatering. Currently accomplished through weekly visual surveys that identify new redds by reach.

- Carcass Surveys: Supplements the redd surveys to account for unobserved redds to help assess the significance of individual redds. Currently accomplished by field crews per well established protocols on the number of adults and the proportion that are female.
- Juvenile Abundance and Timing: Identifies the production of juveniles salmonids (Red Bluff Diversion Dam), migration of salmon for operation of the Delta Cross Channel (Knights Landing Rotary Screw Trap), and the implementation of OMR reverse flow actions (Sacramento Trawl and Chipps Island Trawl).
- Delta Distribution: Informs OMR actions and is currently supported through beach seines, acoustic tagging, and some EDSM.
- Salvage Count: Informs the direct effects on listed fish
- Genetic Identification: Informs the salvage of listed Chinook salmon species versus non-listed Chinook salmon species.
- Delta Smelt
 - Turbidity Stations: Informs the potential for a “turbidity bridge” that would inform OMR Actions.
 - Temperature Stations: Informs the transition between life stages and the need for protective measures.
 - Water Quality Stations: tracks the movement of the low salinity zone and parameters associated with the food web, e.g. chlorophyll.
 - Delta Distribution: Informs the entrainment risk due to OMR actions and is currently would be supported by EDSM.
 - Fish Condition: Informs when adults have spawned and the need for larval protections.
- Steelhead
 - American River and Clear Creek Redd Surveys
 - Salvage Count
- Sturgeon
 - Salvage Count

Table C-1 lists the current programs in place that would support Core Water Operations for the ROC on LTO.

Table C-1. Real-time monitoring

ID	Monitoring Program	Typical Time Of Year Operating	Target Species/Parameter	Site/Region
1	Adult Spring Chinook Escapement Monitoring in Clear Creek.		Chinook carcass and weir abundance counts	Clear Creek
2	Red Bluff Diversion Dam Rotary Screw Trap Juvenile Monitoring Program	January - December	Juvenile Chinook salmon productivity	Red Bluff Diversion Dam, American River, Stanislaus River
3	Juvenile Salmon Emigration Real-time Monitoring (Seines and Trawls)	October 1- November 30	Juvenile Chinook and steelhead relative abundance	North Delta
4	Juvenile Salmon Delta Abundance Trawling (expanded DJFMP trawling)	December-May	Juvenile Chinook salmon abundance and condition	Sacramento and Chipps trawl
5	Genetic Identification of Salmonids and Smelt to Inform Central Valley Project Operations and Bay-Delta Monitoring	January-December	Chinook salmon and Smelt diversity	Central Valley (RBDD to Chipps Island)
6	Lower Sacramento River Juvenile Salmon and Steelhead Monitoring Project	August - June	Juvenile Chinook salmon and Steelhead distribution and productivity	Middle Sacramento River at Knights Landing
7	Winter-run Chinook Salmon Escapement Monitoring	May-August	Winter-run Chinook carcass and redd abundance and distribution	Sacramento
8	Fish Salvage Operations	January - December	Juvenile Fish abundance	CVP and SWP Delta Fish Protection Facilities
9	Enhanced Delta Smelt Monitoring	January-December	Delta Smelt abundance, distribution, condition, and productivity	San Francisco Estuary
10	Delta Flow Measurement and Database Management	January - December	Flow and water quality	Bay-Delta
11	Operation of Thermograph Stations	January - December	Temperature and sediment loads	
12	Hatchery Marking (100% Tagging)		Winter-run Chinook, Spring-run Chinook Salmon, Late-Fall Chinook salmon, Steelhead	Livingston Stone National Fish Hatchery, Feather River Hatchery, Coleman National Fish Hatchery, Nimbus Hatchery

Effects to listed fish due to CVP and SWP operations would be expected from decisions on winter-run temperature dependent mortality to preserve future year classes, redd dewatering to preserve fall-run future winter-run year classes, habitat parameters within the Delta, and salvage at the Delta pumping

facilities of all species. As many effects depend upon hydrology and meteorology beyond the control of Reclamation and DWR, effects would be compared based on the range of conditions within a water year.

Status and Trend Monitoring

Status and trend monitoring characterizes the population of species and their environments over time include the effects of stressors from sources other than the CVP and SWP. Recovery plans characterize the status and trends differently depending upon the species in the general categories of abundance, production, life history diversity, and geographic diversity. In addition to the Core Monitoring, a number of additional programs are anticipated to continue, the majority of which are supported by Reclamation and DWR for CVP, SWP, and Delta watersheds:

- Hatchery Proportion (Constant Fractional Marking)
- Genetic Analyses of California Salmonid Populations: Parentage Based Tagging (PBT) of salmonids in California Hatcheries
- Fall Midwater Trawl
- 20-mm Survey monitoring to determine distribution and relative abundance of Delta Smelt and Longfin Smelt
- Spring Kodiak Trawl
- Estuarine and Marine Fish Abundance and Distribution Survey
- Smelt Larva Survey (SLS)
- Summer Townet Survey
- Environmental Monitoring Program (EMP)

