# 2 Alternatives Including the Proposed Action

This section considers two possible alternatives: the No Action Alternative and the Proposed Action. The No Action Alternative reflects future conditions without the Proposed Action and serves as a basis of comparison for determining potential impacts to the human environment that would result from implementation of the Proposed Action.

Identification of the reasonable range of alternatives for this EA was based upon consideration of the purpose and need. Additional alternatives were considered but eliminated due to them being substantially similar in design and impacts as the Proposed Action (40 CFR § 1502.14(a)).

Additional alternatives were also considered but eliminated due to feasibility or timing. These alternatives were discussed in an "initial Proposed Action". A list of the ideas, a brief description, and the reason why they were not included in this EA are described below:

- Fall X2 averaging period: Under the initial Proposed Action, requirements for Fall X2 in September and October would be averaged over two months, as opposed to individually. Reclamation's evaluation of modeling results and discussions with operators found no meaningful benefits to fish or water supply.
- Non-physical barriers: Under an initial Proposed Action, Reclamation and the California Department of Water Resources (DWR) would install multiple non-physical barrier technologies at Georgiana Slough, including; bioacoustic fish fence (BAFF), floating fish guidance structure (FFGS), and infrasound fish fence (IFF). Reclamation would investigate ways to encourage migration through Sutter and Steamboat Sloughs. These proposals had independent utility and were separated from this EA to better align with the schedule for installing and studying non-physical barriers.
- Salvage efficiency: Under an initial Proposed Action, Reclamation would implement a permanent carbon dioxide injection system in the secondary and primary channels of the Tracy Fish Facility in order to anesthetize and remove predators from the facility. This project has independent utility and is moving forward ahead of this EA.

## 2.1 No Action Alternative

Under the No Action Alternative, Reclamation and the DWR would not implement the proposed action outlined in this EA. Implementation of the RPAs, as described in the LTO EIS and ROD, form the basis for the No Action Alternative in this EA.

## 2.2 Proposed Action Alternative

The Proposed Action would maximize water deliveries consistent with applicable laws, contractual obligations, and agreements without creating additional adverse effects to listed species beyond those analyzed in the 2008 & 2009 BOs by incorporating advancements in the scientific understanding of and impacts into the BOs on Delta Smelt (*Hypomesus transpacificus*), salmonids (*Oncorhynchus tshawytscha, O. mykiss)*, and sturgeon (*Acipenser medirostris*).

### 2.2.1 Old and Middle River Reverse Flows

Old and Middle River (OMR) reverse flow provides a surrogate indicator for how export pumping, tides, reduced inflow, and geomorphic changes in the Delta channels influence hydrodynamics in the south Delta based on two U.S. Geological Survey (USGS) flow measurement stations. Reverse OMR flow (negative) indicates a net flow from the Sacramento River towards the export pumps. Positive OMR flow indicates a net flow towards the ocean. In the 2008 and 2009 BOs, OMR flow criteria are intended to protect listed fish species in the lower Sacramento and San Joaquin Rivers from being entrained into channels at the South Delta and at C.W. "Bill" Jones and Harvey O. Banks Pumping Plants (export pumps). OMR flow criteria are also intended to enhance the likelihood of salmonids successfully exiting the Delta at Chipps Island by creating more suitable hydraulic conditions in the mainstem of the San Joaquin River for emigrating fish (NMFS, 2009).

#### 2.2.1.1 Existing Requirements

2008 Service BO (Actions 2-3)

The 2008 Service BO bases OMR actions, in part, on the Fall Mid-water Trawl (FMWT), Spring Kodiak Trawl (SKT), Delta Smelt salvage at the Jones and Banks pumping plants, and allowances for additional physical and biological monitoring data. The Smelt Working Group (SWG) is a technical team outlined in the 2008 Service BO that evaluates biological and technical issues regarding Delta Smelt. The SWG provides recommendations to the Service and the Water Operations Management Team (WOMT).

*Action 1: First Flush*

"Action: Limit exports so that the average daily OMR flow is no more negative than -2,000 cfs for a total duration of 14 days, with a 5-day running average no more negative than -2,500 cfs (within 25 percent.). Timing: Part A: December 1 to December 20 – Based upon an examination of turbidity data from Prisoner's Point, Holland Cut, and Victoria Canal and salvage data from CVP/SWP (see below), and other parameters important to the protection of Delta Smelt including, but not limited to, preceding conditions of X2, FMWT, and river flows; the SWG may recommend a start date to the Service. The Service will make the final determination. Part B: After December 20 – The action will begin if the 3 day average turbidity at Prisoner's Point, Holland Cut, and Victoria Canal exceeds 12 NTU. However the SWG can recommend a delayed start or interruption based on other conditions such as Delta inflow that may affect vulnerability to entrainment."

*Action 2: Adult Migration and Entrainment*

"Action: The range of net daily OMR flows will be no more negative than -1,250 to -5,000 cfs. Depending on extant conditions (and the general guidelines below) specific OMR flows within this range are recommended by the SWG from the onset of Action 2 through its termination. The Smelt Working Group (SWG) would provide weekly recommendations based upon review of the sampling data, from real-time salvage data at the CVP and SWP, and utilizing most up-to-date technological expertise and knowledge relating population status and predicted distribution to monitored physical variables of flow and turbidity. The Service will make the final determination. Timing: Beginning immediately after Action 1 [First Flush]. Before this date (in time for operators to implement the flow requirement) the SWG will recommend specific requirement OMR flows based on salvage and on physical and biological data on an ongoing basis. If Action 1 is not implemented, the SW may recommend a start date for the implementation of Action 2 to protect adult Delta Smelt."

#### *Action 3: Entrainment Protection of Larval Smelt*

"Action: Net daily OMR flow will be no more negative than -1,250 to -5,000 cfs based on a 14-day running average with a simultaneous 5-day running average within 25 percent of the applicable requirement for OMR. Depending on extant conditions (and the general guidelines below) specific OMR flows within this range are recommended by the SWG from the onset of Action 3 through its termination. … The SWG would provide these recommendations based upon weekly review of sampling data, from real-time salvage data at the CVP/SWP, and expertise and knowledge relating population status and predicted distribution to monitored physical variables of flow and turbidity. The Service will make the final determination. Timing: Initiate the action when … 1) temperature reaches 12 degrees Celcius based on a three-station average at Mossdale, Antioch, and Rio Vista, or 2) Onset of spawning (presence of spent females in SKT or at either facility). Based upon daily salvage data, the SWG may recommnd an earlier start to Action 3. The Service will make the final determination."

### 2009 NMFS BO (Action IV.2.3)

The objective of Action IV.2.3 is to "reduce the vulnerability of emigrating juvenile winter-run, yearling spring-run, and CV steelhead within the lower Sacramento and San Joaquin rivers to entrainment of the South Delta and at the pumps due to the diversion of water by the export facilities in the South Delta. Enhance the likelihood of salmonids successfully exiting the Delta at Chipps Island by creating more suitable hydraulic conditions in the mainstem of the San Joaquin River for emigrating fish, including greater net downstream flows." The 2009 NMFS BO bases the OMR action, in part, on monthly regressions between exports and salvage data for older juvenile Chinook salmon from 1995-2007 and steelhead from 1998-2006. The Delta Operations for Salmonids and Sturgeon (DOSS) is a technical advisory team outlined in the 2009 NMFS BO. DOSS provides recommendations to NMFS and WOMT.

The 2009 NMFS BO outlines that DOSS will provide recommendations for real-time management, track and evaluate implementation, coordinate with SWG and other teams, among other things. DOSS provides weekly entrainment risk outlooks by considering two different categories of entrainment risk based on (a) listed fish distribution and (b) factors that influence their potential for entrainment. The two entrainment risk categories considered include:

- Interior Delta Entrainment Risk- fish in the Sacramento River that have the potential to be entrained into the Interior Delta through the Delta Cross Channel and/or Georgiana Slough; and
- CVP/SWP Facilities Entrainment Risk- fish in the Interior Delta that have the potential to be entrained into the CVP/SWP facilities.

Influencing factors considered include:

- Exposure Risk (for both categories) - estimated scale (low, medium, high) of fish anticipated to be in vicinity of the interior delta or facilities, and
- Routing Risk (only applied to Interior Delta Entrainment Risk) - estimated scale (low, medium, high) that flow conditions could result in fish migrating into the interior delta instead of remaining in main channel.

### Action IV.2.3

"Action: From January 1 through June 15, reduce exports, as necessary, to limit negative flows to -2,500 to -5,000 cfs in Old and Middle Rivers, depending on the presence of salmonids. The reverse flow will be managed within this range to reduce flows toward the pumps during periods of increased salmonid presence. From January 1 to June 15, exports are managed to a level that produces a 14-day running average of the tidally filtered flow of (minus) -5,000 cfs in Old and Middle River (OMR). A five-day running average flow shall be calculated from the daily tidally filtered values and be no more than 25 percent more negative than the targeted requirement flow for the 14-day average flow." More restrictive OMR beyond the -5000 cfs is also required based on First Stage and Second Stage Triggers, which depend on fish loss density in fish per thousand acre-feet (Action IV.2.3).

### First Stage Trigger

This action would be triggered when "(1) Daily SWP/CVP older juvenile Chinook salmon loss density (fish per taf) is greater than incidental take limit divided by 2000 (2 percent WR JPE divided by 2000), with a minimum value of 2.5 fish per taf, or (2) daily SWP/CVP older juvenile Chinook salmon loss is greater than 8 fish / taf multiplied by volume exported (in taf) or (3) CNFH CWT LFR or LSNFH CWT WR cumulative loss greater than 0.5% for each surrogate release group, or (4) daily loss of wild steelhead (intact adipose fin) is greater than 8 fish/taf multiplied by volume exported (in taf).

When triggered, the First Stage action is to "Reduce exports to achieve an average net OMR flow of (minus) -3,500 cfs for a minimum of 5 consecutive days. The five day running average OMR flows shall be no more than 25 percent more negative than the targeted flow level at any time during the 5-day running average period (e.g., -4,375 cfs average over 5 days). Resumption of (minus) -5,000 cfs flows is allowed when average daily fish density is less than trigger density for the last 3 days of export reduction. Reductions are required when any one criterion is met."

### Second Stage Trigger

This action would be triggered when "(1) Daily SWP/CVP older juvenile Chinook salmon loss density (fish per taf) is greater than incidental take limit (2 percent of WR JPE) divided by 1000 (2 percent of WR JPE divided by 1000) with a minimum value of 2.5 fish per taf, or (2) daily SWP/CVP older juvenile Chinook salmon loss is greater than 12 fish/taf multiplied by volume exported (in taf), or (3) daily loss of wild steelhead (intact adipose fin) is greater than 12 fish/taf multiplied by volume exported (in taf)."

When triggered, the Second Stage action is to "Reduce exports to achieve an average net OMR flow of (minus) -3,500 cfs for a minimum 5 consecutive days. Resumption of (minus) -5,000 cfs flows is allowed when average daily fish density is less than trigger density for the last 3 days of export reduction. Reductions are required when any one criterion is met."

#### Water Infrastructure Improvements for the Nation (WIIN) Act: Section 4002 and 4003

Section 4002 of the WIIN Act provides that, "In implementing the provisions of the smelt biological opinion and the salmonid biological opinion, the Secretary of the Interior and the Secretary of Commerce shall manage reverse flow in Old and Middle Rivers at the most negative reverse flow rate allowed under the applicable biological opinion to maximize water supplies for the Central Valley Project and the State Water Project, unless that management of reverse flow in Old and Middle Rivers to maximize water supplies would cause additional adverse effects on the listed fish species beyond the range of effects anticipated to occur to the listed fish species for the duration of the applicable biological opinion, or would be inconsistent with applicable State law requirements, including water quality, salinity control, and compliance with State Water Resources Control Board Order D–1641 or a successor order."

Section 4003 of the WIIN Act provides that, "When consistent with the environmental protection mandate in paragraph (1) while maximizing water supplies for Central Valley Project and State Water Project contractors, the Secretary of the Interior and the Secretary of Commerce, through an operations plan, shall evaluate and may authorize the Central Valley Project and the State Water Project, combined, to operate at levels that result in OMR flows more negative than the most negative reverse flow rate prescribed by the applicable biological opinion (based on United States Geological Survey gauges on Old and Middle Rivers) daily average as described in subsections (b) and (c) to capture peak flows during storm-related events." Paragraph (1) states, "Nothing in this subtitle authorizes additional adverse effects on listed species beyond the range of the effects anticipated to occur to the listed species for the duration of the smelt biological opinion or salmonid biological opinion, using the best scientific and commercial data available."

