Effects to Delta Smelt from Operations of the CVP/SWP

This section analyzes components of the project that have effects to delta smelt as denoted in Table 2: Components of the Proposed Action within the *Description of the Proposed Action* section. Most project elements occur within the Delta and are discussed below. The remaining project components occur upstream of the Delta, where the operations have effects on delta smelt that are not realized until the flow reaches the Delta.

The following CVP and SWP project elements are listed in Table 2: Components of the Proposed Action and included in the modeling results (except where indicated that the modeling does not reflect the PA): (1) Divert and store water consistent with the obligations under water rights and decisions by the State Water Resources Control Board, (2) Shasta critical determinations and allocations to water service and water repayment contractors, and (3) Minimum export rate. The effects of these project elements are consistent with and included in the "Seasonal Operations of Banks and Jones" section below; therefore, the effects of these project elements are not specifically discussed in this effects analysis.

1.1 Seasonal operations of Banks and Jones

1.1.1 Effects of entrainment from seasonal operations and OMR management

Overview

The following effects analysis addresses potential effects of the operation of existing CVP and SWP water facilities in the Delta. Effects that typically result from the operation of large water diversions are entrainment or injury of delta smelt that come in contact with the fish facility as water is being diverted (i.e., salvage). Other impacts are those associated with the actual diversion of large quantities of water from the river, which can affect flow patterns, hydrodynamics, and resulting habitat features and ecological processes that vary with changes in river flows into the estuary.

Entrainment

Entrainment is used to assess direct injury or loss of delta smelt from the diversion of water. Entrainment can occur whenever delta smelt are present in river (or estuary) water that is diverted (or exported), creating the opportunity for delta smelt and/or their food supply to follow the flow of diverted water and become entrained (i.e., lost from the Bay-Delta ecosystem). The entrainment footprint in the south Delta extends beyond the CVP and SWP facilities into adjacent waterbodies (Kimmerer and Nobriga 2008; Andrews *et al.* 2016; Hutton *et al.* 2018).

The entrainment of delta smelt into the south Delta, the CVP and SWP fish facilities, and the Banks and Jones pumping plants is a direct effect of SWP and CVP operations. Salvage has historically been used as an indicator of entrainment resulting from CVP and SWP exports from the south Delta, but as the abundance of delta smelt has continued to decline, salvage has also declined and is currently not considered to be a reliable indicator of entrainment. Salvage is an extrapolated estimate of the number of fish at each fish facility and subsequently returned to the

Delta through a truck and release operation. For a representative description of fish salvage operations, see Brown *et al.* (1996) for a discussion of the Skinner Fish Facility.

Even under the best of conditions, the salvage estimates are indices of entrainment - most entrained fish are not observed (Table 1), so most of the fish are not salvaged and do not survive to be observed at the fish facilities (Castillo *et al.* 2012). Bennett (2005) suggested that many, if not most, of the delta smelt that reach the fish facilities likely die due to handling stress and predation; however, recent studies suggest there may be relatively high survival of adult delta smelt during collection, handling, transport, and release when they are salvaged during cool temperature conditions (Morinaka 2013). There is no data on the survival on these fish post-release. Pre-screen loss due to predation near and within the CVP and SWP fish facilities is an additional cause of mortality for delta smelt. In one study, pre-screen loss of captive-reared delta smelt released into CCF ranged from about 90% to 100% for adults and nearly 100% for juveniles (Castillo *et al.* 2012).

Factor	Adults	Larvae < 20 mm	Larvae >20 mm and Juveniles	Source
Pre-screen loss (predation prior to encountering fish salvage facilities)	CVP: unquantified; SWP: 89.9–100%	Unquantified	CVP: unquantified; SWP: 99.9%	SWP: (Castillo *et al.* 2012)
Fish facility efficiency	CVP: 13%; SWP: 43–89%	~0%	CVP: likely < 13% at all sizes, << 13% below 30 mm (based on adult data); SWP: 24–30%	CVP (Kimmerer 2008; adults only), SWP: (Castillo *et al.* 2012)
Collection screens efficiency	~100%	~0%	<100% until at least 30 mm	(Service 2011)
Identification protocols	Identified from subsamples, then expanded in salvage estimates	Not identified	Identified from subsamples, then expanded in salvage estimates	(Service 2011)
Collection and handling	48-hour experimental mean survival of 93.5% (not statistically different from control) in 2005; 88.3% in 2006 (significantly less than 99.8% of control)	Unquantified	48-hour experimental mean survival of 61.3% in 2005 and 50.9% in 2006 (both significantly less than mean control survival of 82.0–85.9%)	(Morinaka 2013)
Trucking and release (excluding post-release predation)	No significant additional mortality beyond collection and handling (above)	Unquantified	No significant additional mortality than collection and handling (above), although mean survival was 37.4% in 2005	(Morinaka 2013)

Table 1. Factors affecting delta smelt entrainment and salvage.

Presently, the Service considers delta smelt to almost always be entrained (and therefore lost to the population) if they enter Old or Middle rivers except under extremely wet San Joaquin Basin conditions. The salvage of delta smelt does not return meaningful numbers of fish back into the Delta (Castillo *et al.* 2012). Thus, the particular source of mortality of delta smelt in the south Delta is not especially important like it is for fish species that are more effectively salvaged (*e.g.,* Chinook salmon and steelhead). Most delta smelt that enter the southern Delta via Old and Middle river are assumed to be eaten by predators before they reach the fish facilities. However, if not managed carefully, the more negative modeled OMR flows under the PA could increase the entrainment of delta smelt into Old and Middle rivers. Generally speaking, increases in entrainment translate into higher mortality of individuals from predation and the removal of fish from the Bay-Delta ecosystem into canal systems in which they will not survive.