Table C-2. Status and Trends Monitoring

ID	Monitoring Program	Typical Time of Year Operating	Target Species/Parameter	Site/Region
13	Hatchery Proportion (Constant Fractional Marking)		Fall run Chinook salmon	Coleman NFH, Nimbus Hatchery, Feather River Hatchery
14	Genetic Analyses of California Salmonid Populations: Parentage Based Tagging (PBT) of salmonids in California Hatcheries		Hatchery Steelhead	Coleman NFH, Nimbus Hatchery, Feather River Hatchery
15	Fall Midwater Trawl monitoring	September - December	Pelagic fish	San Pablo Bay and Delta
16	20-mm Survey monitoring to determine distribution and relative abundance of Delta Smelt and Longfin smelt	March - July	Delta Smelt and Longfin Smelt	Sacramento-San Joaquin Delta and Upper Estuary
17	Spring Kodiak Trawl	January - May, December	Delta Smelt	
18	Estuarine and Marine Fish Abundance and Distribution Survey (Bay Study)	January - December	Fish and macroinvertebrates	San Francisco Bay and lower Sacramento and San Joaquin Rivers
19	Smelt Larva Survey (SLS)	January - March	Longfin Smelt larvae	Bay-Delta, Suisun Bay, Suisun Marsh
20	Summer Townet Survey	June - August	Young pelagic fish and water quality	Upper San Francisco Estuary, San Joaquin River, lower Sacramento River
21	Environmental Monitoring Program	January-December	Water quality, chlorophyll, phytoplankton, invertebrates	Bay-Delta, Suisun bay, San Pablo Bay
22	Delta Juvenile Salmon Monitoring (DJFMP trawls and beach seining)	January - December	Juvenile Chinook salmon abundance, distribution, and condition	Bay-Delta
23	Juvenile Spring-Run and Steelhead Production Monitoring in Clear Creek		Spring-run Chinook and Steelhead productivity	Clear Creek
24	Adult Steelhead and Late-fall Chinook Escapement Monitoring in Clear Creek		Steelhead and Late-fall run Chinook carcass and weir abundance counts	Clear Creek
25	Spring, Fall, and Late Fall Chinook Salmon and Steelhead Escapement Monitoring in the Upper Sacramento River Basin	May-March	Spring-run Chinook and Steelhead weir and carcass abundance counts	Sacramento River
26	American River Chinook Salmon and Steelhead Escapement Monitoring	September-January	Fall-run Chinook and Steelhead weir, redd, and carcass abundance counts	American River

ID	Monitoring Program	Typical Time of Year Operating	Target Species/Parameter	Site/Region
27	Stanislaus River Chinook Salmon and Steelhead Escapement Monitoring	September-January	Fall-run Chinook and Steelhead weir, redd, and carcass abundance counts	Stanislaus River
28	Enhanced Acoustic Tagging, Analysis, and Real-time Monitoring	November-June	Juvenile Chinook salmonid survival	Central Valley
29	Mossdale Spring Trawl	March-May	Juvenile Chinook and steelhead relative abundance	Lower San Joaquin River

Adaptive Management Special Studies

Ongoing research programs to improve the state of science and address questions by one or more managing agencies occur on an ongoing basis.

Table C-3. Adaptive Management Program Monitoring

ID	Monitoring Program	Typical Time of Year Operating	Target Species/Parameter	Site/Region
1	Estuarine and Marine Fish Abundance and Distribution Survey (Bay Study)	January - December	Fish and macroinvertebrates	San Francisco Bay and lower Sacramento and San Joaquin Rivers
2	Bay Salinity Monitoring	January - December	Conductivity and water temperature	Bay-Delta
3	Directed Outflow Project	April-November	habitat condition, water quality, food web	Bay-Delta

Description of Programs

Monitoring of the Central Valley and Bay-Delta Watershed requires extensive coordination across multiple agencies and offices within the different agencies as well as academia and private entities. The following sections describe the organization into various programs in more detail.

Real-Time Monitoring

Adult Spring Chinook Escapement Monitoring in Clear Creek

The goal of this program is to estimate population size and distribution of adult spring Chinook holding and spawning in Clear Creek. This monitoring information is used to inform Clear Creek in-season operations like spring attraction pulses. This monitoring activity produces annual adult escapement of

spring Chinook into Clear Creek using two methods: video counts and snorkel-based estimates. Count data will be posted on the publicly accessible USFWS website for interested parties.

Objectives:

- Operate a video weir station to count and identify fish entering and leaving the watershed
- Index adult holding population size by visual counts made during snorkel surveys
- Estimate the spatial and temporal distribution of holding and spawning through snorkel surveys
- Estimate spawning population size using redd counts produced during snorkel surveys Spawning success is an indicator of the effectiveness of water and temperature management especially during the summer holding period when reservoir management is particularly important
- Obtain genetic samples, scales, and otoliths to determine run, age, natal origin, and juvenile life history of Chinook spawning in Clear Creek

Red Bluff Diversion Dam Rotary Screw Trap Juvenile Monitoring Project

This program quantifies passage and production of juvenile salmonids produced in the upper Sacramento River. This project allows for evaluation of flow and temperature operations from Whiskeytown and Shasta/Keswick reservoirs and provides real-time information to fishery monitoring team to inform fishery and water operations management. Data on the production trends of endangered winter-run Chinook Salmon, threatened spring-run Chinook, the Central Valley ESU of Steelhead as well as the Southern Distinct Population Segment of the North American Green Sturgeon will be derived. Biweekly catch data and passage estimates will be posted on the publicly accessible USFWS website for interested parties.

Objectives:

- Estimate total annual production of juvenile winter-run Chinook Salmon produced in the mainstem Sacramento River and compare these data to adult escapement estimates.
- Estimate juvenile production of fall, late-fall, and spring-run Chinook Salmon.
- Measure relative abundance of Lamprey and Green Sturgeon passing Red Bluff Diversion Dam.

Juvenile Salmon Delta Emigration Real Time Monitoring (expanded DJFMP seines and trawls)

This Delta Juvenile Fish Monitoring Program (DJFMP) monitoring project includes expanded beach seining and surface trawling 3 additional days/week from October 1st to November 30 near Sacramento (Sacramento and Chipps Island) to detect the arrival of older juvenile Chinook Salmon entering the Delta. Monitoring data are used to inform Delta Cross Channel Gate closure decisions from October 1st to November 30 to minimize the diversion and mortality of emigrating juvenile winter-run sized Chinook Salmon. Catch data will be posted on the publicly accessible USFWS website for interested parties.

Objective:

- Provide data for Delta Cross-channel Gate operational triggers.