### 2.2.1.2 Proposed Action

The proposed action reviews best available science to propose changes to operations groups and decision making for scientifically supported implementation of OMR flow requirements consistent with Section 4002 of the WIIN Act, temporary operational flexibility for storm events consistent with Section 4003 of the WIIN Act, the use of the OMR Index, and Rapid Genetic Protocols. Advancements in the detection and identification of Delta Smelt and salmonids provide a more reliable and accurate understanding of the distribution of fish and how fish may be affected by Delta Project water operations in real-time. The proposed action adds published conceptual models and predictive physical and biological models as the method for determining the real-time risks to Delta Smelt and salmonids.

#### Scientifically Supported Implementation of OMR Flow Requirements

Consistent with Section 4002 of the WIIN Act, the CVP and SWP "shall manage reverse flow in Old and Middle Rivers at the most negative reverse flow rate allowed under the applicable biological opinion to maximize water supplies for the Central Valley Project and the State Water Project, unless that management of reverse flow in Old and Middle Rivers to maximize water supplies would cause additional adverse effects on the listed fish species beyond the range of effects anticipated to occur to the listed fish species for the duration of the [2008 & 2009 BOs]".

This proposed action describes the methods used to manage OMR and avoid additional adverse effects on Delta Smelt and salmonids.

### Delta Smelt

In evaluating historical data for the influence of OMR on Delta Smelt, Grimaldo et al (2017) found that “during first flush periods, salvage at each facility was best explained by water exports (sampling effort), precipitation (recently linked to movement and vulnerability to offshore trawling gear), abundance and Yolo Bypass flow. During the entire adult salvage season, SWP salvage was best explained by SWP exports, Yolo Bypass flow, and abundance whereas CVP salvage was best explained by abundance, Old and Middle River flows, and turbidity. This study suggests that adult Delta Smelt salvage is influenced by hydrodynamics, water quality, and population abundance.” The authors go on to state that, “CVP exports actually played a minor influence in directly affecting CVP salvage and that it had no detectable influence on SWP salvage. OMR flows had a higher influence on CVP salvage, moreso than even CVP exports, suggesting an indirect influence of SWP and CVP efforts as they both contribute to net reverse flows in the south Delta (Monsen et al. 2007). But the influence of OMR flow could also be related to San Joaquin River flow dynamics, especially for Delta Smelt that may take multiple routes to the salvage facilities.”Grimaldo et al (2017) further found “OMR flows have been used as metric for management of adult entrainment risk, because the magnitude of salvage observations was related to OMR in the US Fish and Wildlife’s 2008 Biological Opinion (FWS 2008). Confirming those findings, BRT models of both CVP and SWP expected salvage increased at OMR < -5,000 cfs, when all other variables were held at their averages. While OMR flow was the second most important predictor of CVP salvage, more important than even CVP exports, the OMR threshold of -5,000 cfs was most notable in SWP salvage”.

In addition to the FMWT and SKT, the Enhanced Delta Smelt Monitoring (EDSM) Program provides information to inform entrainment risk by dynamic sampling of Delta sub-regions and improving the representation of near shore occupancy and abundance. However, “abundances near the detection threshold of the sampling techniques makes it very difficult to draw reliable inferences about how many Delta Smelt there are, and where they are located” (2008 Service BO).

Models developed to inform entrainment risk include:

- Models based on DSM2 model (cite) with particle tracking, such as those used by Rose (2013), Wilbur (2000), Miller (2002), and Kimmerer and Nobriga (2008).
- Gross et al (2010, 2018) has developed a three-dimensional Particle Tracking Model (FISH PTM) using the Bay-Delta UnTRIM model (MacWilliams et al., 2008) for the hydrodynamics. The Flexible Integration of Staggered-grid Hydrodynamics Particle Tracking Model (FISH PTM) was developed to represent particle transport processes for a class of hydrodynamic models. The FISH-PTM represents horizontal and vertical transport processes, has flexible particle release capabilities, has representation of movement of particles through structures including culverts and weirs, has representation of particle losses at exports and agricultural diversions, and incorporates vertical swimming behavior.

- Korman et al (2018), statistically evaluated the Gross et al particle-tracking model with swimming behavior to determine which swimming behaviors best fit proportional entrainment loss.
- In addition to the particle tracking models, organizations (such as ICF) are developing statistical models to predict entrainment.

For scientifically supported management of OMR requirements related to Delta Smelt, the proposed action would rely upon the MAST conceptual model (IEP MAST, 2015) for evaluating the adverse effects on Delta Smelt:

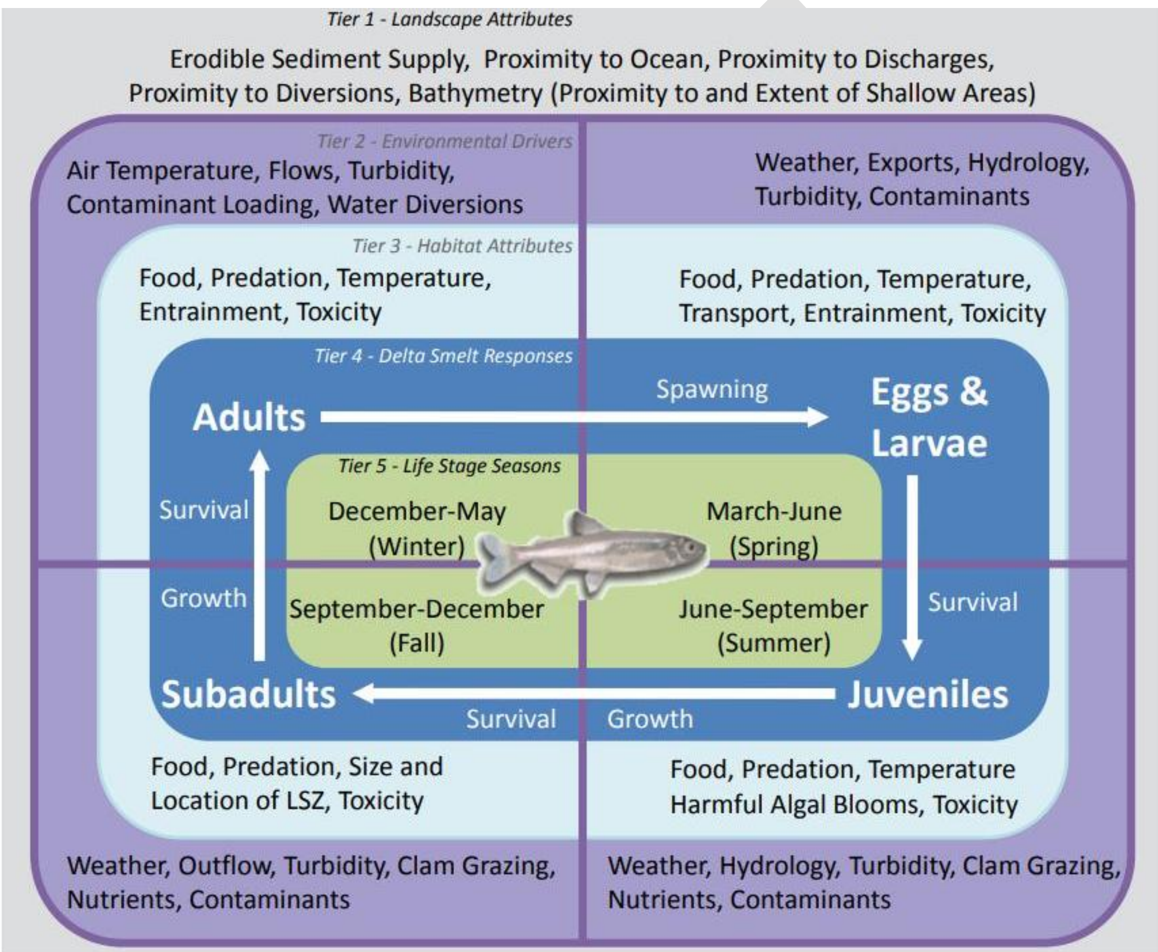


*Figure 1: Delta Smelt Conceptual Model (IEP MAST, 2015)*

The use of published conceptual models is an improvement upon the 2008 Service BO in that it describes a broad range of influences upon Delta Smelt and explicitly states the hypothesized linkages between hypothesized discretion actions by Reclamation and DWR and effects on Delta Smelt.

Reclamation, in coordination with DWR, shall:

- Manage OMR for Delta Smelt to no more negative than -5,000 after the first flush consistent with Action 1 and the findings of Grimaldo, et. al (2017), except:

  - During the first flush of sediment out of the Delta in each water year;
  - During the storm-related flexibilities as described in this proposed action; or
  - When a risk assessment determines there are additional adverse effects. The adverse effects from the 2008 Service are:
    - direct mortality associated with entrainment of pre-spawning adult Delta Smelt by CVP/SWP operations,
    - direct mortality of larval and early juvenile Delta Smelt associated with entrainment by CVP/SWP operations, and
    - indirect mortality and reduced fitness through reductions to and degradation of Delta habitats by CVP/SWP operations, with the fall as a particular concern.”.
- Perform a risk assessment on material changes in hydrology, project operations, or fish distribution to determine when to manage OMR reverse flow at rates less negative than the most negative reverse flow rate prescribed by the biological opinion is necessary to avoid additional adverse effects. The risk assessment shall be performed, at a minimum, when anticipated or actual salvage and loss is greater than 50%, 75%, or 90% of the incidental take limit. The risk assessment shall consider:
  - Significant facts regarding real-time conditions relevant to the determinations of OMR reverse flow rates including:
    - targeted real-time fish monitoring in the Old River pursuant to this section, including as it pertains to the smelt biological opinion monitoring of Delta Smelt in the vicinity of Station 902,
    - near-term forecasts with available salvage models under prevailing conditions of the effects on the listed species of OMR flow at the most negative reverse flow rate prescribed by the biological opinion, and
    - requirements under applicable State law; and
  - relevant factors such as:
    - the distribution of the listed species throughout the Delta,
    - the potential effects of high entrainment risk on subsequent species abundance,
    - the water temperature,
    - other significant factors relevant to the determination, as required by applicable Federal or State laws,
    - turbidity, and
    - whether any alternative measures could have a substantially lesser water supply impact.
- Document in writing, and post to the Bay Delta Office website (www.usbr.gov/mp/bdo), the risk assessment when a decision to manage OMR reverse flow at rates less negative than the

most negative reverse flow rate prescribed by the biological opinion is necessary to avoid additional adverse effects.

In performing the risk assessment, the relevant linkages from the conceptual model are:

- Proximity to water diversion sites can affect entrainment risk for multiple life stages of Delta Smelt (H1 from adult to larvae conceptual model, H4 from larvae to juvenile conceptual model). Reclamation and/or DWR would evaluate effects of water diversion on entrainment risk using PTM and entrainment models.
- Flow releases from upstream reservoirs of the CVP/SWP can affect turbidity, which affects predation risk for many life-stages of Delta Smelt (H3 from larvae to juvenile conceptual model, H2 from juvenile to subadult conceptual model and subadult to adult conceptual model). Effects of flow on turbidity and predation risk would be evaluated qualitatively.
- Flow releases from upstream reservoirs can also affect autochthonous and allochthonous food production and retention, which affects food availability and visibility, which affects multiple life stages of Delta Smelt (H2 from larvae to juvenile conceptual model, H3, H4b from juvenile to subadult conceptual model, subadult to adult conceptual model). Effects of flow on food production would be evaluated qualitatively.
- From March to June, flow releases from upstream reservoirs in the spring can affect water temperature, which affects growth and survival (H1 from larvae to juvenile conceptual model). Effects of flow on water temperature would be evaluated using qualitatively.
- Flow releases from upstream reservoirs also affect the size and location of the LSZ, which affects growth and survival of subadult to adult Delta Smelt in the fall. Reclamation and/or DWR would evaluate the effects of flow on the LSZ using hydrodynamic salinity models such as UnTRIM or DSM2.

The decisions to manage OMR reverse flow would be consistent with the triggers, timing, and off-ramp criteria under Actions 2 and 3 of the 2008 Service BO. Reclamation would additionally manage OMR reverse flow rates to avoid exceeding the levels of concern for permitted “take” and conduct additional monitoring and studies, as described under “Addressing Uncertainty”.

Reclamation and DWR shall collaborate with the Service and others in the performance of the risk assessment and seek technical assistance through the SWG and WOMT.

- The SWG shall meet weekly, or as otherwise determined by the Service, during OMR management season and provide to Reclamation and DWR a report on:
    - Delta Smelt distribution, including available information from EDSM to inform the relative proportion of fish in different strata relevant to project operations;
    - Abiotic factors that would affect the future distribution of Delta Smelt based on the MAST conceptual model or an updated conceptual model;
    - Assist Reclamation and DWR to develop and update conceptual models as new information becomes available;

- Assist Reclamation and DWR in developing and updating entrainment models for Delta Smelt; and
- Assist Reclamation and DWR in the development of alternative measures that could have a substantially lesser water supply impact.