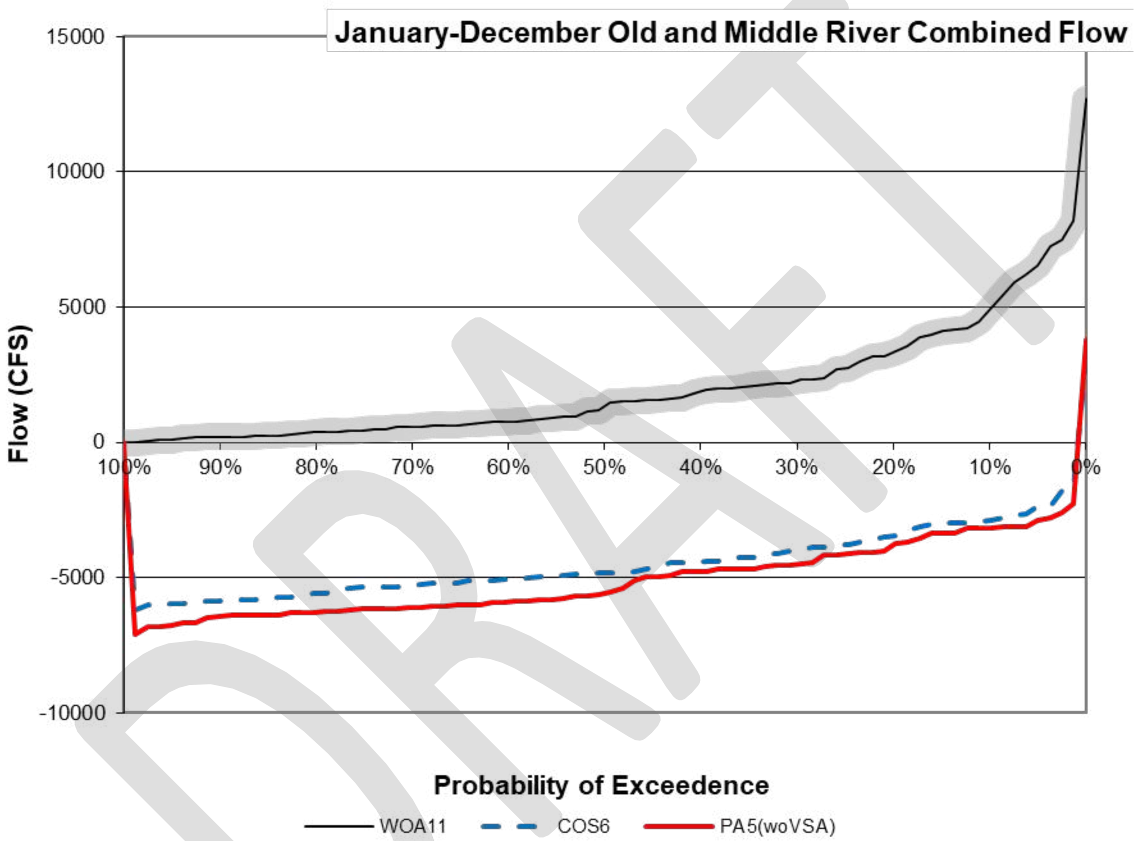


Figure 1. Modeled OMR flow. (Source: ROC BA 2019).

Larval, juvenile, and adult delta smelt are entrained into the south Delta during the migration, spawning, and transport periods of their life cycle (Kimmerer 2008; 2011; Grimaldo *et al.* 2009; Sommer *et al.* 2011). Delta smelt were previously considered 'semi-anadromous' and assumed to make a somewhat coordinated and generally eastward spawning migration into the Delta (Service 1993; Bennett 2005; Sommer *et al.* 2011). Newer research suggests that rather than a "migration", the fish disperse in multiple directions during winter storms (Murphy and Hamilton 2013; Polansky *et al.* 2018). Adult delta smelt show up in fish salvage counts typically during the winter dispersal period. Salvage of adults has mainly occurred from December through March (Kimmerer 2008; Grimaldo *et al.* 2009).

For adults, the risk of entrainment is influenced by net negative flow (stronger flood tides than ebb tides) and turbidity in the south Delta (Grimaldo *et al.* 2009; Figure 1). Project pumping (*i.e.,* the export of water from the Delta) can cause the tidally filtered or "net" flows in Old and Middle river and other south Delta channels to move "upstream" toward the facilities. This occurs when water removed by Banks and Jones, along with other diversions in the area, is back-filled by tidal and Sacramento River flows. This phenomenon is mathematically depicted as negative flow. The net OMR flows indicate how strongly the tidally averaged flows in these channels are moving toward Banks and Jones pumping plants. More net negative OMR flows and higher turbidity are often associated with adult delta smelt entrainment, but no particular OMR flow assures entrainment will or will not occur. It is possible the net flows themselves are the mechanism that increases entrainment risk for young delta smelt. However, high exports can also lead to strong tidal asymmetry in Old and Middle rivers where flood tides toward the pumps become much stronger than the ebb tides away from the pumps (Service 2008), so altered tidal flows are a second, covarying, mechanism that could increase risk of entrainment particularly of adult delta smelt if they are using tide-surfing behaviors to move (Sommer *et al.* 2011; Bennett and Burau 2015). The real-time management of adult delta smelt entrainment risk proposed in the PA is based on OMR flow and turbidity management.

As discussed in the *Status of the Species Within the Action Area* and *Status of the Critical Habitat Within the Action Area* section for delta smelt, the Service has explored the development of models indicating historical increases in proportional entrainment during observations of higher turbidity during the period of December-February (Appendix 2). Additionally, since 2008, turbidity management has become a widely accepted concept for managing adult delta smelt entrainment, following the concept that delta smelt dispersal in response to winter flow pulses will more often than not coincide with higher turbidity (Sommer *et al.* 2011).