Juvenile Salmon Delta Abundance Trawling (expanded DJFMP trawling)

This program involves surface trawling (Sacramento and Chipps Island) for increased capture of specific CWT groups released with acoustically tagged releases of juvenile hatchery salmonids during the winter and spring. This includes expanded surface trawling to achieve daily trawling at these sites for at least 5 days/week during the period these groups are likely to be encountered. This period is flexible dependent on the requirements of the releases, but typically runs from early December until early May, approximately five months. If acoustic tag groups are not released, this monitoring study should not be undertaken.

Objective:

- Provide CWT recapture data for estimating the number of juvenile salmonids entering and exiting the Delta.
- Collect tissue samples for genetic stock identification of fish at Chipps and Sacramento trawl.

Genetic Identification of Salmonids and Smelt to Inform Central Valley Project Operations and Bay-Delta Monitoring

Project operations requires accurate information regarding what species are being encountered at various locations in the Central Valley. Historically, juveniles salmonid have been identified based on two length-at-date models, which have been demonstrated to be inaccurate. The population-of-origin is determined for juveniles by comparing their genotypes to reference genetic baselines in order to quantify the number and distribution of true ESA-listed (genetic) winter and spring runs categorized by length-at-date criteria models. The overarching goal of this work is to directly target (and reduce) one source of uncertainty in the estimation of loss for listed Chinook Salmon (but primarily winter run) at South Delta fish salvage facilities and from other CVP monitoring sites. Also, this study provides genetic information at various locations in the Delta to improve accuracy of identifying juvenile salmonids and larval fishes to inform operations and monitoring activities. Species identification information is relied upon to estimate the effects of project operations. Annual genetic identification data will be incorporated into the annual incidental take report for interested parties.

Objectives:

- Genetic classification of Chinook salmon captured from SWP and CVP fish protection facilities for improved estimation of facility loss. This information is provided through multiple potential time steps including: rapid (<48hours), biweekly, and seasonally.
- Genetic classification of Chinook salmon in monitoring programs (e.g., RBDD, Sacramento Trawl, Chipps Island Trawl, Knights Landing, Upper Sacramento stranding surveys). These data are required for agency estimates of juvenile production at Red Bluff Diversion Dam and Sacramento and Chipps trawls.
- Assist with species identification of fish larvae or other difficult to identify samples collected at the fish protection facilities.

Lower Sacramento River Juvenile Salmon and Steelhead Monitoring Project

This program monitors out-migrant juvenile Sacramento River Chinook salmon and steelhead utilizing rotary screw traps located near Knights Landing on the Sacramento River. Juvenile salmonid monitoring in the upper Sacramento River between Red Bluff Diversion Dam and confluence with the Feather provide an early warning of increases in emigration rates of listed salmonids out of the upper Sacramento River toward the Sacramento-San Joaquin Delta. This near real-time data and early warning information provided by the program allows for data related triggers for the operation of the DCC. Daily catch data are posted on the publicly accessible CalFISH website for interested parties.

Objectives:

- Monitor and report the outmigration of juvenile salmonids from the Sacramento River as they move toward the Sacramento-San Joaquin Delta on a real-time basis.
- Monitor, record and compare movements of emigrating salmonids during specific environmental conditions.
- Estimate emigrating salmonid numbers and composition in the lower Sacramento River above the Delta.
- Examine the influences of Sacramento River flood relief structures on emigrating juvenile salmonids.

Winter-run Chinook Salmon Escapement Monitoring

This project monitors the annual abundance, timing, distribution, and several life history characteristics of naturally spawning winter Chinook salmon. Estimates of abundance of Sacramento River Winter Chinook Salmon provide the basis for monitoring the population status and trends of this endangered species. Information generated from this project also provides the basis for evaluating the supplementation program at the winter run Chinook salmon conservation propagation program at Livingston Stone National Fish Hatchery. Recoveries of coded-wire tags from this project feed into cohort reconstructions, which provide the basis for estimating survival rates and evaluating the effects of ocean harvest upon this endangered species. Recoveries of coded-wire tags will be reported to the Regional Mark Information System for use in a cohort reconstruction analysis. Weekly carcass data are posted on the publicly accessible CalFISH website for interested parties.

Objectives:

- Estimate of winter Chinook spawner abundance generated based on carcass mark-recapture estimation methods.
- Estimate escapement and contribution to natural spawning by natural and hatchery origin winter Chinook.
- Estimate of pre-spawning mortality

Fish Salvage Operations

Sampling of entrained fish at the Tracy Fish Collection Facility (TFCF) and Skinner Delta Fish Protective Facility (SDFPF) is the source for CDFW's daily salvage and loss estimates for the monitoring of incidental take of listed fish species.

Fish salvage and loss information at the SDFPF and TFCF is used extensively in water project monitoring and planning. The Fish Facilities Monitoring Project manages the data collected on fish entrained and salvaged at the SDFPF and TFCF. This project maintains one of the largest historical databases on Delta species available and has been used in assessing the effects of new facilities and programs, water project operations proposals, and evaluation of proposed CALFED alternatives. Daily data can be obtained via the California Department of Fish and Wildlife's Bay-Delta FTP server.

Objectives:

- Report fish salvage count data for regular operations and special studies
- Report physical and operational conditions at SDFPF and TFCF including temperature, bypass operations, facility flows, primary and secondary channels flows and depths, and holding tank flows.
- Collect tissue samples for distribution to Agency tissue archives.

Enhanced Delta Smelt Monitoring

High-frequency sampling of the Enhanced Delta Smelt Monitoring (EDSM) program is stratified by regions that, based on differences in hydrodynamics, differ in Delta Smelt density and risk of entrainment. The EDSM program provides an early warning of entrainment events in a broader context than the previous Early Warning Survey and employs a stratified sampling design that includes multiple crews trawling concurrently at multiple sites in pre-defined density strata within the low- and/or high-risk zones of entrainment in the San Francisco Estuary. Stopping rules were developed to minimize the impact of take on the population and effort can be modified to adapt to changing management needs and priorities.

For real-time purposes, EDSM may replace a number of historic trawls. However, for Delta species status and population trends, the long-running trawls may provide useful comparative information. These trawls have been included below in the Status and Trends Monitoring section.