- The WOMT shall:
  - Provide technical advice on when a risk assessment shall occur; and
  - Review significant facts and relevant factors.

Reclamation, in coordination with DWR, would incorporate feedback from the SWG and WOMT in the risk assessment and management of OMR. To address uncertainty in the best available science, Reclamation shall undertake certain monitoring and studies as described in "Addressing Uncertainty" below.

### Salmonids

ESA listed salmonids include winter-run Chinook salmon, spring-run Chinook salmon, and San Joaquin origin Central Valley steelhead. The Salmonid Scoping Team (SST) issued a two-volume report in 2017 that looked at hydrodynamics, juvenile migration behavior of salmon and steelhead, and survival of juvenile salmon and steelhead in the San Joaquin River and central Delta. Neither Coded Wire Tag (CWT) nor acoustic tag (AT) data show a strong and consistent relationship between survival and exports (SST 2017). For hydrodynamic effects, the Salmonid Scoping Team (2017) stated that "the effects of SWP and CVP exports on hydrodynamics is greatest in channels located in close proximity to the export facilities and decreases as a function of distance both upstream and downstream of the facilities."

For the Sacramento River, Perry (2010) found, "survival of juvenile salmon migrating through the interior Delta, where water pumping stations are located, was consistently less than for fish that migrated via the Sacramento River". He also states that "survival is low when fish migrate via a route in which more water can flow inland than towards the ocean". Perry et al. (2010) noted that "travel times for fish migrating through the interior Delta were longer than alternative routes, possibly contributing to lower survival through the interior Delta." Releases of CWT fall run Chinook salmon between 1993 and 2003 in the Sacramento and San Joaquin Rivers were analyzed by Zeug and Cavallo (2013). This study found that tributary conditions (temperature, water quality) and fish size may be more important, and the authors state there "was little evidence that large-scale water exports or inflows influenced recovery rates in the ocean during this time period". The authors note that the use of ocean recovery data also may have influenced the lack of a detectable flow effect. Michel et al. (2012) found that water velocity was negatively correlated with movement rates for late-fall run yearling Chinook salmon from the Sacramento River. Cavallo et al, 2015 found that both inflows and diversions had relatively small effects on the predicted routing of fish into the interior Delta at tidally dominated junctions. The authors concluded that "preventing migrating salmonids from entering unfavorable distributary routes in the Delta may require the use of physical or nonphysical barriers rather than hydrodynamic manipulation to produce detectable effects". A multi-year analysis of flow-survival relationships in the North Delta revealed that flow effects were only significant in reaches that switch from bidirectional to unidirectional as flow increases, whereas flow has no detectable effect where flow is always bidirectional (Perry et al., 2018). This emerging science indicates that exports may have minimal effect in tidal regions.

On the San Joaquin River, Holbrook et al (2009) found the highest survival of San Joaquin River fall-run Chinook salmon through the San Joaquin River, and stated that “once tagged fish entered Old River, only fish collected at two large water conveyance projects and transported through the Delta by truck were detected exiting the Delta, suggesting that this route was the only successful migration pathway for fish that entered Old River”. DWR’s stipulation study found that for the “OMR flow treatments tested in this study, there appeared to be little influence of OMR flows tested on steelhead tag travel times on the route-level and steelhead tag movement at the junctions and routes examined in this study” (DWR 2014). The junctions and routes examined in the study were relatively far from Jones and Banks Pumping Plants. In the San Joaquin Basin, habitat conditions may be so poor that even positive OMR flows do not have an effect on survival, which remains low (SJRG 2011, SJRG 2013). Tag results from the six-year acoustic study suggest Vernalis flows accounted for more of the variation in steelhead survival than: exports, inflow/export ratio, flow at the head of Old River, or OMR flows. “Exports did not appear to have an effect on route entrainment at the head of Old River, but flows, or rather, flow and stage did” (Reclamation, 2018). Independent review panels have found that “…simple flow metrics like OMR may have too much uncertainty to be an appropriate basis for setting standards,” (Monismith et al., 2014) and “…the lack of relationships between OMR inflows/exports and smolt movement/survival suggest that these were insensitive indicators for evaluating effectiveness of Delta operations on salmonids” (Anderson et al. 2012, p. 31).

In considering the Density Dependent Triggers under 2009 NMFS BO, Appendix A – Juvenile Chinook Salmon Distribution and Timing draws upon data from the SacPAS website on the historical migration and timing of winter-run Chinook salmon. As stated by Rosario et al (2013), “Winter-run appear to be present in the Sacramento River system or Delta nearly year round—they are first detected emigrating from their natal grounds at Red Bluff in July, and last detected leaving the Delta at Chipps Island as smolts as late as May”. The conceptual model Reclamation presents in Appendix A shows that rearing fish are less vulnerable to the effects of exports as they are in slower moving or shallower areas less likely to be drawn towards the facilities. The presence of one of these rearing salmonids in the Jones or Banks Pumping Plants may not indicate a population level effect, as the rearing salmonids are at a different timing than migratory smolts and may be in smaller groups. However, significant numbers of winter-run passing Chipps Island may indicate that fish are beginning their emigration phase and may be vulnerable to adverse effects due to exports.

For scientifically supported management of OMR requirements related to salmonids, the proposed action would rely upon the SAIL conceptual model (Windell et al, 2017; Heublein et al, 2017) for evaluating the adverse effects on salmonids. Below is an example of one of the 7 conceptual models for Winter-run Chinook salmon. SAIL conceptual models also exist for each life stage of green sturgeon and white sturgeon.

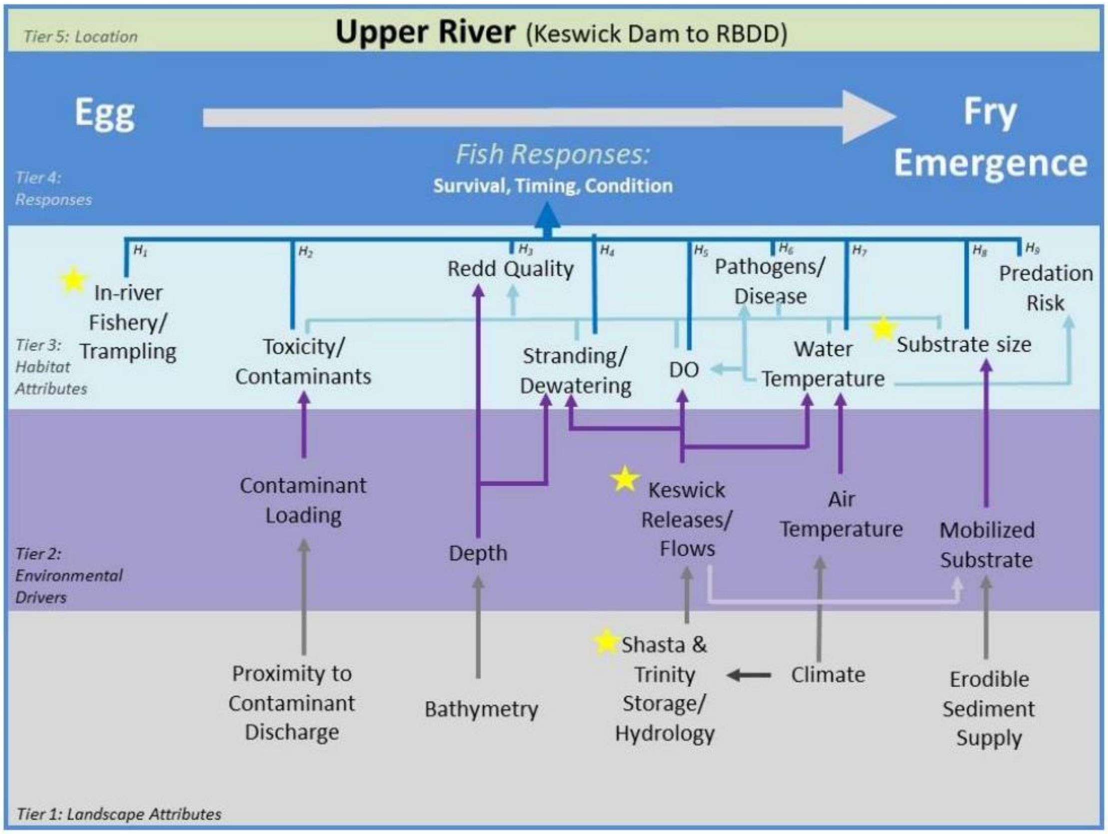


*Figure 2: Egg to Fry Winter-run Chinook Salmon conceptual model*

The use of published conceptual models is an improvement upon the 2009 NMFS BO in that it describes a broad range of influences upon salmonids and explicitly states the hypothesized linkages between hypothesized discretion actions by Reclamation and DWR and effects on salmonids.

Reclamation, in coordination with DWR, shall:

- Manage OMR for salmonids to no more negative than -5,000 after when DOSS reports that more than 5% of listed salmonids have entered the Delta, but no earlier than January 1, until 95% of listed salmonids have passed Chipps Island, except:
    - During the storm-related flexibilities as described in this proposed action; or
    - When a risk assessment determines there are additional adverse effects. A risk assessment would be done when DOSS reports that a portion of the salmonid is migrating and therefore vulnerable to entrainment, as represented by more than 5% migrating past Chipps Island. The adverse effects from the 2009 NMFS BO are:
        - loss in the interior delta,
        - loss in export facilities, and
        - altered delta hydrodynamics.

- Perform a risk assessment on material changes in hydrology, project operations, and fish distribution to determine when to manage OMR reverse flow at rates less negative than the most negative reverse flow rate prescribed by the biological opinion is necessary to avoid additional adverse effects (i.e. -5000 cfs). The risk assessment shall consider:
    - Significant facts regarding real-time conditions relevant to the determinations of OMR reverse flow rates including:
        - near-term forecasts with available salvage models under prevailing conditions of the effects on the listed species of OMR flow at the most negative reverse flow rate prescribed by the biological opinion, and
        - requirements under applicable State law; and
    - relevant factors such as:
        - the distribution of the listed species throughout the Delta,
        - the potential effects of high entrainment risk on subsequent species abundance,
        - the water temperature,
        - other significant factors relevant to the determination, as required by applicable Federal or State laws,
        - turbidity, and
        - whether any alternative measures could have a substantially lesser water supply impact.
- Document in writing, and post to the Bay Delta Office website (www.usbr.gov/mp/bdo), the risk assessment when a decision to manage OMR reverse flow at rates less negative than the most negative reverse flow rate prescribed by the biological opinion is necessary to avoid additional adverse effects.

In performing the risk assessment, the relevant linkages from the SAIL conceptual model for Winter-run Chinook salmon are

- Proximity to water diversion operations affects entrainment risk of salmonid juveniles, which affects survival, timing, and growth. Reclamation would use models such as the enhanced Particle Tracking Model (ePTM) for Winter-run Chinook salmon, based on the DSM2 one-dimensional hydrodynamic model built by DWR with swimming behavior incorporated and calibrated by the USGS and the NMFS Southwest Fisheries Science Center. Swimming behavior incorporated includes swimming velocity, daytime holding probability, velocity holding threshold, selective tidal stream transport, and the probability of mis-assessing downstream direction (Perry, 2017). The XT survival model (Anderson et al. 2005) is used to estimate survival based on the length of time a fish is in a given reach, mean predator-prey distance and a random encounter velocity. Reclamation may also use a machine learning approach as developed recently by ICF (2018) for steelhead and four Chinook salmon runs.
- Water diversions also affect the fish assemblage, which affects predation and competition, which affects the survival, timing, and growth of salmonid juveniles. Reclamation will assess the effects of operations on fish assemblage and predation with XXXX.

Currently, NMFS RPA Action IV.2.3 requires an OMR no more negative than -5000 cfs from January 1 to June 15. Restriction by date and by detection in salvage may unnecessarily reduce water export abilities if listed salmonids are not present or life stages are such that exports do not have a population effect. The decision to manage OMR reverse flow at rates less negative than the most negative reverse flow rate prescribed by the biological opinion (i.e. -5000 cfs) would be based upon fish entering a vulnerable life stage, as indicated by DOSS reports that a portion of the population is migrating and therefore vulnerable to entrainment, as represented by more than 5% migrating past Chipps Island. Prior to fish entering a migration life-stage, Reclamation would not implement Density Dependent Triggers. Reclamation would additionally manage OMR reverse flow rates to avoid exceeding the levels of concern for permitted "take" and conduct additional monitoring and studies, as described under "Addressing Uncertainty".

Reclamation and DWR shall collaborate with NMFS and others in the performance of the risk assessment and seek technical assistance through the DOSS and WOMT.