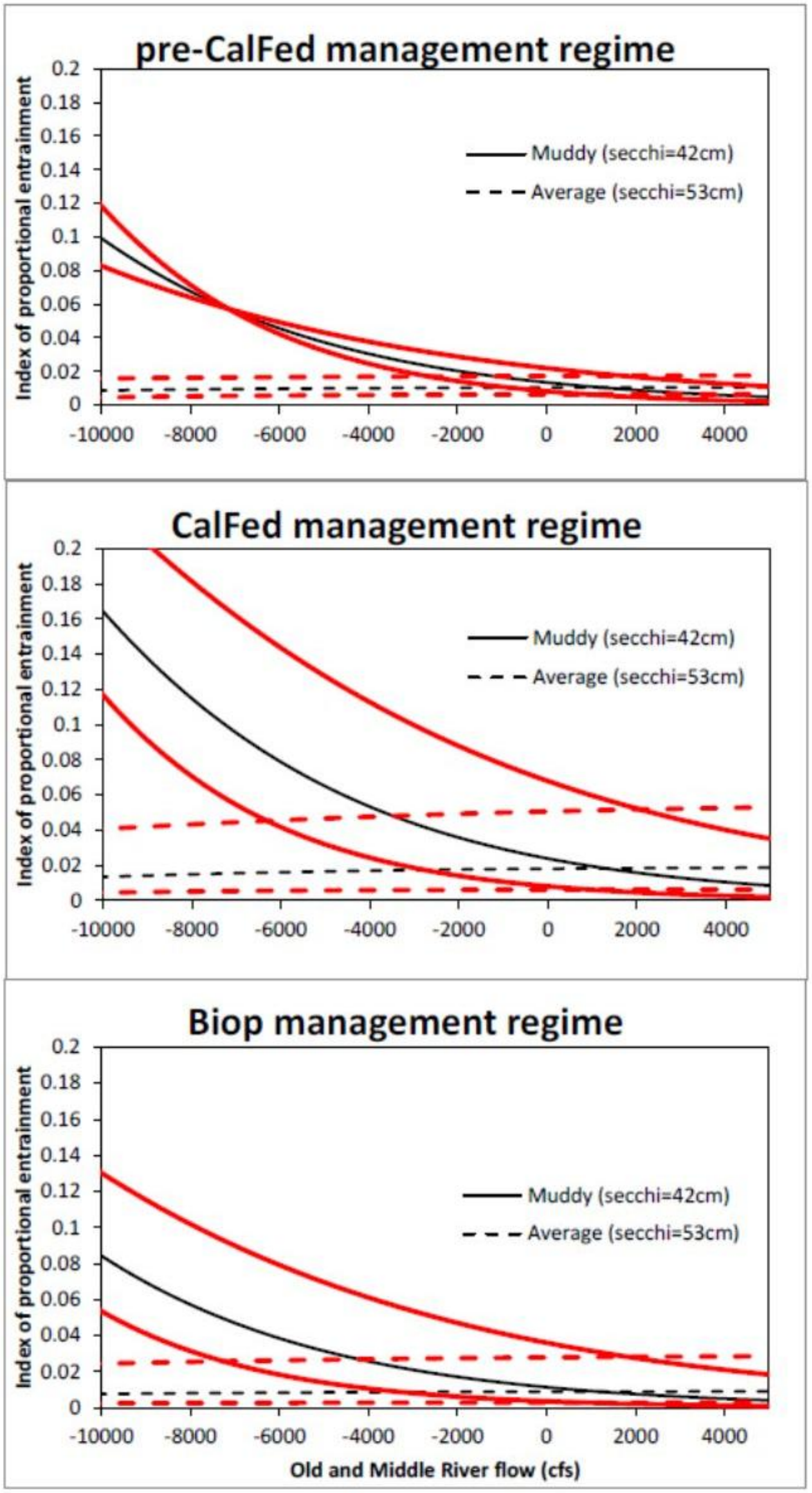


Figure 2. Predictions from a beta regression model of the variability in an index of proportion of the adult delta smelt population entrained into the south Delta fish facilities and pumping plants that can be explained by an interaction between OMR flow and

average Secchi disk depth measured in concurrent fish surveys (December-March). See Appendix 2 for further details. Source: USFWS unpublished data analysis.

Given there are demonstrated relationships between delta smelt entrainment and salvage with OMR flows (Kimmerer 2008; Grimaldo *et al.* 2009), this effects analysis evaluates the differences between the PA and the current operations scenario (COS) as they are modeled using CalSim II. To analyze entrainment effects, we will examine the modeled OMR flows by each month during which delta smelt protections may be in place, from December through June. Important assumptions that were used in the CalSim II model that differ from what is described in the PA are depicted in the Table 2.

OMR Management Action	CALSIM II Modeling Assumptions	PA Implementation Language
Integrated Early Winter Pulse Protection (for delta smelt)	After December 1, when the 3-day average turbidity is 12 NTU or greater at Old River at Bacon Island (OBI), Prisoner's Point (PPT) and Victoria Canal (VCU), projects will operate to 14-day average OMR index of -2,000 cfs for 14 days.	Projects will maintain an OMR flow of -3,500 cfs instead of -2,000 cfs. The modeling simulates more protective flows than real-time implementation.
Turbidity Bridge Avoidance (for adult delta smelt)	If Rio Vista flow is greater than or equal to 20,000 cfs, projects will operate to 14-day average OMR index of -2,000 cfs for five days in January and February.	Freeport flow must be greater than or equal to 20,000 cfs and turbidity at Freeport must be greater than or equal to 50 NTU.
WIIN Act Storm-Related OMR Flexibility	In AN and BN years, there will be one opportunity in January and one opportunity in February to operate to a 14-day average OMR index of -6,000 cfs when increased pumping due to a storm is possible. In Dry years, only one opportunity in January or February is modeled. In Wet years, no flexibility is modeled.	The maximum (otherwise-permitted) export rate of 14,900 cfs may be taken, if turbidity at Bacon Island does not exceed 12 NTU. This could result in a range of OMR flow values. A duration of action is not specified.
Species-specific cumulative salvage or loss threshold	In AN and BN years, OMR during April and May will be -3,500 cfs.	Projects will operate OMR to -3,500 cfs when 50% loss threshold is reached. Projects will operate OMR to -2,500 when 75% loss threshold is reached (or more positive if determined by Reclamation).

Table 2: Key differences between modeling assumptions and PA actions.

OMR flow can be estimated from CalSim II, but turbidity cannot. Therefore, the expected entrainment resulting from the PA cannot be estimated accurately and conditions have to be evaluated in real-time. The differences between modeling assumptions and how OMR management is described in the PA are important when considering the bounds of possible OMR flow scenarios during real-time implementation of the PA. For these four elements highlighted in the table, the modeling will depict a scenario that is more protective for delta smelt than the PA as written. The decision-making groups described in the PA will assess the appropriate real-time OMR management response to these variables, which may result in implementation of the PA as written, or operation closer to that depicted in the modeling, depending on real time conditions.

The analyses of the potential effects of the PA on different life stages of delta smelt that are presented in the sections below address direct effects of water exports (such as entrainment) and indirect effects (such as predation).

Adult Entrainment

In December, OMR flows described in the PA will be similar to current operational conditions (ROC BA 2019; Figure 3). OMR flow under current conditions is almost always more negative than -4,000 cfs in December, during which it is typical to see high rates of pumping. Under the PA, unless conditions trigger the Integrated Early Winter Pulse Protection of the OMR Management actions, OMR flows will be similar to current conditions, though the PA modeling does not reflect this action precisely.