Objectives

- Biweekly estimates of life stage specific abundance
- Biweekly estimates of distribution within different regions of the Bay-Delta.

Delta Flow Measurement and Database Management

The Delta Flow Network consists of 35 flow and water quality monitoring stations located throughout the Sacramento-San Joaquin Delta; eleven of these stations are supported by the IEP. Data from this network of stations are used by Delta managers and scientists to make real-time decisions and plan for future events such as climate change, water operations, restoration projects, evaluate fish transport, and migration issues. In addition, these data are used to calibrate and validate numerical models that are used

to predict water levels, flow speeds, and spatial and temporal evolution of salinity in the Delta. The data collected at these stations are critical for understanding the circulation and mixing patterns in the complex and interconnected channels that comprise the Delta region. Understanding Delta hydrodynamics is imperative to understanding the impacts of proposed major infrastructure projects and regulatory actions being taken to protect endangered species in the Delta.

Objective:

- Provide accurate continuous flow data throughout Bay-Delta.

Operation of Thermograph Stations

This program provides continuous information on the temperature and sediment regimes in the rivers in order to evaluate effects on the restoration of native species fisheries, amphibians and other aspects of the aquatic ecosystem. An additional goal is to better understand the transition from cold water to warm water regimes and how flow magnitude interacts to control the transition.

Objectives:

- Provide accurate continuous temperature readings.
- Provide data regarding sediment loading.

Status and Trends Monitoring

Existing monitoring techniques below assist in understanding species status and population trends. The information may also be useful in annual reporting and demonstrating compliance with ESA. However, they do not necessarily provide real-time operational benefits.

Genetic Analyses of California Salmonid Populations: Parentage Based Tagging (PBT) of salmonids in California Hatchery Programs.

The purpose of this task is to collect tissue samples and conduct the genetic analyses necessary to evaluate the genetic pedigree relationships of California salmonid hatchery broodstock. This information is used to inform hatchery broodstock management, including supporting recovery actions for ESA listed Central Valley salmonids stocks.

California hatcheries release a large number of juvenile salmonids every year, and genetic parentage based tagging (PBT) of adult spawners provides critical information about spawner age distribution, inbreeding, distribution of reproductive success among spawners, migration among Central Valley hatcheries, and other population parameters. The California Hatchery Scientific Review Group recommended PBT as an effective monitoring tool for the management of hatchery broodstock programs.

Objectives

- Genotype samples
- Use broodstock PBT to support Central Valley salmon and steelhead monitoring programs and hatchery broodstock management by identifying hatchery-of-origin and brood year for field caught and hatchery return samples and monitoring inbreeding and migration among Central Valley salmon and steelhead hatcheries.

- Evaluate genetic data for special hatchery broodstock projects to improve broodstock management

Fall Midwater Trawl

Fall Midwater Trawl Survey (FMWT) sampling began in 1967 to measure the abundance and distribution of age-0 Striped Bass and has since collected similar information on a suite of pelagic fishes including Delta Smelt and Longfin Smelt. Survey staff calculates annual abundance indices based on September through December monthly sampling data collected from San Pablo Bay through the Delta. The survey sampling has expanded into Cache Slough and the Sacramento Deepwater Ship Channel and may include zooplankton sampling and processing.

The survey's catch data provides means to calculate adult Delta Smelt incidental take at the export facilities. The State Water Project Incidental Take Permit for Longfin Smelt requires the FMWT Longfin Smelt abundance index to calculate the incidental take limit for the salvage facilities.

Objectives:

- To annually measure the relative abundance and distribution of selected species of pelagic fishes in the estuary.
- To detect introductions of new exotic fish and invertebrates.
- Provide baseline data to evaluate management plans and habitat restoration projects.
- To measure availability of fall planktonic food resources (since 2010).

20-mm Survey monitoring to determine distribution and relative abundance of Delta Smelt and Longfin smelt

The 20-mm Survey monitors juvenile Delta and Longfin Smelt distribution and abundance throughout their historic spring range in the Sacramento-San Joaquin Delta and upper Estuary. This survey monitors Delta Smelt around 20 mm TL in size which is the size that larval "take" is counted against the SWP and CVP. This information allows managers to vary water operations and provide sufficient flows to maintain Delta Smelt rearing habitat away from the south and central Delta and minimize entrainment.

Objectives:

- Determine the distribution of juvenile Delta and Longfin Smelt in relation to the major water diversions
- Compare current relative abundance to historical relative abundances
- Provide concurrent zooplankton density information to monitor the suitability of their food supply

Spring Kodiak Trawl

The Spring Kodiak Trawl (SKT) began in 2002 and is designed to provide information on the distribution of pre-spawning and spawning Delta Smelt, to improve our ability to detect adult Delta Smelt, obtain maturity status data, and provide results on a near "real-time" basis to assist in water management and export decisions. The survey is designed to determine pre-spawning and spawning distribution of adult Delta Smelt in relation to the CVP and SWP water export facilities. Due to its superiority in sampling efficiency to the earlier Fall Midwater Survey, the early results of the SKT are also been used to help estimate the relative abundance of adult Delta Smelt at extremely low population levels.

Objectives:

- Determine the distribution of maturing Delta Smelt during the period of December through May
- Evaluate the sexual maturation of Delta Smelt during this period and detects the start of spawning migration
- Report current relative abundance compared to historical estimates

Estuarine and Marine Fish Abundance and Distribution Survey

Since 1980, 52 channel and shoal stations from South San Francisco Bay to the lower Sacramento and San Joaquin rivers have been sampled monthly with a midwater and otter trawl. In addition to tracking abundance trends and distributional changes of individual species, data from this study is used to determine changes in the fish communities over time.

Objectives:

- Determine the effects of outflow related mechanisms on the abundance and distribution of estuarine and marine fishes.