- The DOSS shall meet weekly, or as otherwise determined by NMFS, during OMR management season and provide to Reclamation and DWR a report on:
    - Salmonid distribution, including available information from the Rapid Genetic Protocol (RGP) identifies ESA-listed fish species that fit within the older juvenile size-at-date criteria at the fish salvage facilities. Genetic analysis is an improvement on existing techniques that assume the fish species based solely on its size and the date. Aqueous Environmental DNA (eDNA) also shows promise as a non-invasive method of determining salmonid presence (Turner, 2015). SAIL and EDSM to inform the relative proportion of fish in different strata relevant to project operations;
    - Abiotic factors that would affect the future distribution of salmonids based on the MAST conceptual model;
    - Assist Reclamation and DWR to develop and update conceptual models as new information becomes available;
    - Assist Reclamation and DWR in developing and updating entrainment models for salmonids; and
    - Assist Reclamation and DWR in the development of alternative measures that could have a substantially lesser water supply impact.
- The WOMT shall:
    - Provide technical advice on when a risk assessment shall occur.
    - Review significant facts and relevant factors.

Reclamation, in coordination with DWR, would incorporate feedback from the DOSS and WOMT in the risk assessment and management of OMR. To address uncertainty in the best available science, Reclamation shall undertake certain monitoring and studies as described in "Addressing Uncertainty" below.

### Temporary Operational Flexibility for Storm Events

Reclamation manage OMR to capture peak flows during storm-related events, in accordance with WIIN Act 4003. Reclamation would identify a storm event based upon forecasted precipitation within the Central Valley where the predicted Delta Outflow Index indicates a higher level of flow available for diversion. Biological conditions that would not warrant proceeding to a risk assessment include:

1) Service Action 1, First Flush - Exempted from WIIN;
2) Service Action 2 consistent with 4002 - Biological Factors indicate that -5,000 OMR flow index values would cause additional adverse effects; therefore, there would be no justification to evaluate more negative OMR conditions as modified by this proposed action;
3) Service Action 3 consistent with 4002 - Biological Factors would indicate that -5,000 OMR flow index values would cause additional adverse effects; therefore, there would be no justification to evaluate more negative OMR conditions as modified by this proposed action;
4) NMFS Action IV.2.3 consistent with WIIN Act 4002 - Biological Factors indicate that -5,000 OMR flow index values would cause additional adverse effects; therefore, there would be no justification to evaluate more negative OMR conditions as modified by this proposed action.
5) April 1 to May 31: No changes in operations pursued, unless the Secretary of Commerce finds that some or all of such applicable requirements may be adjusted during this time period to provide emergency water supply relief without resulting in additional adverse effects using the best scientific and commercial data available as modified by this proposed action;

If none of the above are triggered, Reclamation and/or DWR will conduct risk assessment which will evaluate whether increasing pumping during the storm event could result in additional adverse effects. Reclamation and/or DWR will evaluate the risk of additional adverse effects based on:

1) The degree to which the Delta outflow index indicates a higher level of flow available for diversion;
2) Relevant physical parameters including projected inflows, turbidity, salinities, and tidal cycles;
3) The real-time distribution of listed species and including existing/current and anticipated/projected distribution.

Reclamation and/or DWR would determine if they are outside of the effects analysis in the 2008 and 2009 BOs based on the factors and process described above.

### Smelt

The 2008 Service BO identified adverse effects due to: "1) direct mortality associated with entrainment of pre-spawning adult Delta Smelt by CVP/SWP operations; 2) direct mortality of larval and early juvenile Delta Smelt associated with entrainment by CVP/SWP operations and 3) indirect mortality and reduced fitness through reductions to and degradation of Delta habitats by CVP/SWP operations, with the fall as a particular concern." Reclamation will implement the proposed action if Reclamation determines that the proposed action's effects are within the range and type of effects to listed species for the duration of the USFWS 2008 Biological Opinion.

The factors below provide examples of the information on the relevant physical parameters and the real-time and anticipated distribution of listed species that could be considered in an operations plan. As our scientific understanding improves, it is anticipated that the information on the relevant physical parameters and real-time and anticipated distribution of listed species, and the relationship to additional adverse effects, will change. The types of factors that would be relevant to a WIIN Act evaluation for Delta Smelt include:

1) Turbidity at Bacon Island: A determination that the proposed operations plan is not likely to occur during, or result in, conditions with higher than those established by consensus developed threshold, e.g. 12 NTUs, or turbidity data from other locations and transects in the south Delta along the Old and Middle River corridor, between the lower San Joaquin River at Jersey Island and Prisoners Point and the Project facilities.

2) Turbidity Relationship: Application of the Collaborative Science and Adaptive Management Program and Delta Smelt Scoping Team's entrainment project. This approach utilizes the turbidity-OMR relationship to predict entrainment with and without more negative OMR. The relationship can be used to assess whether more negative OMR would be expected to increase entrainment. A determination of a low potential for increased entrainment based on turbidity-OMR relationship supports action.

3) EDSM: A determination that a 3 week average of percent of total abundance in the South Delta and Eastern strata is minimal, e.g. 5%, and that the proposed operations plan is not likely to cause more than a minimal increase in the south Delta distribution, would support action.

4) Spring Kodiak Trawl: An evaluation of catches of adult Delta Smelt at stations 809, 812, 815, 902, 906, 910, 912, 914, and 915.

5) 20 mm Larval Survey: An evaluation of catches of juvenile Delta Smelt in the south and central Delta stations (809, 812, 901, 906, 910, 914, 915, 918, and 919).

6) eDNA: eDNA in Old and Middle River or the CVP Fish Collection Facilities: The absence of Delta Smelt DNA could support action. Application of eDNA in this manner is new and is still being developed. Therefore, eDNA is not yet a reliable indication of species distribution but is a reliability indicator of species presence.

Factors that are indicative of additional adverse effects rely upon biological and physical monitoring survey information. Greater risks for additional adverse effects are associated with the increased exposure of Delta Smelt in the South Delta and/or indicators of behavioral mechanisms that may increase entrainment of fish into the South Delta. Cumulatively, the addition of real-time analysis of biological factors provides valuable information regarding the predicted environmental effect of potential WIIN actions that may be linked to the real-time distribution and behavior of Delta Smelt to best characterize the scale and scope of impacts potentially caused by the proposed WIIN operational action.

The operations plan will determine if the proposed WIIN Act action would be expected to increase effects (as compared to operations without the WIIN action) to the extent that there could be additional adverse effects on the species, not all ready analyzed in the Delta Smelt Biological Opinion. In making this determination Reclamation will evaluate whether taking a WIIN action would change Delta conditions to the extent that the new conditions would have additional adverse effects on the species (e.g., early winter, turbidity over 12 NTU and species distribution increasing in south Delta).

Under WIIN Act Section 4003(d), capturing peak flows shall not count toward the 5-day and 14-day running average for OMR flow requirements. However, Biological Opinion actions may be required to protect species as consistent with Section 4002.

#### *Salmonids*

The NMFS 2009 Biological Opinion related to OMR identified adverse effects of: loss in the interior delta, loss in export facilities, project operations, or altered delta hydrodynamics. Reclamation will implement the proposed action if Reclamation determines that the proposed action's effects are within the range and type of effects to listed species for the duration of the NMFS 2009 Biological Opinion.

The factors below provide examples of the information on the relevant physical parameters and the real-time and anticipated distribution of listed species that could be considered in a risk assessment. As our scientific understanding improves, it is anticipated that the information on the relevant physical parameters and real-time distribution of listed species, and the relationship to Additional Adverse Effects, will change. The types of factors that would be relevant to a WIIN Act evaluation for salmonids include:

1) Survey data: Applying the method used by DOSS, use Knights Landing and Chipps survey data in conjunction with south Delta tagging efforts to estimate percent of population in Delta, and to inform when population may be moving into ocean.

2) Cumulative Routing Risk: A proposed operations plan that is not likely to substantially modify the flow split conditions to favor migration of Sacramento River fish into the Interior Delta supports an action.

3) Acoustic Tagging: Use of real-time acoustic tagging technology in the south Delta. By adding receivers in the south Delta, exposure risk could be assessed. Low fish presence supports action.

4) Hydrology alteration model: This model can assess project related changes in velocity. Model would be used to predict whether more negative OMR would result in changes in velocity in the south Delta. No significant change in velocity resulting from proposed changes in OMR suggests a low risk of additional entrainment, which supports action.

5) Entrainment Risk: Proposed operations plan is not likely to increase the likelihood that an exposed fish would be entrained in the facilities, e.g. exceed a density dependent trigger.

6) Entrainment model: This model developed in collaboration with USFWS and ICF can compare current conditions with and without more negative OMR. Entrainment model considers a variety of environmental factors and species distribution to predict

entrainment. Model results comparing entrainment risk between current conditions and the PA suggesting no significant increase in entrainment supports action.

Factors that are indicative of additional adverse effects are evaluated using biological and physical monitoring survey information. Greater risks for additional adverse effects are associated with the increased salmonid exposure to entrainment into the Central and South Delta and/or indicators of behavioral mechanisms that may increase entrainment of fish into the South Delta. Cumulatively, the addition of real-time analysis of biological factors provides valuable information regarding the predicted environmental effect of potential WIIN actions that may be linked to the real-time and anticipated distribution and behavior of salmonids to best characterize the scale and scope of impacts potentially caused by the proposed WIIN operational action.

The operations plan will determine if the proposed WIIN Act action would be expected to increase effects (as compared to operations without the WIIN action) to the extent that there could be additional adverse effects on the species, beyond those analyzed in the Salmon Biological Opinion. In making this determination Reclamation will evaluate whether taking a WIIN action would change Delta conditions to the extent that the new conditions would have additional adverse effects on the species (e.g., change to salvage compared to baseline, increased interior Delta entrainment, increased routing risk).

Under WIIN Act Section 4003(d), capturing peak flows shall not count toward the 5-day and 14-day running average for OMR flow requirements. However, Biological Opinion actions may be required to protect species as consistent with Section 4002.

### OMR Index

OMR reverse flows is measured by the United States Geological Survey from data telemetered from acoustic gages. The daily average tidally filtered USGS values are a combination of two real-time gages, for the day before, today, and the day after. Data availability lags by approximately 3-days and cannot be used on a real-time basis. Equipment failure or damage results in missing measurement over 30% of the time (Sereno, 2012). Changes in flow due to the tidal cycle, wind, atmospheric pressure, precipitation, channel barriers and local in-Delta diversions and return flows also affect OMR in ways and magnitudes beyond the control of water project operations. The residual magnitude of OMR flows is several orders of magnitude smaller than the instantaneous tidal flow values that are summed and averaged to calculate the residual flow. In 2014 Reclamation proposed an alternative way of calculating Old and Middle River flow that could be used in "real time" for scheduling releases and exports to meet the Old and Middle River flow requirements listed in the 2008 and 2009 BOs. This method is commonly referred to as the Old and Middle River Index calculation.

The OMR Index calculation allows exports to be scheduled on a daily basis by project operators, and therefore improves response times for meeting the RPA action. It ignores large, short-term OMR flow fluctuations that are independent of water project exports. The OMR Index is affected by Vernalis flow, Delta depletion, south Delta barrier placement and water project exports. Implementing the OMR Index allows the CVP and SWP to improve operational stability and simplify accounting for the many factors affecting OMR flow, resulting in more efficient CVP and SWP water and power operations. Advantages of the index include: 1) there is only one metered flow gage in the index, so there is a lower risk of missing data (zero days missing from

2011-2017), 2) San Joaquin River flow at Vernalis is outside of tidal influence which makes it more predictable and eliminates delays in reporting, and 3) use of the prior day San Joaquin River flow allows the projects to know what is required the next day for compliance (Giorgi, 2017).

The OMR Index, $OMR_i$, in cubic feet per second (cfs), is calculated as:

$$OMR_i = A \cdot Q_{SJR} + B \cdot Q_{SDD\&E} + C$$

Where,

A, B, and C are calibrated coefficients;

$Q_{SJR}$ = prior day flows on the San Joaquin River at Vernalis (cfs);

$Q_{SDD\&E}$ = South Delta Diversions and Exports (cfs), and;

$$Q_{SDD\&E} = Q_{CCF} + Q_{JPP} + Q_{CCWD,Total} - Q_{CCWD.Canal} + \frac{1}{4} Q_{Delta\ Depletions}$$

Where,

$Q_{CCF}$ = Clifton Court Forebay Intake (cfs);

$Q_{JPP}$ = Jones Pumping Plant Exports (cfs);

$Q_{CCWD,\ Total}$ = Total CCWD diversions (cfs);

$Q_{CCWD,}$ Canal = Contra Costa Canal Diversions (cfs); and

$Q_{Delta\ Depletions}$ = Delta Net Channel Depletions (cfs).