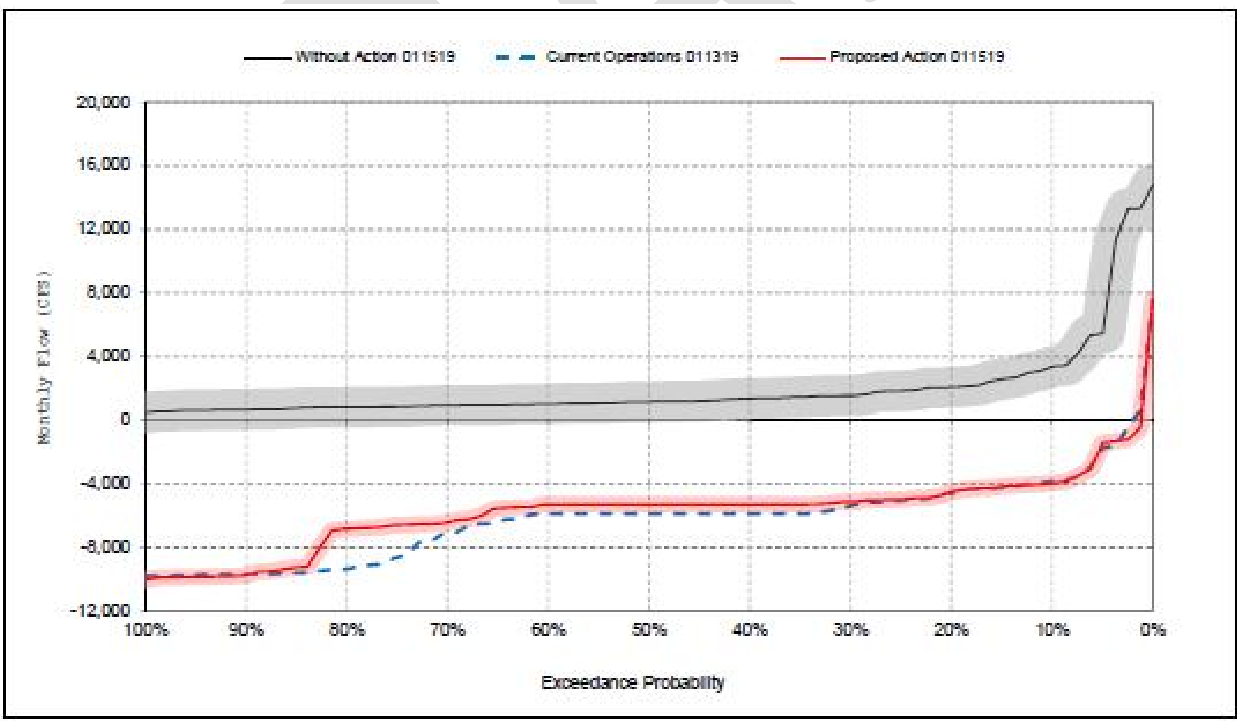


Figure 3. Mean Modeled Old and Middle River Flows, December (ROC BA 2019)

Under the PA, average OMR flows may be slightly more negative than current operations in January, February, and March, but generally will not exceed -5,000 cfs due to the Additional Real-Time OMR restrictions. As noted in Table 2, storm flexibility actions may be taken that were modeled at -6,000 cfs. During the adult delta smelt spawning dispersal, OMR flows in the PA are expected to be slightly more negative than the COS but generally bounded at -5,000 cfs by the implementation language in Table 2 (ROC BA 2019; Figures 4-6).

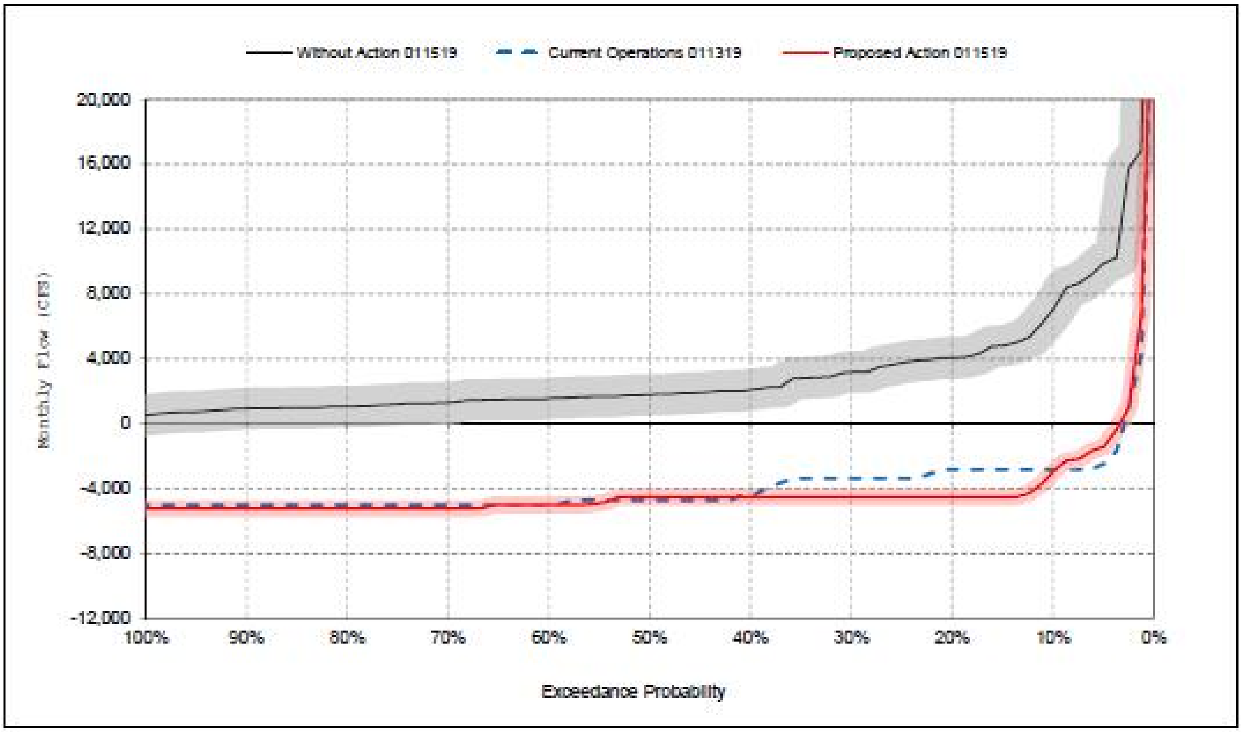


Figure 4. Mean Modeled Old and Middle River Flows, January. (ROC BA 2019)

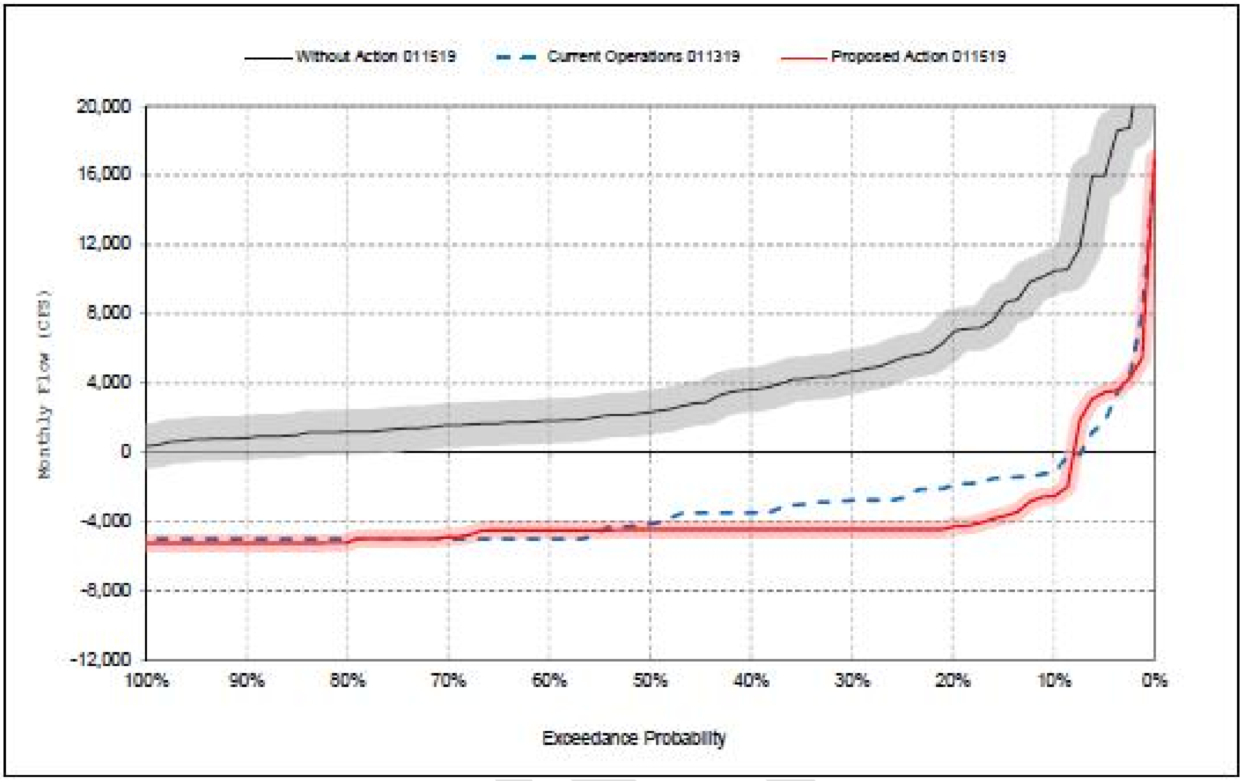


Figure 5. Mean Modeled Old and Middle River Flows, February. (ROC BA 2019)