Smelt Larva Survey (SLS)

This survey provides near real-time abundance and distribution data for Longfin (LFS) Smelt larvae in the Delta, Suisun Bay and Suisun Marsh. Data are used by agency managers to assess vulnerability of Longfin Smelt larvae to entrainment in south Delta export pumps. Sampling begins within the first two weeks in January and repeats every other week through the second week in March. The data is used to assess the risks of entrainment by the SWP and CVP and to determine OMR levels designed to minimize take of juvenile LFS at these facilities.

Summer Townet Survey

Summer Townet Survey (STN) is a long-term effort to monitor young pelagic fishes in the upper San Francisco Estuary. Since 1959, STN has sampled fixed locations from eastern San Pablo Bay to Rio Vista on the Sacramento River, and to Stockton on the San Joaquin River; and a single station in the lower Napa River. The study area was expanded in 2011 to include the Sacramento Deep Water Ship Channel and Cache Slough. Currently, 40 stations are sampled every other week June through August using a conical, fixed-frame net, which is pulled obliquely through the water column 2 to 3 times at each station. Data collected at 31 stations are used to calculate annual relative abundance indices for age-0 Striped Bass (*Morone saxatilis*) and Delta Smelt (*Hypomesus transpacificus*). The remaining 8 stations are sampled to increase our understanding of juvenile fish abundance and distribution in the lower Napa River and the north Delta. In 2005, STN added a zooplankton net to assess fish food resources at each station. A subset of the fish collected are retained for diet analysis. The STN also measures water temperature, water clarity and specific conductivity. Managers and researchers use the data collected by STN to inform decisions and improve our understanding of the health of the upper San Francisco Estuary.

While the original intent was to monitor the population of age-0 Striped Bass throughout the upper San Francisco Estuary, its scope has broadened to include other species of fish such as Delta Smelt and the food resources they rely upon.

Objectives:

- Measure annual abundance of selected age-0 fish

- Measure factors affecting abundance and distribution of age-0 Striped Bass, Delta Smelt and other fish in the estuary
- Measure availability of summer planktonic food resources
- Examine summer diets of young Striped Bass, Delta Smelt, and other pelagic fishes

Environmental Monitoring Program

The Environmental Monitoring Program (EMP) was established in 1971 to collect environmental data for resource management, to better understand estuarine processes, and to document compliance with State Water Resources Control Board Water Right Decision D-1379. This program collects water quality, chlorophyll, phytoplankton, benthic, and zooplankton samples at fixed locations in the Sacramento-San Joaquin Delta, Suisun Bay, and San Pablo Bay. Two of the program's strengths are continuity and data integration; the EMP is one of the nation's oldest environmental monitoring programs and has compiled over four decades of consistent and comprehensive water quality and biological data.

This is a comprehensive monitoring program that helps to ensure compliance with water quality objectives and standards, which were established to protect the beneficial uses of water in Sacramento-San Joaquin Delta and Suisun Marsh.

Objectives:

- Provide accurate and validated water quality and biological information to managers for real-time and adaptive management of the SWP and CVP
- Document and evaluate long term water quality and ecological trends in the San Francisco Estuary
- Detect and document invasive species, such as *Microcystis aeruginosa* and *Potamocorbula amurensis*, and conduct special studies to discern their impact on native species, the food web, and human health.

Delta Juvenile Salmon Monitoring (DJFMP seines and trawls)

This program involves year-around beach seining and surface trawling (Mossdale, Sacramento, and Chipps Island) throughout the San Francisco Estuary to monitor the relative abundance and distribution (spatial and temporal) of juvenile Chinook Salmon and other native species in the Central Valley of California.

Objectives:

- Determine the status and trends of juvenile Chinook Salmon in the San Francisco Estuary.
- Examine factors influencing the status and trends of juvenile Chinook Salmon.

Juvenile Spring-Run and Steelhead Production Monitoring in Clear Creek

The goal of this program is to estimate production of juvenile salmonids in Clear Creek. Clear Creek juvenile salmon and steelhead production estimates are used to guide and evaluate the effectiveness of proposed actions. It also serves a status and trend purpose to provide information for ESA status consideration. This monitoring activity results in juvenile production estimates for spring-run and steelhead in Clear Creek. Biweekly count and passage estimates data will be posted on the publicly accessible USFWS website for interested parties.

Objectives:

- Operate a rotary screw trap to catch, identify, and count juvenile fish leaving Clear Creek.
- Use rotary screw trap capture-efficiency trials to transform juvenile counts into total production estimates for salmon and steelhead.
- Estimate spawning success by combining juvenile production estimates with adult population estimates. Spawning success can be an indicator of the effectiveness of water management, habitat restoration and environmental variables.

Adult Steelhead and Late-fall Chinook Escapement Monitoring in Clear Creek

The goal of this program is to estimate population size and distribution of adult steelhead and late-fall Chinook spawning in Clear Creek. This monitoring activity is used to guide and evaluate the effectiveness of the proposed actions. It also serves a status and trend purpose to provide information for ESA status consideration. The activity estimates annual adult populations of steelhead and late-fall Chinook in Clear Creek using two methods: video counts and kayak-based redd counts. Count data will be posted on the publicly accessible USFWS website for interested parties.

Objectives:

- Operate a video weir station to count and identify fish entering and leaving the watershed.
- Estimate spawning population size using redd counts produced during kayak surveys.
- Estimate spawning success by combining redds counts with estimates of the number of juvenile fish produced. Spawning success can be an indicator of the effectiveness of water management and habitat restoration.
- Collect spawning habitat data for use as an indicator of the effectiveness of habitat restoration.
- Estimate the spatial and temporal distribution of spawning through kayak-based surveys.

Spring, Fall, and Late-fall Chinook Salmon and Steelhead Escapement Monitoring in the Upper Sacramento River Basin

Conduct mark-recapture carcass surveys, aerial and wading redd surveys, video counts, and snorkel surveys of the mainstem Sacramento River and its major tributaries (Battle Creek, Cow Creek, Bear Creek, Antelope Creek, Mill Creek, and Deer Creek) to estimate adult salmon and steelhead escapement. Data collected may include: hatchery mark status, gender, tag status, carcass condition, spawning status, fork length, and disposition, from all or a subset of carcasses handled. Other samples may include biological samples, such as: head, fin tissue, otoliths, and scales, from a subset of carcasses handled during the survey. Annual data are posted on the publicly accessible CalFISH website for interested parties.