The United States Fish and Wildlife Service submitted a letter to Reclamation in 2014 approving use of the Index (Lohoefener 2014). On February 27, 2014, NMFS determined that the OMR Index Demonstration Project, as conditioned, will have no additional adverse effects on the listed anadromous fish species and Southern Resident killer whales and designated critical habitats than were considered in the 2009 Biological Opinion. NMFS has approved 1-year extensions of the OMR Index Demonstration Project each year since 2014. It is currently approved through September 2018 (Thom, 2017). Reclamation proposes to permanently implement the OMR Index.

## Rapid Genetics Protocols

The CVP and SWP may, at its discretion, use existing rapid genetics protocols in lieu of length-at-date criteria for the identification of winter-run. Length-at-date criteria may lead to mis-identification of runs of Chinook salmon, and rapid genetics can fix this concern. When implementing rapid genetic protocols, the CVP and SWP would have up to 2 days to complete the identification prior to scheduling reductions to pumping under 2009 NMFS Biological Opinion Action IV.2.3, as modified by this Proposed Action. Providing 2 days to complete the identification prior to scheduling reductions would prevent Reclamation from making unnecessary operational changes. Data will be posted to DFW salvage ftp site within 2 days. An annual report is posted to the Delta Operations for Salmon and Sturgeon page.

#### 2.2.1.4 Addressing Uncertainty

The science used in the implementation of OMR flow requirements has uncertainty. The following measures are included to address uncertainty:

1) Reclamation shall continue to monitor salvage and track the "take" of listed species including the levels of concern for "take";
    a. For Delta Smelt,
        i. If the level of concern reaches 50% of permitted take; or
        ii. If the level of concern reaches 75% of permitted take.
    b. For salmonids,
        i. If the Particle Tracking or entrainment models predict 50%, 75% or 90% entrainment and loss of the incidental take limit of any salmonid species, or
        ii. If salvage or loss at Jones and Banks for steelhead, Delta Smelt, green sturgeon, or Winter-run Chinook salmon exceeds 50%, 75% or 90% of the incidental take limit, or
        iii. If fifty percent of the cumulative loss of each release group of hatchery winter-run Chinook salmon is exceeded, or
        iv. If cumulative loss of each release group of the Coleman National Fish Hatchery Coded wire tagged late fall-run Chinook salmon (Spring-run surrogates) is greater than 0.25%, 0.375%, or 0.45%.
2) Reclamation would make permanent implementation the pilot Enhanced Delta Smelt Monitoring Program (EDSM) and Salmon and Sturgeon Assessment of Indicators by Life-stage (SAIL) programs though the Interagency Ecological Program (IEP) while these modification to OMR management are in place; and
3) Reclamation and would assist NMFS in the performance of studies to more accurately refine the Juvenile Production Estimate and refine the JPE based estimates of permitted "take".

The EDSM and SAIL programs are anticipated to provide broad benefits above and beyond the implementation of OMR flow requirements through supporting overall species status and trends, life-cycle model development, and the relationship to factors beyond the discretion of Reclamation and DWR. Working through the collaborative processes of the IEP will increase the buy-in across agencies and stakeholders. Both the Service and NMFS may permit or reject submittals through the IEP.

### 2.2.2 San Joaquin Inflow to Export Ratio

The San Joaquin River inflow-to-combined export pumping ratio (I:E Ratio) seeks to reduce the vulnerability of emigrating central-valley steelhead within the lower San Joaquin River to entrainment into the channels of the South Delta and at the export pumps and to enhance the likelihood of salmonids successfully exiting the Delta at Chipps Island be creating more suitable hydraulic conditions in the mainstem of the San Joaquin River for emigrating fish, including greater net downstream flows.

#### 2.2.2.1 Existing Requirements

##### 2009 NMFS BO (Action IV.2.1)

Objectives: "To reduce the vulnerability of emigrating CV steelhead within the lower San Joaquin River to entrainment into the channels of the South Delta and at the pumps due to the diversion of water by the export facilities in the South Delta, by increasing the inflow to export ratio. To enhance the likelihood of salmonids successfully exiting the Delta at Chipps Island by creating more suitable hydraulic conditions in the main stem of the San Joaquin River for emigrating fish, including greater net downstream flows" (NMFS 2009).

Action: The table below depicts the required Vernalis flow-to-combined export ratios, based on a 14-day running average, as described in the 2009 NMFS BO. Vernalis flow equal to or greater than 21,750 cfs results in unrestricted exports until flows recede below 21,750 cfs. There is also an exception for multiple dry years and health and safety.

| San Joaquin Valley Classification | I:E Ratio |
|---|---|
| Critically Dry | 1:1 |
| Dry | 2:1 |
| Below Normal | 3:1 |
| Above Normal | 4:1 |
| Wet | 5:1 |

"Reclamation has limited discretion to require additional flows from the Tuolumne and Merced rivers that are necessary in the long run to meet the needs of outmigrating juvenile steelhead" (NMFS 2009). In addition, proceedings to establish minimum flows in the San Joaquin River basin by the State Water Resources Control Board as described in the 2009 NMFS BO have not been completed.

##### Water Infrastructure Improvements for the Nation (WIIN) Act: Section 4001.(b)(7)

Requires adopting a 1:1 inflow to export ratio for the increment of increased flow, as measured as a 3-day running average at Vernalis during the period from April 1 through May 31, that results from the voluntary sale, transfer, or exchange, unless the Secretary of the Interior and Secretary of Commerce determine in writing that a 1:1 inflow to export ratio for that increment of increased flow will cause additional adverse effects on listed salmonid species beyond the range of the effects anticipated to occur to the listed salmonid species for the duration of the salmonid biological opinion using the best scientific and commercial data available.

#### 2.2.2.3 Proposed Action

The Vernalis Adaptive Management Plan (VAMP) was a scientific experiment designed to test hypotheses concerning the effects of river flow and exports on juvenile salmon survival rates in the San Joaquin River and Delta and in response to the presence or absence of the Head of Old

River Barrier (HORB). VAMP studies indicated that as San Joaquin River flows increase and exports decrease relative to flows there should be corresponding increases in smolt survival and adult escapement 2 1/2 years later (VAMP 2003:2006). However, the analysis of the VAMP could not find a statistically significant relationship between exports and survival. Reclamation proposed VAMP-like flows at Vernalis in the 2008 Biological Assessment of Long term operations. The current San Joaquin River inflow to combined export (I:E) requirement addresses steelhead survival by limiting exports to a percentage of flow in the San Joaquin River. This approach presented a method thought to safeguard the ability of Central Valley steelhead to persist in the San Joaquin River basin. However, since the issuance of the RPA that clarified the similar operational flows to VAMP, the scientific understanding of the export to flow relationship has been expanded and new information has been published. Studies and reports have shown that San Joaquin river inflow has a direct influence on survival and emigration to the ocean (Baker and Morhardt 2001, Mesick et al. 2007), while exports have limited area of influence (Cavallo et al. 2015, SST 2017).

Hydrologic modeling that varied exports and inflows was presented by the Salmon Scoping Team (SST) (2017). They concluded that the effects of exports and inflow were spatially heterogeneous within the Delta. Increasing exports affected flow and velocity most in the channels just downstream of the export facilities and attenuated toward the mouth of Old and Middle Rivers with only minor effects in the San Joaquin River main stem. Increasing San Joaquin River flow had the strongest effects from just downstream of Head of Old River to Rough and Ready Island and attenuating toward Jersey Point. Greater inflows also increased flow and velocity in Old River upstream of the facilities. This suggests inflow and exports affect Delta hydrodynamics differentially in different regions of the Delta and are not directly related as is assumed by use of a ratio not equivalent across all regions of the Delta.

Recent statistical modeling of the relationship between flow and survival in the North Delta revealed that significant relationships exist in reaches that change from bidirectional to unidirectional as flow increases (Perry et al. 2018). Perry statistical modeling showed survival improved when flow changes from bidirectional to unidirectional (2018). This same effort found that flow did not affect survival in reaches where flow is always bidirectional. This suggests that these “transitional reaches” between bidirectional and unidirectional zones are where flow survival relationships are realized. Buchanan et al. (2018) reported in the San Joaquin River where survival in reaches from release to Turner Cut and release to the export facilities was greater when flow was higher whereas survival downstream of those areas was consistently low regardless of flow. Although Buchanan et al (2018) did not perform a quantitative analysis of flow effects; the pattern of increased survival with flow in transitional reaches appears to support the findings of Perry et al. (2018). Upstream of the Delta, Zeug et al. (2014) reported a significant positive relationship between Chinook salmon survival and flow in the Stanislaus River. Thus, increasing inflow can benefit salmonids from upstream tributaries through unidirectional regions of the Delta whereas exports are primarily affecting fish in the channels just downstream from the facilities.

Unlike the findings related to flow, attempts to quantify the effect of exports on survival have not produced conclusive results. This has often been attributed to correlation between San Joaquin River flow and exports and the limited range of exports during studies. Without observations outside of the current regulation, strong quantitative evidence from statistical modeling will remain elusive. Zeug and Cavallo (2014) modeled the effect of several hydrologic variables on salvage of coded wire tagged Chinook salmon released in the Sacramento and San Joaquin rivers. They reported including inflow and exports separately was superior to modeling them as a ratio. Although the response variable in that analysis was salvage, it suggests the two factors have different effects. This is further supported by Six-Year Acoustic Telemetry Steelhead Study results for 2013 which reported that "exports did not appear to have an effect on route entrainment at the head of Old River, but flows, or rather, flow and stage did". Finally the SST found that "there was no well-defined pattern of survival of San Joaquin River steelhead relative to exports except for fish that migrated through the CVP, in which case higher exports were associated with higher survival probabilities to Chipps Island."

Reclamation, in coordination with DWR, shall

- Operate to a 1:1 Inflow to export ratio for all Water Year Hydrologic Classifications in the San Joaquin Valley including transfers, as measured as a 3-day running average at Vernalis on the San Joaquin River.

The proposed ratio reflects updates science on the need for species. Although beyond Reclamation's discretion, the proposed ratio will incentivize voluntary sales, transfers, or exchanges which will result in additional flows that have not been realized in previous years due to restrictions required by the NMFS 2009 Biological Opinion. Economic gains and utility are considered as the motivating force in any market transaction (Spulber and Sabbagh 1998). Thus by increasing gains and utility of CVP water for contractors through voluntary sales, transfers, or exchanges it would be likely that additional flows would be released for export. The Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook salmon and Central Valley Spring-run Chinook salmon and the Distinct Population Segment of California Central Valley Steelhead identified the need to "establish partnerships and agreements that promote water transactions, water transfers, shared storage, and integrated operations that benefit both species needs and water supply reliability".

To address uncertainty in the best available science, Reclamation shall undertake certain monitoring and studies as described in "Addressing Uncertainty" below.

#### 2.2.2.4 Addressing Uncertainty

The science used to implement the San Joaquin I:E ratio has uncertainty. The following measures are included to address the uncertainty:

1) Reclamation will continue to implement Action III.1.3, which maintains minimum flow rates on the Stanislaus River. The flows released during the April to May time period on the Stanislaus, including all Sales, Exchanges, and Transfers will be managed by the Stanislaus River Operations Group, so that timing, shape and magnitude provide for migratory cues.
2) Also, Reclamation will continue to implement Action IV.2.3 Old and Middle River Management (OMR Management), as modified by this proposed action.
3) Reclamation will implement a second phase of the 6-year steelhead telemetry study and coordinate with the San Joaquin River Restoration Program on the monitoring array and

tagging of fish through the IEP. Such study, in combination with the 1:1 ratio and natural hydrologic variability is more likely to address the gaps identified due to the limited range of exports during prior study periods.

The 6-year steelhead telemetry study is anticipated to provide broad benefits above and beyond the implementation of this proposed action through the development of information on factors beyond the discretion of Reclamation and DWR.

### *2.2.3 Low Salinity Zone Management*

The function and size of the low salinity zone (LSZ) in the Delta can be indexed by X2, the 2 practical salinity unit (psu) isohaline, described in kilometers (km) from the Golden Gate (Figure X). The 2008 Service BO uses X2 as a surrogate indicator of fall habitat for Delta Smelt based on analyses described by Feyrer et al. (2010). The location of X2 is commonly reported in practical salinity units (psu), in accordance with a change in units in 1978, but psu are approximately equivalent to ppt. The location of X2 is also used as an indicator of delta outflow and habitat suitability for organisms in the San Francisco Estuary. A lower X2 – i.e. salts pushed further out to sea – results in more LSZ habitat.