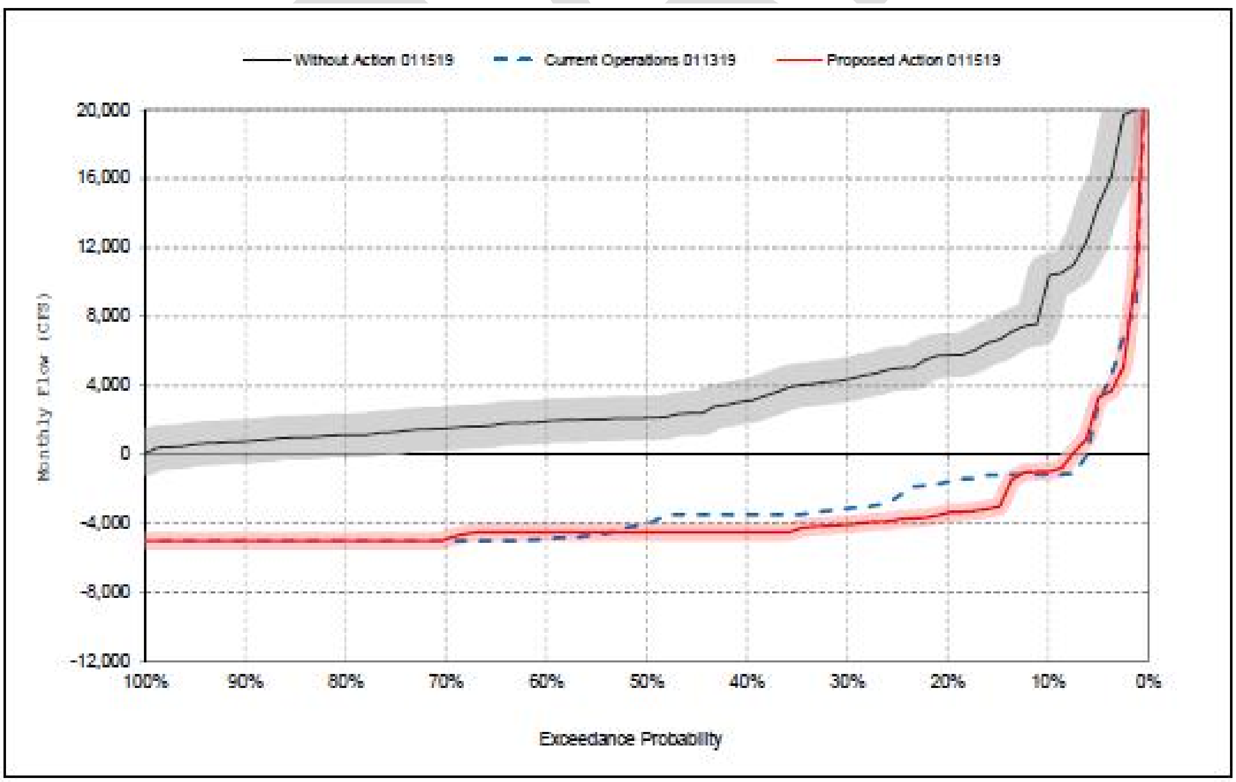


Figure 6. Mean Modeled Old and Middle River Flows, March. (ROC BA 2019)

Given that projected OMR flow conditions overall are expected to become more negative during the peak of the spawning dispersal from January through March under the PA, it is important to consider entrainment risk during this time in the context of OMR and turbidity. While there is no OMR flow value that guarantees entrainment of delta smelt, the exploration of the effects of turbidity management actions since 2008 have shown promising results for reducing entrainment when initiated early.

Adult entrainment risk, related to exports from the south Delta, may increase as a result of more negative OMR flows as modeled in the PA. The PA proposes to use a suite of protective actions, identified in the PA as Additional Real-time OMR Management, to manage entrainment risk of delta smelt in real-time. Under turbid conditions, entrainment risk may increase if the Directors of NMFS and USFWS choose to authorize Reclamation and DWR to operate to a more negative OMR than what is specified in "Additional Real-Time OMR Restrictions", but no more negative than -5,000 cfs.

The PA proposes the suite of OMR Management actions described in Table OMR. The Early Integrated Winter Pulse Protection action is meant to replace Action 1 of the 2008 BiOp, which called for the projects to reduce negative OMR flows to -2,000 cfs for 14 consecutive days if a turbidity trigger was met; the 2008 trigger was based on three-day averages being greater than or equal to 12 NTU at three separate stations in the south Delta. The Early Integrated Winter Pulse Protection action uses the Freeport station on the Sacramento River as an early indicator of turbidity dispersal into the Delta. The Freeport station, which is on the Sacramento River, is used because most of the sediment that enters the Delta is delivered by the Sacramento River (including the Yolo Bypass), and can provide advance warning that operational changes may be needed. If the Freeport inflow and turbidity triggers are met, the facilities would modify operations, including reducing exports if necessary, in order to reduce negative OMR flows to -3,500 cfs for 14 consecutive days.

As described in the *Status of the Species Within the Action Area* and *Status of the Critical Habitat Within the Action Area* sections, based on current information, the Service believes that adult delta smelt disperse during early winter storms. The storms increase river inflows to the Delta, and therefore, net westward flows. When inflows increase enough, they can bring large quantities of sediment into the Delta and increase water turbidity. The tides and net flows then interact to disperse that turbidity. Delta smelt appear to respond to this seasonal change in their environment by spreading out (increasing their spatial distribution; Sommer *et al.* 2011; Murphy and Hamilton 2013). Not all of the delta smelt's movements during this seasonal dispersal are upstream. However, some individuals do move upstream and it is believed that net upstream movement against net downstream flow is facilitated by fish changing their distribution in the channel in response to tidal flows (Bennett and Burau 2015; Polansky *et al.* 2018).

Some of the delta smelt that disperse upstream move up the Sacramento River and some move up the San Joaquin River. Suitable spawning habitat is believed to be available in both primary channels. This seasonal re-distribution of adult delta smelt makes it clear that they can resist net flow directions and therefore, modeling tools like DSM-2 PTM that provide information about net flow directions will not be able to predict adult delta smelt movements. However, PTM modeling can provide information about the hydrodynamic influence of the Banks and Jones pumping plants on net water movement in the Delta (e.g., Kimmerer and Nobriga 2008) enabling an evaluation of how different OMR flows draw water off of potential spawning locations like the main stem of the San Joaquin River.