Objectives:

- Estimate of spring run, fall run, and late-fall run Chinook and steelhead spawner abundance generated based on carcass mark-recapture or Vaki/video count estimation methods on the mainstem Sacramento River.
- Estimate escapement and contribution to natural spawning by natural and hatchery origin winter Chinook.
- Estimate of pre-spawning mortality in upper Sacramento River

American River Chinook Salmon and Steelhead Escapement Estimation

Conduct mark-recapture carcass surveys, aerial and wading redd surveys and snorkel surveys of the American River to estimate fall run Chinook and steelhead escapement. This activity generally runs mid-September through March. Data collected may include: hatchery mark status, gender, tag status, carcass condition, spawning status, fork length, and disposition, from all or a subset of carcasses handled. Other samples may include biological samples, such as: head, fin tissue, otoliths, and scales, from a subset of carcasses handled during the survey. Weekly carcass data are posted on the publicly accessible CalFISH website for interested parties.

Objectives

- Estimate the number of Chinook salmon spawning in the lower American River on an annual basis, beginning in mid-September.
- Estimate of escapement and contribution of hatchery-origin fish
- Estimate of pre-spawning mortality

Stanislaus River Chinook Salmon and Steelhead Escapement Estimation

Conduct mark-recapture carcass surveys, aerial and wading redd surveys and snorkel surveys of the American River to estimate fall run Chinook and steelhead escapement. This activity generally runs mid-September through March. Data collected may include: hatchery mark status, gender, tag status, carcass condition, spawning status, fork length, and disposition, from all or a subset of carcasses handled. Other samples may include biological samples, such as: head, fin tissue, otoliths, and scales, from a subset of carcasses handled during the survey. Weekly carcass data are posted on the publicly accessible CalFISH website for interested parties.

Objectives

- Estimate the number of Chinook salmon spawning in the Stanislaus River on an annual basis, beginning in mid-September.
- Estimate of escapement and contribution of hatchery-origin fish
- Estimate of pre-spawning mortality

Enhanced Acoustic Tagging, Analysis, and Real-time Monitoring

This monitoring program supports an acoustic receiver network and associated real-time and retrospective modeling of the data. This monitoring may include (1) the deployment of real-time receivers that will provide timely information on migrating salmon smolt and green sturgeon location and timing, (2) expansion of the existing autonomous acoustic array to increase the coverage and detection efficiency; (3) development of new metrics for the real-time data for key management relevant questions such as entrainment estimates at critical junctions (Georgiana Slough and Delta Cross Channel); and (4) retrospective analyses directly geared toward improving the quality and robustness of forecasting models (e.g., enhanced particle tracking models, fish migration models). Survival modeling and forecasting will be posted on the publicly accessible NOAA-Fisheries website for interested parties.

Objectives:

- Real-time estimates of reach-specific survival for juvenile salmonids in the Sacramento River and Delta

- Real-time estimates of route-entrainment for juvenile salmonids in the Delta

Mossdale Spring Trawl

This monitoring program is a long-term San Joaquin River basin juvenile Chinook salmon monitoring using a trawl net. The project samples on San Joaquin River near Mossdale County Park. This program identifies annual juvenile Chinook salmon production in the San Joaquin River Basin. Catch data will be posted on the publicly accessible CalFISH website for interested parties.

Objectives:

- Determine annual juvenile Chinook salmon production in the San Joaquin River Basin
- Determine how water quantity and quality conditions affect smolt production trends and *Oncorhynchus mykiss* passage at Mossdale trawl.

Adaptive Management Program Monitoring

Tidal Wetland Monitoring Studies

This program collects fish and invertebrate data near existing and tidal wetlands and planned tidal wetland restoration sites. These data provide information on how fish and invertebrate communities change pre-/post-restoration. Tidal wetland habitat restoration in the Sacramento-San Joaquin Delta and Suisun Marsh is important for improving habitat and food web resources for threatened fishes. This program is responsible for biological monitoring in these restored tidal habitats to assess their success for providing benefits for at-risk native fishes. Pre-project monitoring data allows project managers to evaluate the effectiveness of tidal wetland restoration projects.

Objectives:

- Determine the extent to which long-term sampling reflects conditions in nearby shallow water and wetland habitats.
- Determine whether gear efficiency evaluations are feasible using new sampling technology
- Determine the level of spatial and temporal replication necessary to make sampling design recommendations for long-term monitoring.
- Continue developing a baseline of biomass, community composition, and fish condition for fish and invertebrates near planned tidal restoration and comparison sites. This will allow us to make pre-and-post-restoration comparisons for evaluating restoration progress.

Bay Salinity Monitoring

Salinity and water temperature are collected in San Francisco Bay. Data are used to better understand the hydrodynamics of the estuary and calibration of multi-dimensional flow and transport models. Understanding how these variables are distributed around the Bay leads to a better understanding of habitat types and distribution in the Bay. Time series of water temperature and specific conductance (salinity is calculated from conductivity and water temperature) are needed (1) to improve our understanding of the hydrodynamics of the estuary (e.g., gravitational circulation), (2) for calibration of multi-dimensional flow and transport models of the Bay, (3) to better understand the distribution of

physio-chemical habitat types throughout the Bay, and (4) to provide supporting data for numerous estuarine studies of the Bay and Delta.