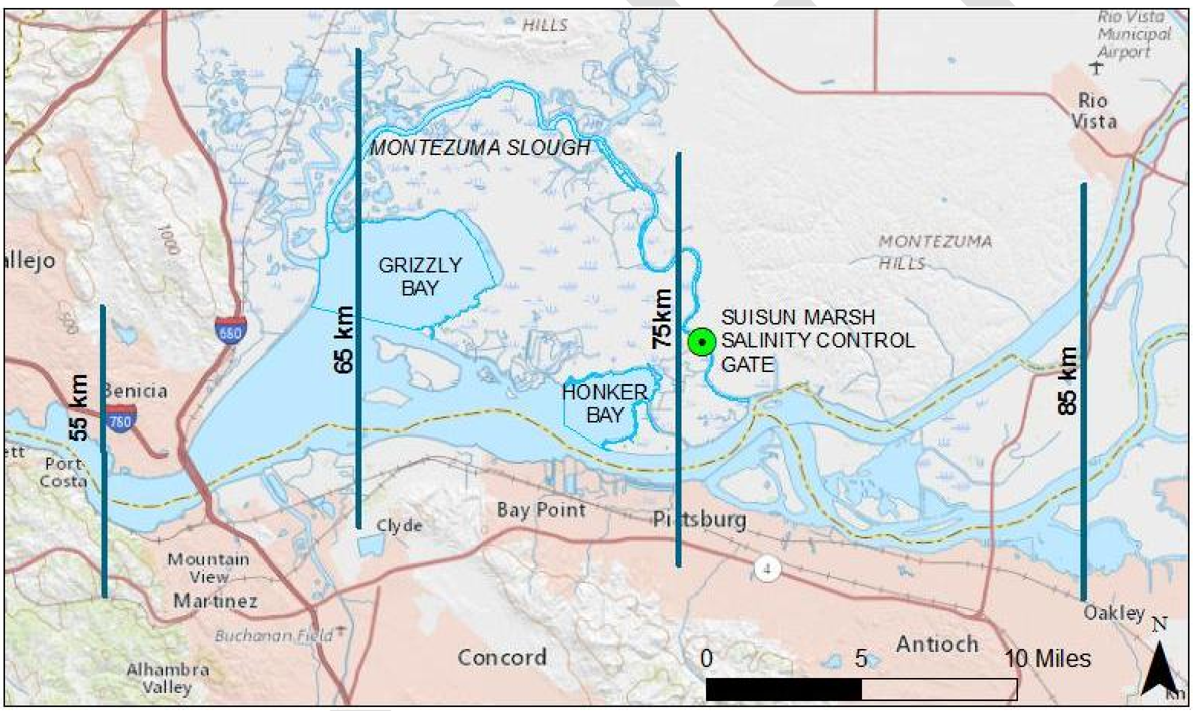


Figure X. Overview map of Suisun Marsh with distances from the Golden Gate

#### 2.2.3.1 Existing Requirements

2008 Service BO RPA Action 4

The 2008 Service BO uses Fall X2 as a surrogate indicator for fall habitat.

Objective: **"**Improve fall habitat for Delta Smelt by managing of X2 through increasing Delta outflow during fall when the preceding water year was wetter than normal. This will help return ecological conditions of the estuary to that which occurred in the late 1990s when smelt populations were much larger. Flows provided by this action are expected to provide direct and indirect benefits to Delta Smelt. Both the direct and indirect benefits to Delta Smelt are considered equally important to minimize adverse effects" (2008 Service BO).

Action: **"**Subject to adaptive management as described below, provide sufficient Delta outflow to maintain average X2 for September and October no greater (more eastward) than 74 km in the fall following wet years and 81km in the fall following above normal years. The monthly average X2 must be maintained at or seaward of these values for each individual month and not averaged over the two month period. In November, the inflow to CVP/SWP reservoirs in the Sacramento Basin will be added to reservoir releases to provide an added increment of Delta inflow and to augment Delta outflow up to the fall target. The action will be evaluated and may be modified or terminated as determined by the Service" (2008 Service BO).

In the 2008 BO Primary Constituent Elements (PCE) for critical habitat of Delta Smelt include PCE3 flow affecting the extent of the LSZ and PCE4 salinity influencing the location and extent of the LSZ.

#### 2.2.3.3 Proposed Action

(Merz 2011) observed Delta Smelt occurred over 51,800 hectares, including San Francisco Bay, Sacramento River to its confluence with Feather River, and the San Joaquin River south of Stockton, Napa River, Cache Slough, American River, Yolo Bypass and others. "Delta Smelt were observed more frequently and at higher densities (at all life stages) near the center of their range, from Suisun Marsh down through Grizzly Bay and east Suisun Bay through the Confluence to the Lower Sacramento region, and into the Cache Slough region." New information also indicates that Delta Smelt reside year-round in freshwater circumstances far upstream from the location of X2 in the estuary (Sommer and Mejia 2013, Sommer et al. 2011). Delta Smelt otolith data suggest there are three main life history strategies, 1) freshwater resident, 2) brackish water resident, 3) migratory (Bush 2017). The latter can be divided into early, middle and later migrators as they leave the freshwater habitat to the brackish and then back to fresh for spawning.

A National Research Council (NRC) Report published in 2010 described the relationship between the trawl indices and X2 as weak and confounding. It goes on to explain that, as a result, the justification for RPA Action 4 is "difficult to understand," and RPA Action 4 is based on a stepwise set of relationships "with each step being uncertain" (NRC 2010). Kimmerer et al. (2013) explains, "First, our use of salinity as the only variable that defines habitat is clearly inadequate…Given the difficulty in determining the controls on the Delta Smelt population it is not surprising that such a simple descriptor [salinity] of habitat is inadequate for this species". Delta Smelt fall occurrence is generally greatest in the LSZ and Delta Smelt generally moves upstream as the salinity field moves upstream (Sommer et al. 2011). The distribution of all life stages of Delta Smelt are affected by salinity, but "are most common in low-salinity habitat (less than 6 psu) with high turbidities (greater than 12 NTU) and moderate temperatures (7 °C to 25 °C)" (Sommer and Mejia 2013). The overall distribution of Delta Smelt occurs over a broader range of salinity than solely the LSZ; Moyle et al. 2016). A laboratory experiment tested the metabolic rates of sub-adult Delta Smelt at 0.4 psu, 2.0 psu, and 12.0 psu and found Delta Smelt "exhibited no difference in metabolic rate across the three salinities" (Hammock et al. 2017).

Additionally, during trawls in 2011 and 2014, CDFW collected Delta Smelt between 0.1 psu and 15.6 psu, with 99.7% caught at less than 12 psu. "Although Delta Smelt are physiologically euryhaline (i.e., are able to tolerate 0.4 – 34.0 ppt), the cumulative costs associated with physiological adjustments required to achieve homeostasis across a large, fluctuating salinity gradient may be higher than the continual maintenance cost for homeostasis within LSZ salinities" (Komoroske 2016). "The position of the 2 per thousand isohaline (a measure of the physical response of the estuary to freshwater flow) and increased water clarity over the period of analyses were two factors affecting multiple declining taxa (including fishes and the fishes' main zooplankton prey)" (Mac Nally et al 2010).

Studies since the 2008 Service BO did not find a significant population-level response to changes in habitat associated with Fall X2 (Mac Nally et al. 2010; Thomson et al. 2010; Maunder and Deriso 2011; Miller et al. 2012). Changes in abiotic habitat at least are known to occur with changes in position of X2. Manly et al. (2015) state that the Delta Smelt habitat index used in Feyrer et al. 2011 could be improved by "including static regional effects, dynamic salinity and turbidity effects, and an independent abundance index." Rose et al, 2013 modeled population dynamics of Delta Smelt in good and bad years, looking at factors such as salinity, temperature, zooplankton densities, hydrodynamics, and eggs per one year olds. Results suggested that management actions must address multiple stressors and different life stages. Maunder and Deriso (2011) indicated that recruitment is based on a variety of factors act different life-stages. Hamilton and Murphy (2018) using a life-cycle model identified seasonal food availability as the most frequent and pervasive factor limiting the abundance of Delta Smelt. In contrast to the relatively high productivity in the LSZ before clam invasions, the LSZ is now a net sink for phytoplankton, organic matter, and zooplankton (Jassby 2008; Kimmerer and Thompson 2014; Kayfetz 2014). Clam grazing, light limitation and ammonium inhibition all may contribute to limiting the accumulation of phytoplankton biomass (Brown et al, 2016). As Delta waters became clearer (Schoellhamer et al. 2016), and algae blooms became commonplace and invasive submerged aquatic vegetation became more pervasive, Nitrogen and Phosphorus may be more important for fish (Dahm et al 2016). Management of clams, nutrient ratios, and off-channel habitat subsidies may assist in food production in the Delta (Durand, 2015).

In 2014, the Interagency Ecological Program (IEP) Management, Analysis, and Synthesis Team (MAST) released the Fall Low Salinity Habitat (FLaSH) report to suggest studies to explore the importance of fall low-salinity habitat for Delta Smelt (Brown et al. 2014). The FlaSH report contains a lookup table between X2 and Delta Smelt fall abiotic habitat index (Brown et al. 2014). An independent science review panel noted deficiencies in the FLaSH Report and urged the agencies tasked with implementing RPA Action 4 to "formulate an explicit work plan capable of evaluating changes in the health and condition of [Delta Smelt] in response to the X2 manipulation" (Reed et al. 2011). In 2015, MAST released an updated Delta Smelt conceptual model (Figure 1) addressing factors affecting Delta Smelt throughout their life cycle. "The data generally supported the idea that lower X2 and greater area of the LSZ would support more subadult Delta Smelt (Table 6). The greatest LSZ area and lowest X2 occurred in September and October 2011 and were associated with a high FMWT index which was followed by the highest SKT index on record, although survival from subadults to adults was actually lower in 2011 than in 2010 and 2006." (IEP MAST 2015). "The position and area of the LSZ is a key factor determining the quantity and quality of low salinity rearing habitat available to Delta Smelt."

(IEP MAST 2015). Figure 1 above shows a Delta Smelt specific conceptual model (Brown et al. 2014).

A Public Water Agency 2017 Fall X2 Adaptive Management Proposal looked recruitment of Delta Smelt, LSZ area, prey density, turbidity, and temperature (ICF 2017). This analysis was used in adaptive management and altering the X2 km requirement under Action 4 for 2017.

For the effects on Delta Smelt that the management of the LSZ was intended to address, there are opportunities to meet the same habitat objectives of the Action 4 through alternative operations. The Suisun Marsh Salinity Control Gates are operated on Montezuma Slough and are currently operated by DWR from October through May to help reduce salinity in Suisun Marsh. Currently the gates operate on ebb and flood tide to induce a net downstream flow in Montezuma Slough. The SMSCG consists of three 36’ radial gates, a boat lock, and 120’ stop logs. The gates are operated based on flow in Montezuma Slough, which empties into the Grizzly Bay portion of Suisun Marsh (Figure X). Delta Smelt are “commonly found in shallow shoal areas such as Honker and Grizzly Bays in the Suisun Bay region of the estuary and larger marsh sloughs such as Suisun and Montezuma Sloughs in Suisun Marsh” (Brown et al. 2014). As described in Bever et al (2016), Grizzly Bay and Honker Bay are key regions for Delta Smelt.

Fall X2 requires large amounts of water to achieve the existing kilometer requirement in the months of September and October.

Reclamation, in coordination with DWR, shall

- Operate the gates during September and October following AN and W Water Years to achieve LSZ area in Grizzly and Honker Bays, in accordance with the objectives of Action 4. In place of a current kilometer requirement for X2 in the existing 2008 BO, Reclamation would operate, to meet a modeled hectare requirement of LSZ area. By focusing flow through Montezuma Slough, Reclamation would more effectively achieve salinity objectives. This would also help achieve habitat in key regions as described in Bever 2016. The proposed action would allow operation of the SMSCG during additional months outside (June – September) of the current operating window (October – May). Under the Proposed Action, DWR could operate the gates, in accordance with coordinated water operations, to improve habitat conditions in the Suisun Bay.
- Work with DWR to add a Western Drain to the Roaring River Distribution System (RRDS). This drain could provide food-rich water to Grizzly Bay. Adding nutrients from the RRDS into Grizzly Bay could improve food limitations described above. This improvement may also have potential to assist in achieving salinity objectives of Action 4 and the Proposed Action.
- Operate to the greatest degree practicable in November and not augment outflow in December. Currently, agreed upon implementation of the BO requires augmenting Delta outflow in December if storage is increased in November.

To address uncertainty in the best available science, Reclamation shall undertake certain monitoring and studies as described in “Addressing Uncertainty” below.