The Integrated Early Winter Pulse Protection action is not represented in the PA modeling, so the Service summarized available DSM-2 PTM data to evaluate the hydrodynamic difference between the proposed -3,500 cfs action and the -2,000 cfs limit in Action 1 of the 2008 biological opinion. On average, predicted entrainment of (neutrally buoyant) particles off of the mainstem San Joaquin River is higher at -3,500 cfs than -2,000 cfs (Figure 7). However, at -3,500 cfs, particles released in the river main stem are still at least as likely to avoid entrainment as to be entrained. This contrasts the results for particles released into Old and Middle rivers, which have a high likelihood of being entrained at both -2,000 and -3,500 cfs. This suggests that at -3,500 cfs, the projects' hydrodynamic influence on the river main stem where the Service believes spawning may occur would not be excessive and that tide-surfing fish could ascend the river to the modeled locations without being strongly cued to enter Old and Middle rivers where their entrainment or the entrainment of their progeny would be a likely outcome.

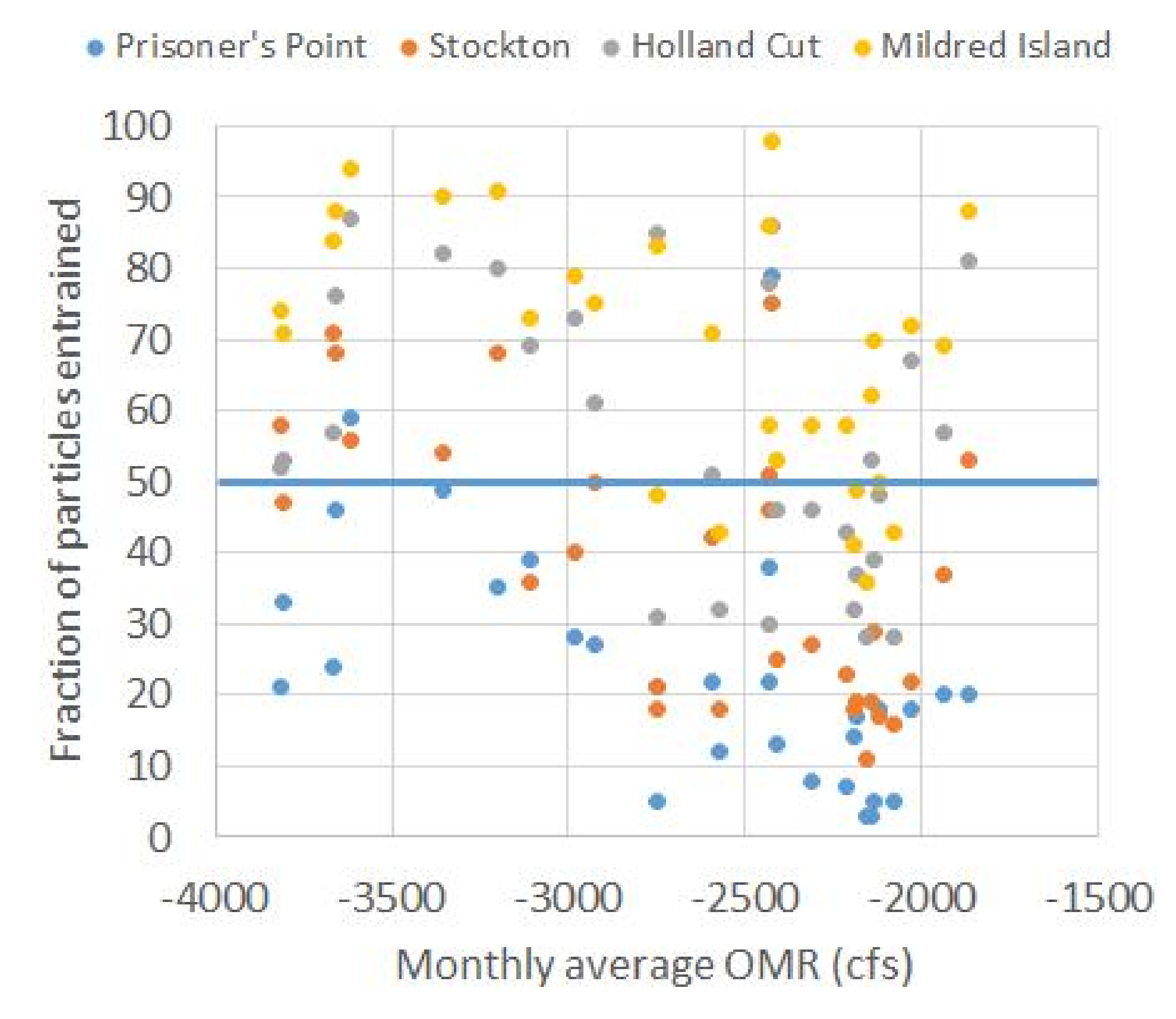


Figure 7. Scatterplot of monthly average OMR flow versus predicted particle entrainment 30 days after release from the four locations listed in the legend. Prisoner's Point and Stockton represent particle release sites on the main stem of the San Joaquin River. Holland Cut and Mildred Island represent particle release sites in Old and Middle rivers, respectively. Data points above the solid blue line reflect model runs in which particles were more likely than not to be entrained into the Banks and Jones pumping plants, whereas data points below the line reflect model runs in which particles were more likely than not to avoid being entrained. Data source: USFWS unpublished summary of data provided by CH2M Hill. Service staff queried the results from a comprehensive database of DSM-2 PTM runs for month-year combinations that bracketed an OMR range of -2,000 to -3,500 cfs; the -3,500 cfs trigger was proposed as a threshold in the ROC on LTO BA as part of the winter pulse protection action (see Table 2). For each release site, results are presented for 31 month-year combinations.

In drier year types, the onset of an initial winter pulse flow is not certain to occur in the early winter months due to lack of precipitation, but adult delta smelt will undergo their upstream dispersal by February to March regardless of flow signals. Without clear flow pulses, it becomes more difficult to track and predict the movements of the population given record-low abundances that have caused population numbers to fall below the detection threshold for current survey methodology. In years where conditions do not trigger the Integrated Early Winter Pulse Protection action, Reclamation proposes to implement Additional Real Time OMR Restrictions by February 1 to manage OMR to more positive than -5,000 cfs. The first of these actions is Turbidity Bridge Avoidance. Under this action, if the Early Integrated Winter Pulse Protection has not occurred, the projects will manage OMR to no more negative than -5,000 cfs beginning on February 1 even if turbidity in the south Delta remains low. The objective of Turbidity Bridge Avoidance is to maintain OMR flow no more negative than -5,000 cfs if daily average turbidity at Old River at Bacon Island (OBI) station reaches 12 NTU. OBI was selected by the five agencies as the best available station to assess the formation of a turbidity bridge based on the last 11 years of operations. It is located about halfway down the Old River corridor and Reclamation has proposed to redundantly telemeter this station in the event of vandalism or malfunction.