Upper Estuary Zooplankton Sampling

The Zooplankton Study has estimated the abundance of zooplankton taxa in the upper San Francisco Estuary since 1972 as a means of assessing trends in fish food resources and is part of a D-1641 mandate to monitor water quality and related parameters. Sampling with three gear types occurs monthly at 22 stations located throughout San Pablo Bay, Suisun Marsh, Suisun Bay, and the Delta. Zooplankton are an important trophic link between primary producers and fish. The Zooplankton Study provides abundance estimates and distributional data for fish food resources in the upper San Francisco Estuary. This information is used by aquatic ecologists to understand the lower food web and some biological drivers of the Delta Smelt population. The study also detects and monitors zooplankton recently introduced to the estuary and determines their effects on native zooplankton species.

Objectives:

- Determine abundance and distribution of zooplankton in the upper San Francisco Estuary
- Determine the relationships between species abundance and temperature, salinity, turbidity, and chlorophyll
- Determine long-term abundance trends for all species and if these trends show significant declines or increases
- Determine if introduced species becoming established in the estuary

Upper Sacramento River Habitat Restoration Monitoring Project

Sacramento River Spawning and Rearing Habitat Restoration Monitoring Program

- Determine the effectiveness of habitat improvement project sites at improving habitat for adult and juvenile Chinook salmon and steelhead trout.
- Determine species presence assemblage and density over time through repeated surveys.
- Collect spatial fish data by snorkel, videography, seine, or electrofish surveys.
- Compare habitat attributes between control and treatment sites before and after project implementation. Metrics can include water temperatures, velocities, depths, substrates, cover, vegetation, temperature stratification in backwaters, hyporheic conditions, and macroinvertebrate metrics.

Reporting

Various reporting is completed by the multiple agency and consultants completing the monitoring describe above. The Real Time Monitoring activities currently provide their data through various sites. Communication of these data has typically been supported through email, and more recently through web-based aggregation and visualization sites such as Bay-Delta Live, SacPAS, and SHOWR. These sites will continue to support the needs for rapid analytical and reporting of Real Time Monitoring data.

Bay-Delta Live

Bay-Delta Live is a collaborative community of interests with the goal of expanding open and transparent sharing of information essential in understanding the complex and dynamic ecosystem of the Sacramento-San Joaquin Bay Delta. Bay-Delta Live provides information from multiple sources using enhanced visual interfaces. Bay-Delta Live is used by resource managers, scientists, conservationists, policy makers, academics, and others local community interestes. BDL is supported through contributions from federal and state agencies, as well as community and agency information.

<https://www.baydeltalive.com/>

SacPAS

This website provides monitoring, evaluation, and web-based data products and services for primary and associated activities funded by the U.S. Bureau of Reclamation (USBR) and mandated by the Endangered Species Act (ESA). It serves as a means by which information integration services can be provided to the Central Valley Project Improvement Act (CVPIA) and ESA participants. Web-based services relate fish passage to environmental conditions and provide resources for evaluating the effects of river management and environmental conditions on salmon passage and survival. This website is maintained by University of Washington with funds from US Bureau of Reclamation.

<http://www.cbr.washington.edu/sacramento/>

Objective

- Provide a publicly accessible, web-based query and reporting system of historical and current fish, environmental, and hydrologic information, vital to year-round planning and adaptive management of the Central Valley Project and State Water Project.
- Provide basic conditions, performance measures, and threshold-based alerts are available through data aggregation and analysis of environmental conditions.

SHO-WR

SHOWR is designed to help decision makers and interested stakeholders understand and engage in the complicated process of managing Shasta Reservoir operations to protect Winter Run Chinook Salmon. The SHO-WR application demonstrates the power of open data paired with open source analytics and visualization tools for California water resources management. The application has been developed iteratively as part of a demonstration project led by the Sacramento River Settlement Contractors (SRSC). The primary objective of this demonstration project is to integrate diverse flow, water operations, fishery, and water quality data into a single, open data environment that facilitates more data-driven and timely decision making. On the section of the Sacramento River immediately below Lake Shasta, the fishery agencies have targeted water temperature as the most critical resource to successful spawning of winter-run Chinook salmon from late April through September. This single parameter controls the operation of Shasta Reservoir, SRSC diversions, the Central Valley Project (CVP), other project reservoirs, and the Bay Delta.

<https://flowwest.shinyapps.io/showr/>

Table C-4: Availability of data generated by Real Time Monitoring Projects.

Id	Monitoring Program	Bay Delta Live	Sacpas	Showr
1	Adult Spring Chinook Escapement Monitoring in Clear Creek.		Adult escapement	
2	Red Bluff Diversion Dam Rotary Screw Trap Juvenile Monitoring Program		Juvenile Production	
3	Juvenile Salmon Emigration Real-time Monitoring (Seines and Trawls)	Abundance Index, Distribution	Abundance Index, Distribution	
4	Juvenile Salmon Delta Abundance Trawling (expanded DJFMP trawling)			
5	Genetic Identification of Salmonids and Smelt to Inform Central Valley Project Operations and Bay-Delta Monitoring			
6	Lower Sacramento River Juvenile Salmon and Steelhead Monitoring Project	Abundance Index, Distribution	Abundance Index, Distribution	
7	Winter-run Chinook Salmon Escapement Monitoring			
8	Fish Salvage Operations	Daily Loss	Daily Loss	
9	Enhanced Delta Smelt Monitoring	Daily distribution		
10	Delta Flow Measurement and Database Management	Flow Characteristics	Flow Characteristics	
11	Operation of Thermograph Stations	Temperature Characteristics	Temperature Characteristics	Temperature Characteristics
12	Hatchery Marking (100% Tagging)		Smolt-to Adult Return ratios, Daily Loss	

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Johnson, RC, S. Windel, PL Brandes, JL Conrad, J Ferguson, PAL Goertler, BN Harvey, J Heublein, JA Israel, DW Kratville, JE Kirsch, RW Perry, J Pisciooto, WR Poytress, K Reece, BG Swart. 2017. Science Advancements Key to Increasing Management Value of Life Stage Monitoring Networks for Endangered Sacramento River Winter-Run Chinook Salmon in California. San Francisco Estuary and Watershed Science. 15: 1-41.