#### 2.2.3.4 Addressing Uncertainty

Action 4 of the 2008 Service BO calls for adaptive management to identify and understand uncertainties of its efficiency. The adaptive management process includes six-steps: development of conceptual models; conceptual model review and preparation of study design; performance of the action; studies to elucidate operative mechanisms; peer-review; service review and action adjustment. In August 2011, Reclamation transmitted to the Service the Adaptive Management of Fall Outflow for Delta Smelt and Water Supply Reliability (AMP), which the Service found consistent with the RPA. Although the AMP did not establish specific management actions beyond 2011, it provided a framework that could be used for adaptively managing the action in future years. The AMP includes a review of Action 4 and evaluates habitat, X2 as a surrogate, evidence for the link between habitat and abundance, hydrology, and specifics of action. The key questions identified in the AMP that remain unanswered include ecological mechanisms that link outflow to abundance, other drivers of abundance, and if there are more water-efficient ways to provide the necessary benefits.

The Proposed Action for LSZ management seeks to find more water-efficient ways to provide the necessary benefits. The Proposed Action seeks to maintain flow affecting the extent of the LSZ (PCE3) and the appropriate salinity influencing the location and extent of the LSZ (PCE4). The 2008 Service BO describes that CVP and SWP operations influence river flows (PCE3) and alter the location of the LSZ (PCE4).

Action 4 also requires a 10-year comprehensive review of the outcomes of the action and effectiveness of the AMP. The Service plans to complete the independent peer review of the full history of the action in early 2019. The 10-year review will evaluate the current state of the science, and inform the development and implementation of future actions to improve fall habitat. Elements of the review may help address uncertainty of Action 4 and the proposed action.

As part of this process, Reclamation will conduct a collaborative fall outflow and habitat monitoring, analysis and synthesis report each year for five years from the signing of the biological opinion, or sooner if circumstances warrant. Another review of the Fall X2 action will be conducted to incorporate the syntheses from the five-year period.

Reclamation is also implementing the Directed Outflow Project to study outflow actions and their benefit to Delta Smelt through paired data collections (same location and time) of abiotic and biotic habitat constituents. Sampling will occur during the Delta Smelt juvenile rearing-stage, a period known to be associated with the location of the LSZ. Results should strengthen understanding of the mechanisms and drivers impacting Delta Smelt vital rates and associated habitat features with a focus on outflow conditions. Results should assist in evaluating the benefit and feasibility of future flow augmentation actions and inform evaluations on which particular outflow-related action or group of actions provides the most benefit for Delta Smelt.

In addition, hydrodynamic models such as CalSim, DSM2 and potentially two-dimensional and/or three-dimension models will improve understanding of LSZ area in Grizzly and Honker Bays.

### *2.2.4 Transfer Window Expansion*

#### 2.2.4.1 Existing Requirements

Reclamation 2008 Biological Assessment

"Proposed Exports for Transfers apply only to the months July through September. For transfers outside those months, or in excess of the proposed amounts, Reclamation and DWR would request separate consultation." (Reclamation 2008).

#### 2.2.4.2 Proposed Action

Since the 2008 and 2009 Biological Opinions, California has experienced historic drought and facilitated increased transfers of water in order to improve flexibility and management options. As part of this proposed action, Reclamation proposes to increase the transfer window to July through November. Allowing fall transfers may provide flexibility to improve Sacramento River temperature operations, such as occurred during the 2014-2015 drought.

Water transfers (relevant to this document) occur when a water right holder within the Delta or Sacramento-San Joaquin watershed undertakes actions to make water available for transfer by export from the Delta. Most transfers occur at Banks pumping plant because reliable capacity is not likely to be available at Jones pumping plant except in the driest years. CVP's Jones Pumping Plant, with no forebay for pumped diversions and with limited capability to fine tune rates of pumping, has little surplus capacity, except in the driest hydrologic conditions. SWP has the most surplus capacity in critical and some dry years, less or sometimes none in a broad middle range of hydrologic conditions, and some surplus again in some above normal and wet years when demands may be lower because contractors have alternative supplies.

Water agencies or others seeking water transfers generally acquire water from sellers who have surplus reservoir storage water, sellers who can pump groundwater instead of using surface water, or sellers who will fallow crops or substitute a crop that uses less water in order to reduce normal consumptive use of surface diversions. This document does not address the upstream operations that may be necessary to make water available for transfer. Also, this document does not address the potential impacts of water transfers to terrestrial species. The upstream effects of other transfers and effects to terrestrial species from transfers in October and November would require a separate ESA consultation with FWS and/or NMFS.

The 2008 Biological Assessment states that most of the transfers would occur during July through September. However, in 2014 and 2015 in particular, there were several transfers that occurred in October and November. There was a October 2015 reservoir release from South Feather Water and Power Agency with 8,000 AF delivered to County of Kings, Dudley Ridge WD, Kern County WA, and MWDSC. In addition, October and Nov 2015 reservoir release from Yuba County Water Agency under the Lower Yuba River Accord to SWP and CVP of an exported amount of 2,916 acre-feet over October and November. In addition to these, there were 12 different transfers from north of delta agencies to San Luis Delta Mendota Water Authority or East Bay Municipal Utility District in October and November of 2015, totaling 179,819 acre-feet of water made available. Similarly, in 2014 there were 7 different transfers from north of Delta water agencies to San Luis and Delta Mendota Water Authority totaling 82,907 acre-feet. In 2015, Reclamation requested NMFS to extend the 2009 Biological Opinion transfer window through Nov 15, 2015 due to the drought conditions to cover these actions.

Water transfers relevant to this BA occur when a water user north of the Delta undertakes actions to make water available for transfer, generally for use south of the Delta. Water transfers requiring export from the Sacramento River watershed at the SWP and CVP Delta pumping facilities include transfers for dry-year transfer agreements, limited EWA, the Yuba Accord Water Purchase Agreements, the proposed Sacramento Valley Water Management Program, if implemented, and other agreements that may be developed between water users.

Transfers requiring export from the Delta are done at times when pumping and conveyance capacity at the CVP or SWP export facilities is available to move the water. Additionally, operations to accomplish these transfers must be carried out in coordination with CVP and SWP operations, such that the capabilities of the Projects to exercise their own water rights or to meet their legal and regulatory requirements are not diminished or limited in any way. Other than the expanded transfer window, exports for transfers would have to be consistent with the terms of the 2008 and 2009 Biological Opinions and could not infringe upon the capability of the Projects to comply with the other terms of the opinions. In particular, parties to the transfer are responsible for providing for any incremental changes in flows required to protect Delta water quality standards. Transfers that result in elevated flow in the Sacramento River in fall-run spawning areas would be carefully timed or restricted to small flow increases to avoid fall-run redd dewatering concerns after the transfer, conflicting with Winter-run cold water pool management. All transfers will be in accordance with all relevant regulations and requirements.

Reclamation and DWR intend to apply all response plan criteria consistently for JPOD uses as well as water transfer uses. When summer or fall pumping capacity is available at Banks or Jones Pumping Plant to facilitate water transfers, JPOD may be used to further facilitate the water transfer.

Although transfers may occur at any time of year, proposed exports for transfers apply only to the months July through November. In consideration of the estimates of available capacity for export of transfers during July-November, the transfers in October and November that occurred in 2014 and 2015, and in recognition of the many other possible operations contingencies and constraints that may limit actual use of that capacity for transfers, the proposed use of SWP/CVP export capacity for transfers is as follows:

| Water Year Type | Maximum Transfer Amount |
|---|---|
| Critical | Up to 800 Thousand Acre-Feet |
| Dry (following Critical) | Up to 600 Thousand Acre-Feet |
| Dry (following Dry) | Up to 600 Thousand Acre-Feet |
| All other years | Up to 360 Thousand Acre-Feet |
| | |

The structure for proposed transfers would ensure that resulting flows in the Sacramento River in Fall-run Chinook Salmon spawning areas are timed or restricted to small flow increases to avoid redd dewatering and avoid conflicting with Winter-run Chinook Salmon cold water pool management.

To address uncertainty in the best available science, Reclamation shall undertake certain monitoring and studies as described in “Addressing Uncertainty” below.

#### 2.2.4.2 Addressing Uncertainty

Reclamation and DWR would implement redd monitoring and temperature monitoring and modeling, per the existing 2008 and 2009 BOs to address uncertainty related to the transfer window expansion. These actions would be coordinated through operations groups and collaborative forums as appropriate.

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## *Section 2.2.4*

Reclamation, 2018. “Six-Year Acoustic Telemetry Steelhead Study.”

# Appendix A – Juvenile Chinook Salmon Distribution and Timing

The figure below shows Sacramento Beach seine raw catch from 2003-2016. Beach seining is used to monitor and assess the effects of water operations on the inter- and intra-annual abundance and distribution of juvenile Chinook salmon occurring in mostly unobstructed nearshore habitats (for example beaches and boat ramps; Kjelson et al, 1982). Beach seine and trawl data results indicate that fry and smolt sized individuals occupy both open water mid-channel and near shore littoral habitats (Speegle et al, 2013). Delta beach seine data and other investigations (e.g., Kjelson et al. 1982) imply that fry may prefer near-shore littoral habitat and that smolts may prefer to occupy open water mid-channel habitat during the day (Speegle et al, 2013). While beach seine data is used to assist in estimating abundance of out-migrating juvenile Chinook salmon, it may be representative of Winter-run Chinook salmon fry rearing, as beach seines sample from the littoral zone at the edges of the channel.

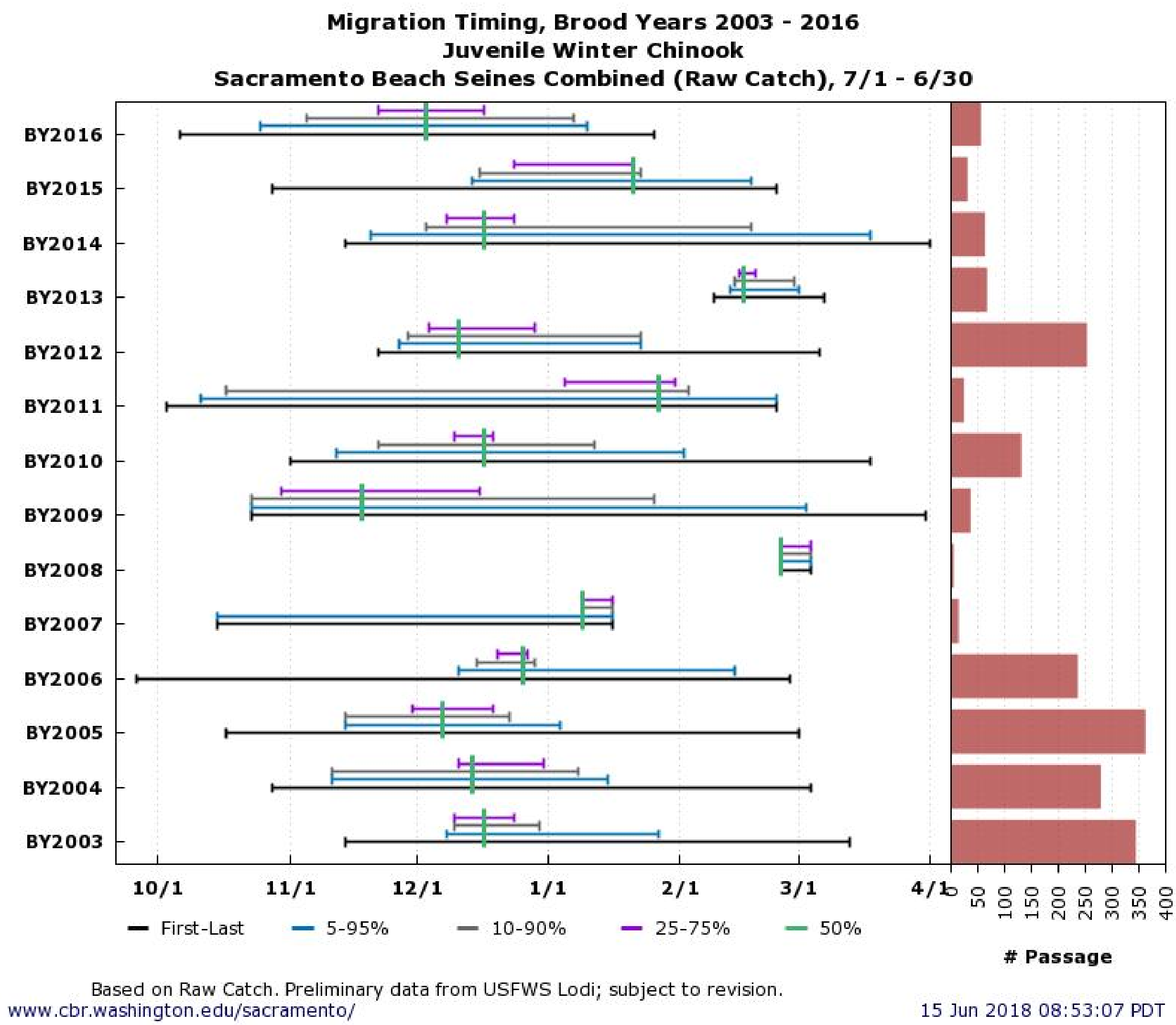


Figure 1. Winter-run Juvenile Chinook Salmon Sacramento Beach Seines. Figures from SacPAS.