Following the logic of the proportional entrainment model, OMR flow of -5,000 cfs may prevent increases in proportional entrainment of adults under clear water conditions.

Larval and Early Juvenile Entrainment

For the months of April and May, south Delta exports will increase significantly under the PA in comparison to COS. This is a result of removal of the NMFS 2009 BiOp Inflow:Export RPA action from the PA. Absent implementation of the Inflow:Export RPA action, exports in all water year types will increase in April and May, as demonstrated in the exceedance plots from the modeling provided in the BA. The modeling shows that conditions in June will be similar between the PA and COS. From April through June, OMR flow shall be no more negative than -5,000 cfs.

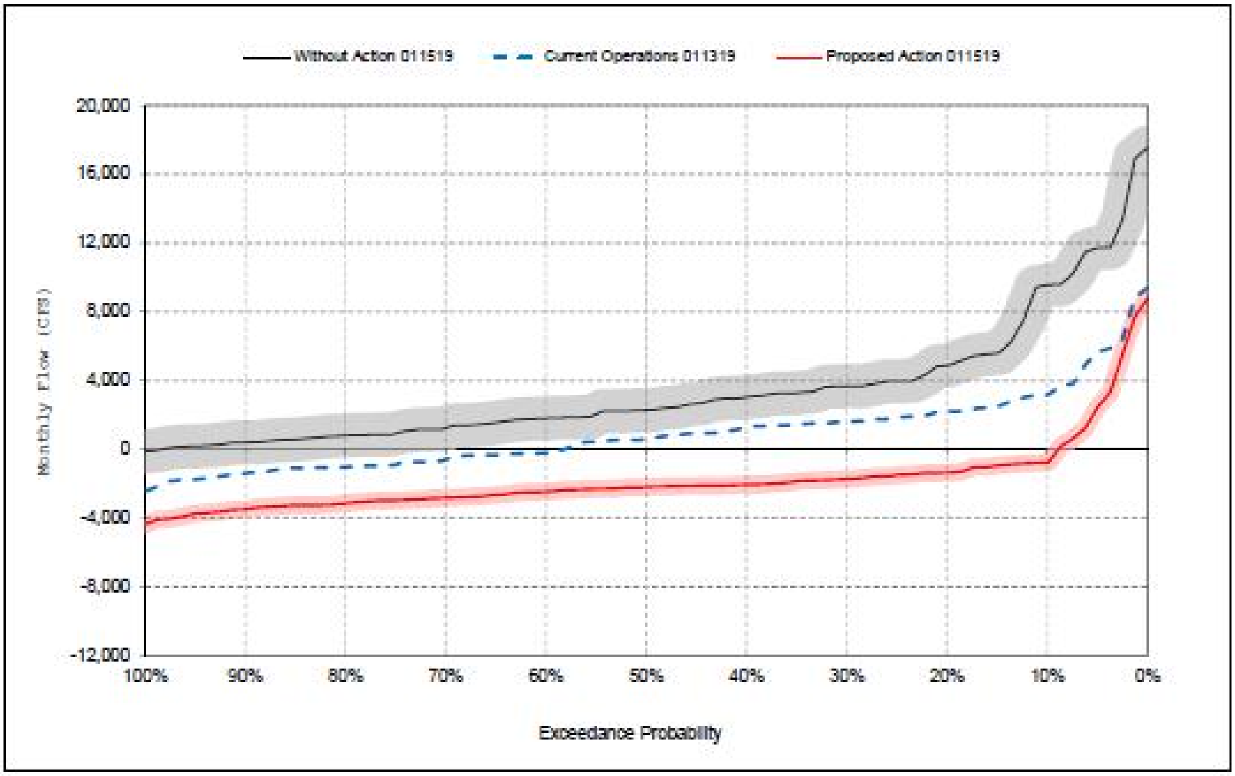


Figure 8. Mean Modeled Old and Middle River Flows, April. (ROC BA 2019)

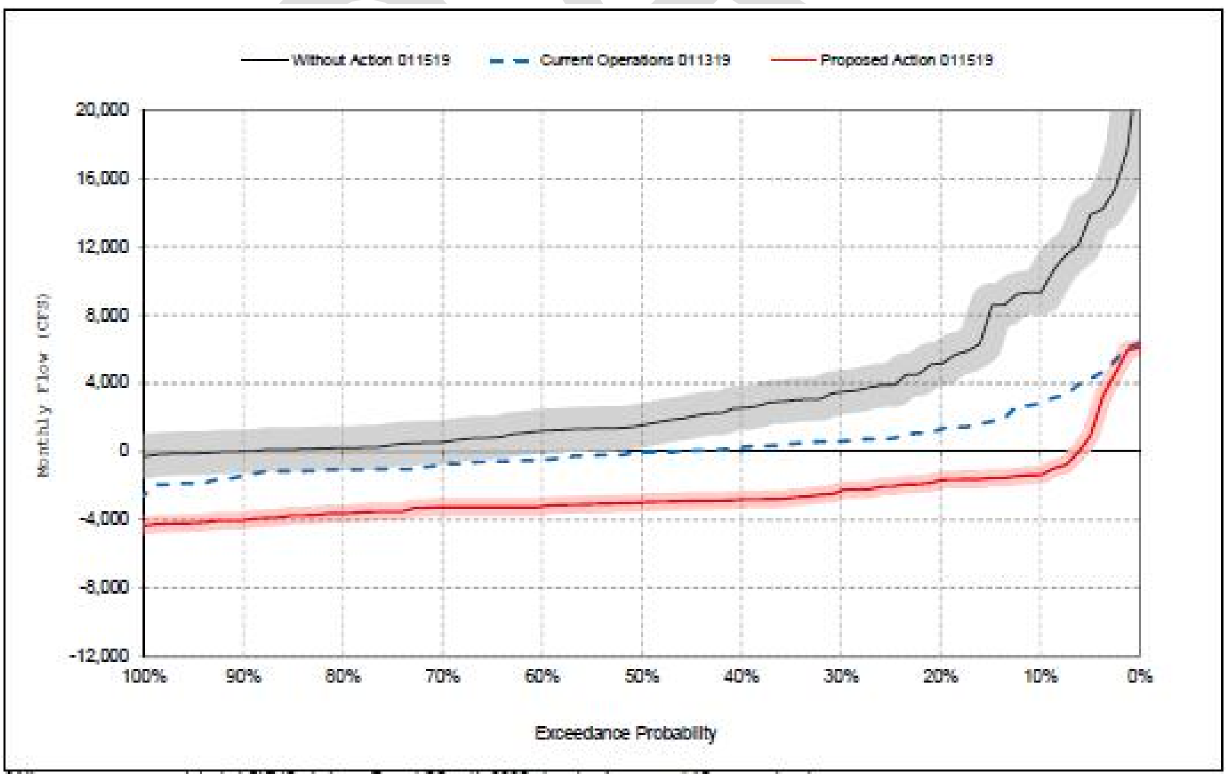


Figure 9. Mean Modeled Old and Middle River Flows, May. (ROC BA 2019)