Exhibit B - Real-Time Species Distribution and Lifestage

Fish monitoring technical teams shall regularly report the following information from December through June as appropriate to the species' lifestage.

Salmonids

Upper Sacramento Fish Monitoring: redd counts and sampling at rotary screw traps

Lower Sacramento Fish Monitoring: sampling in trawls and beach seines.

Fish Distribution: Estimated percentage of the population upstream of Knight's Landing, In the Delta, and Past Chipps Island for winter-run, and spring-run Chinook salmon.

Delta Distribution: Estimated percentage of the population is different strata within the Delta.

Migration Cues: Other factors and indicators of fish distribution and lifestage.

Smelt

Environmental Data: water temperature thresholds, turbidity, food indicators, etc.

Fish Monitoring: gear deployments, counts by strata, and body condition from EDSM

Migration Cues: Other factors and indicators of fish distribution and lifestage.

Salvage

Salvage: reports from the state and federal facilities.

Exhibit - C Water Operation Status

Monthly, Reclamation shall provide a report on the status of CVP and SWP operations including:

- Reservoir Storage
- Reservoir Inflow
- Deliveries and Delta Outflow
- Delta Water Quality Stations
- VA Experiments

Exhibit D.a. - Old and Middle River Storm Event

See WIIN

Exhibit D.b. - Shasta Cold Water Pool Management

See SRTTG

Exhibit D.c. - Folsom Cold Water Pool Management

See ARG

Exhibit D.d. - Suisun Marsh and Fall Delta Smelt Habitat

Reclamation and DWR shall investigate Delta Smelt fall habitat to determine how the components of habitat interact with the species and affect its viability. Components of habitat include food, turbidity, salinity, velocity, and temperature - the physical and geographic features. Viability includes stomach fullness, length, and overall fitness including freedom from disease. This study program shall use a scientific approach of hypothesis identification, testing, and synthesis through Structured Decision Making, as discussed in the Adaptive Management Program. The Delta XXXX group would meet to

determine how to implement this action each year. To inform the Delta XX group, Reclamation and/or DWR would conduct Delta hydrodynamic modeling on an annual basis to evaluate the potential action(s). Each year, this program shall implement actions that may include (but are not limited to): monitoring, modeling, surveys, changes in existing physical structures or gates, additional flow, and/or the addition of substrate or turbidity. The synthesis and results from these investigations shall be published annually. Reclamation, DWR and Service shall conduct a comprehensive review of the outcomes of the Fall Investigations and the effectiveness of the adaptive management program ten years from the signing of the biological opinion, or sooner if circumstances warrant. This review shall entail an independent peer review. The purposes of the review shall be to evaluate the outcomes of the investigations to determine the then-current understanding of fall habitat, and to evaluate the effectiveness of the adaptive management program. At the end of 10 years or sooner, these investigations, based on the peer review and Service determination as to its efficacy shall either be continued, modified, or terminated.

Exhibit E - Outlier Years

In the event Reclamation and DWR identify conditions outside of the range of the Proposed Action, Reclamation and DWR will provide the following information to CDFW, FWS, and NMFS for technical assistance.

- Real-Time Species Distribution and Life History
- Water Operation Status
- Forecasts at the 50% and 90% confidence levels
- Potential Alternative Actions
- Other Relevant Information

Reclamation and DWR anticipate additional information may be required and would be developed through collaboration on the technical assistance.

Exhibit F - Habitat Restoration Updates

Annually and/or as needed, Reclamation and DWR would list the planned, under construction, and recently completed habitat restoration actions. For each action, the list would include:

- Name of the Project
- Completion Date (Planned or Actual)
- Changes to Operational Metrics (e.g. Acres Inundated, X2 Relationship)
- Changes to Habitat Metrics (e.g. Rearing, Spawning, Foraging, Etc.)
- Relevant Flow Experiments

Exhibit G.a. - Shasta Cold Water Pool Management

By the end of December of each year, Reclamation shall provide information on the prior year's management of the Shasta cold water pool in order to inform the upcoming temperature management season due April 1. Information will include, at minimum:

- Adult Winter-Run Carass Survey
- Winter-Run Chinook Salmon Redd Timing and Location
- Reservoir Inflow and Meteorology
- Narrative on the use of Cold Water Resources
- Measured Reservoir Profiles and Water Temperatures
- Estimated Temperature Dependent Mortality
- Monthly Water Operation Status Reports
- Shasta Cold Water Pool Status Reports
- Technical Assistance and Other Fish Agency Communications to Reclamation

Exhibit G.b. - Shasta Storage Rebuilding and Spring Pulse

By the end of June of each year, Reclamation shall provide information on the outcomes of fall-winter and spring actions to rebuild storage in Shasta Reservoir to inform actions for the upcoming fall. Information will include, at minimum:

- Rice Decomposition Schedules
- Number of Winter-Run Redds Dewatered
- Number of Fall-Run Redds Dewatered
- Estimated Increase in Storage due to Actions
- Flood Conservation Space Releases, if Taken
- Spring Pulse Action, if Taken

Exhibit G.c. - Annual Summary Of Water Supply and Fish Operations

On or about the end of September of each year, Reclamation and DWR propose to provide to the USFWS, NMFS, and CDFW a report on the prior year activities through the spring of each year. The annual report shall include, at minimum:

- Hydro-Meteorology: Precipitation; reservoir inflow; air temperatures; and other environmental factors affecting water availability and demands.
- Non-Flow Construction: Summary of projects committed to in this consultation that are initiated; ongoing; and completed.
- Water Operations Summary: Conditions from the prior year (spring to spring); allocations; flows; diversions; and reservoir, release, and river temperatures.
- Flow Experiments under Voluntary Agreements: Accounting for conditions and the flow actions including.
- Fisheries Performance: Results from monitoring stations; surveys; salvage; harvest; and physical factors influencing fish populations.
- Intervention Measures: Hatchery intakes; releases; and other measures.
- Predictive Tools: Summary of the performance of the risk analysis tools used during the year.

Appendix XX provides an outline of the annual report.