Figure 2 below shows the emigration timing of juvenile Winter-run Chinook salmon from brood years 2008-2016 from SacPAS, based on raw catch data at the Chipps Island trawl from the

USFWS in Lodi. As can be seen on the figure, the first fish may begin emigrating out of the Delta as early as December, but in years like 2011, this first fish is not indicative of the whole population. This figure also shows that migration timing is highly variable. In 2015, the majority of the population migrated out of the Delta in early April, but in 2013, the majority migrated out in early March.

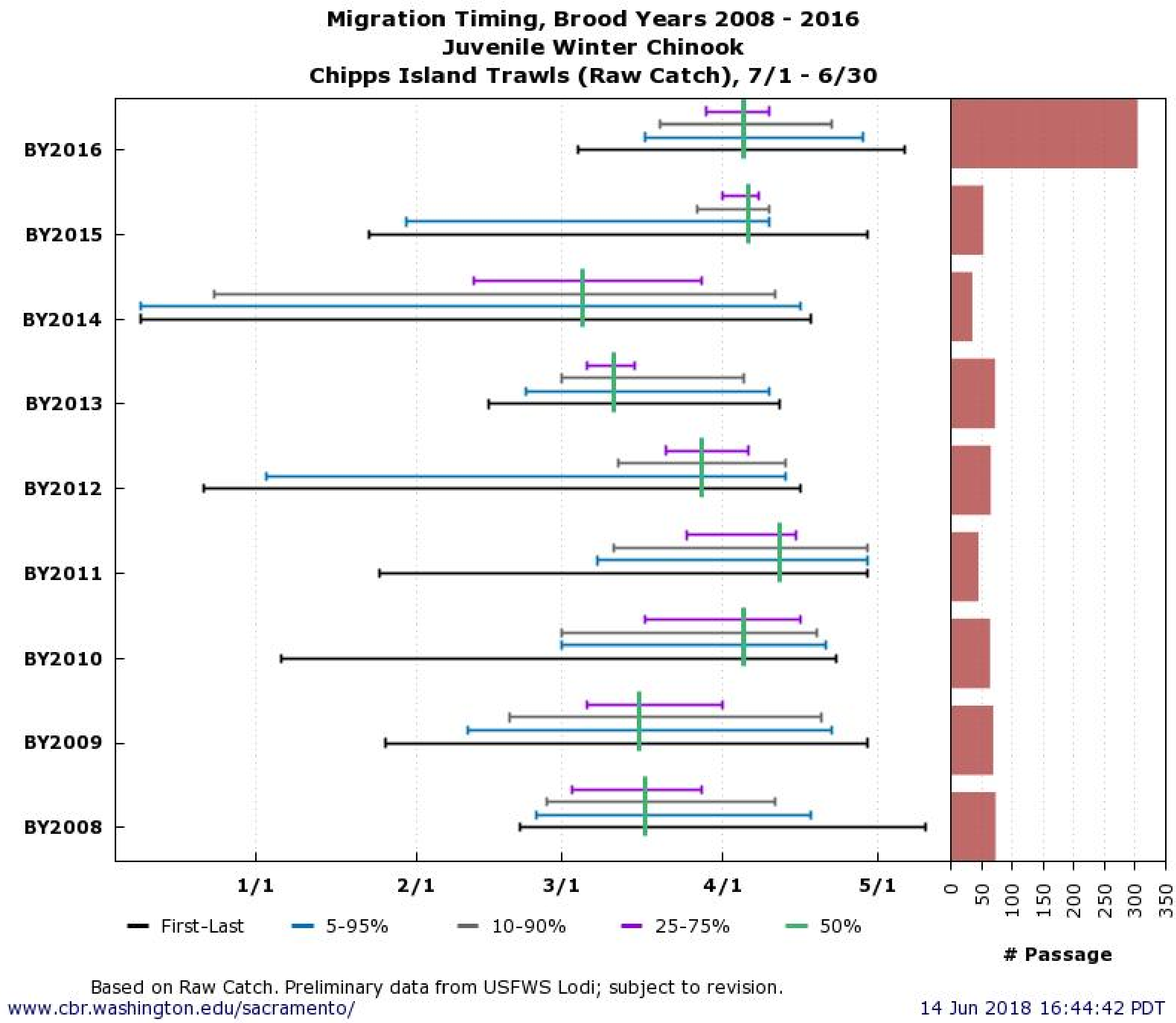


Figure 2: Juvenile Winter-run Chinook Salmon Migration Timing. Figures from SacPAS: http://www.cbr.washington.edu/sacramento/data/query_hrt.html

Comparing Figure 1 to Figure 2, we can see that juvenile Winter-run Chinook salmon are in the littoral zone at a different timing than they are migrating past Chipps Island. This behavior, possible fry rearing, happens earlier in the year.

Relatively limited study has been done of rearing salmonids in the Delta. Erkkila et al (1950) stated that “the population of juvenile fish in the Delta from February to June is composed entirely of seaward migrant king salmon”. While current populations and species assemblage are certainly much different than those observed in 1950, it appears that some juvenile Chinook salmon may rear in the Delta before migrating out. Kjelson et al. (1982) demonstrated that CWT fry (<70 mm FL) reared in the Estuary for up to two months, primarily in the upper freshwater portion of the Delta. As stated by Rosario et al (2013), "Winter-run appear to be present in the Sacramento River system or Delta nearly year round—they are first detected emigrating from their natal grounds at Red Bluff in July, and last detected leaving the Delta at Chipps Island as smolts as late as May. Typically, the 50th percentile of the sampled population passes Red Bluff in early October, enters the Delta at Knights Landing 2 months later in December, and leaves the Delta at Chipps Island 3 months later in March. Apparent residence time between arrival at Knights Landing and departure at Chipps Island was, on average, 87 days, or nearly 3 months. In some cases, average residence time was short, approximately 40 days (e.g., 2000, 2001), and in others it was long, over 110 days (e.g., 2002, 2006). The range of arrival time into the Delta was broad, as influenced by the timing of the first flow events that triggered migration; whereas the range of departure time was relatively narrow, suggesting winter-run juveniles tend to leave around the same time each year."

Based on the trawl and seine data presented above as well as the studies showing some rearing of salmon in the Delta, Reclamation's conceptual model is that Chinook salmon migrate downstream to the Delta during the fall and winter, rear (and continue smoltification) in the Delta during the winter and spring, and complete the emigration process by leaving the Delta in the spring. Reclamation believes that the purpose of OMR triggers are to identify when a population level effect is about to occur and avoid it before occurrence. Reclamation conceptualizes that rearing in the Delta is done in small groups of juvenile fish, and that these rearing fish are less vulnerable to the effects of exports as they are in slower moving or shallower areas less likely to be drawn towards the facilities. Reclamation conceptualizes that if one of these rearing salmonids is entrained into Jones or Banks Pumping Plants, this entrainment may not indicate a population level effect is imminent, as the rearing salmonids are at a different timing than migratory smolts and may be in smaller groups.

Therefore, Reclamation proposes using 5% of the winter-run population passing Chipps Island as an alert to Reclamation that fish are beginning their emigration phase and may be vulnerable to adverse effects due to exports. At this point, Reclamation would begin the OMR salmonid action with OMR flows no more negative than -5000 cfs.

Reclamation proposes using the fish distribution estimates produced by DOSS to inform Reclamation when fish are exhibiting the migratory behavior, and therefore, are at greater risk of adverse effects due to exports. As shown by Figure 5-2 below from the 2015 DOSS report, DOSS fairly accurately predicts on a weekly basis when fish are yet to enter the Delta, in the Delta, and have exited the Delta. The distribution estimates produced by DOSS are based on all relevant monitoring conducted in the region and represent use of the best available scientific data. DOSS' estimate of fish passing Chipps Island exceeding 5% of the winter-run population will be used as an alert to Reclamation that fish are beginning their emigration phase and may be vulnerable to adverse effects due to exports. Reclamation would then use this alert to evaluate initiating the OMR action and likely limit OMR flows to no more negative than -5000 cfs (with the exceptions noted below) until DOSS estimates 95% or more of the winter-run have passed Chipps Island.

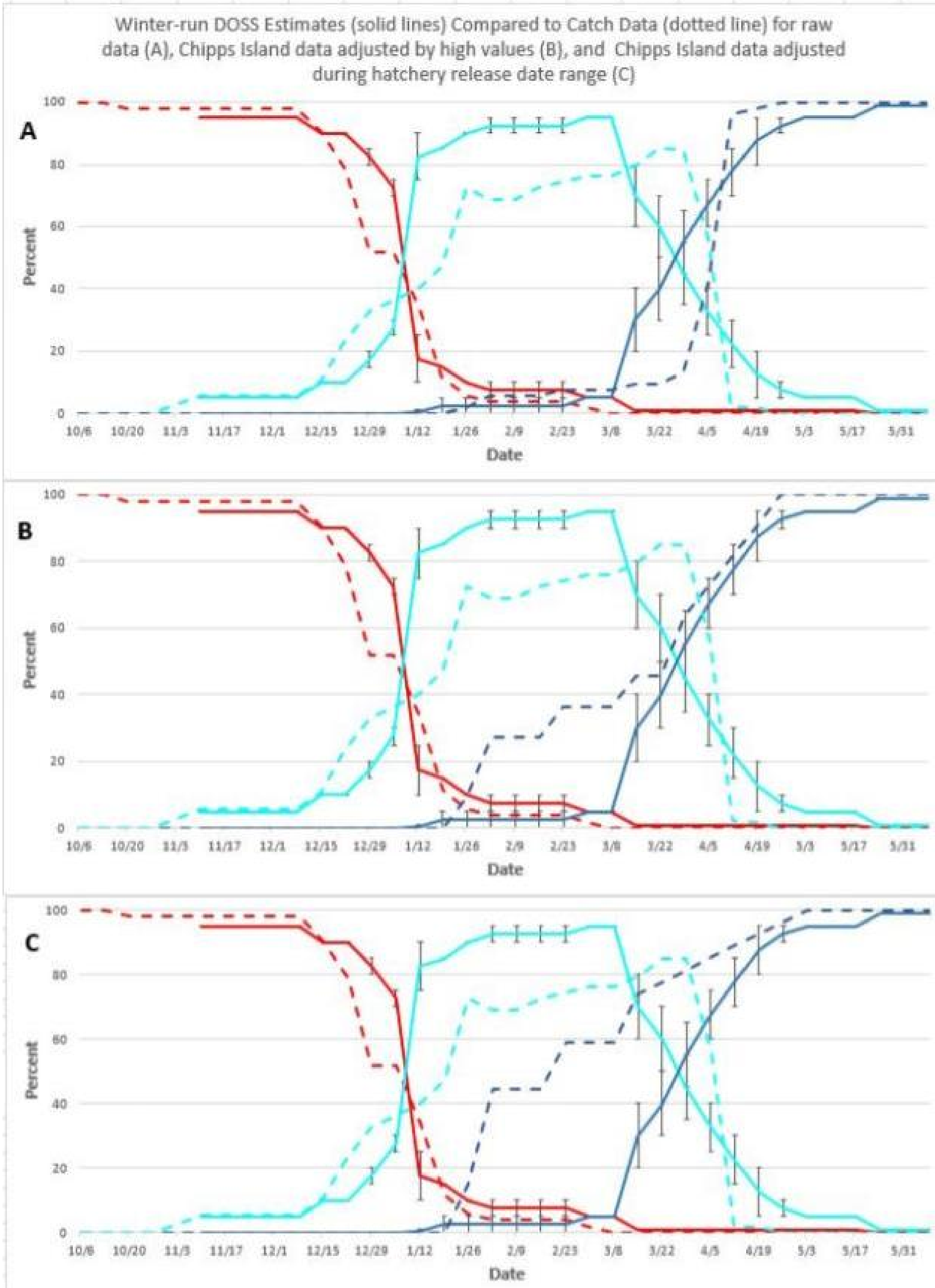


**Figure 5-2** Winter-run weekly DOSS estimates compared to raw data (A), adjusted high values only (B), and adjusted hatchery release date range (C). Red lines indicate "Yet to Enter the Delta", turquoise lines indicate "In Delta", and dark blue lines indicate "Exited the Delta". Solid lines are weekly DOSS estimates and dashed lines are catch data.