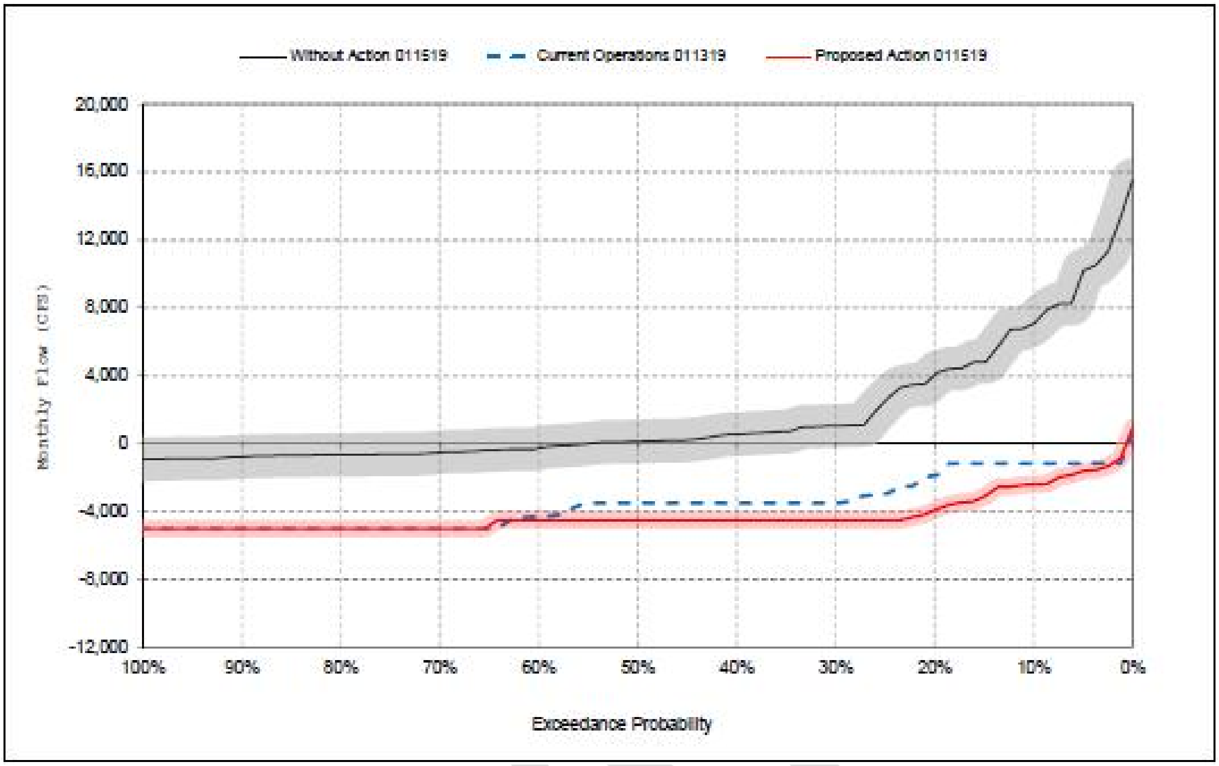


Figure 10. Mean Modeled Old and Middle River Flows, June. (ROC BA 2019)

[Placeholder for larval and juvenile entrainment analysis]

Delta Smelt Predation

[Placeholder for adult predation]

Larval and Early Juvenile Predation

[Placeholder for larval and juvenile predation]

Future Increases in Entrainment

The Delta Fish Species Conservation Hatchery will be constructed and operational by 2030 under the PA. With increased populations from active hatchery supplementation of delta smelt, entrainment of delta smelt is reasonably certain to occur. However, this action is expected to somewhat offset the negative effects of entrainment by supplementing a wild population that is more resilient to withstanding the effects of entrainment. In the interim until the hatchery is operational, Reclamation proposes to support the Fish Conservation and Culture Laboratory supplementation efforts to develop necessary information to begin a supplementation program, focus on capturing existing genetic diversity and expansion of FCCL to produce maximum numbers of delta smelt. This includes development of a strategy within one year of the issuance of this BiOp with a goal of increasing production by 2025 to a number and the life stages necessary to effectively augment the population as determined by the Service. This interim measure will increase the likelihood that the population of delta smelt will be sustained in the wild and able to withstand the multiple factors that have led to its decline, including entrainment and associated predation resulting from seasonal operations of the Banks and Jones facilities.

1.1.2 South Delta Fish Facilities and Clifton Court Forebay Activities

This section addresses elements of the PA that would be encountered after entrainment of individuals. The entrainment of delta smelt into the south Delta by the Banks and Jones pumping plants is a direct effect of SWP and CVP operations. The only mechanism through which delta smelt could potentially survive the poor habitat conditions of the south Delta is through salvage at the fish facilities, but the reasons why few if any delta smelt survive the process under current conditions and operations protocol are discussed below. Therefore, the Service considers the effects of the elements of the PA that are encountered post-entrainment already discussed under entrainment effects. The interim measure of expanding production at the FCCL and associated development of the supplementation strategy, as well as future operation of the Delta Fish Species Conservation Hatchery, will return more robust numbers of delta smelt into the wild by the year 2030 and result in a larger number of delta smelt subjected to these actions post-entrainment. The following is a brief discussion of activities under which delta smelt may be encountered after entrainment into the south Delta.

1.1.2.1 Tracy Fish Collection Facility (TFCF) and Skinner Fish Facility

Each of the pumping plants have a respective fish facility to manage fish salvage. The Tracy Fish Collection Facility screens fish before they reach the Jones Pumping Plant and the Skinner Fish Facility screens fish before they reach the Banks Pumping Plant. The efficiency of each facility is described in Table 1. Each of these facilities uses behavioral barriers to guide entrained fish into holding tanks from which they are loaded into trucks and transported to release sites in the Delta. The proposed salvage process for the fish facilities includes regular fish sampling of exported water for 30 minutes out of every 120 pumping minutes, though this sampling rate may vary based on debris load, mechanical failure, or other factors (ROC BA 2019).

Due to low population numbers, it is likely that the 25% subsampling rate may not accurately depict the number of delta smelt that pass through the fish facilities. Especially under conditions when fish arrive at the fish screens along with large masses of aquatic weeds and debris that hinder operations and clog fish screens and other machinery, the sampling rate and efficiency may decrease significantly depending on the debris load and the effort required to clean the louvers. In some instances, exports continue without fish sampling due to mechanical issues and any fish present are not recorded. Salvage of delta smelt of any life stage has become increasingly rare in recent years, mirroring the overall decline of the population discussed in the *Status of the Species Within the Action Area* and *Status of the Critical Habitat Within the Action Area*. Total salvage for water year 2018 for both facilities was four delta smelt, a historic record low. The trend indicates that salvage is no longer a suitable indicator for entrainment.

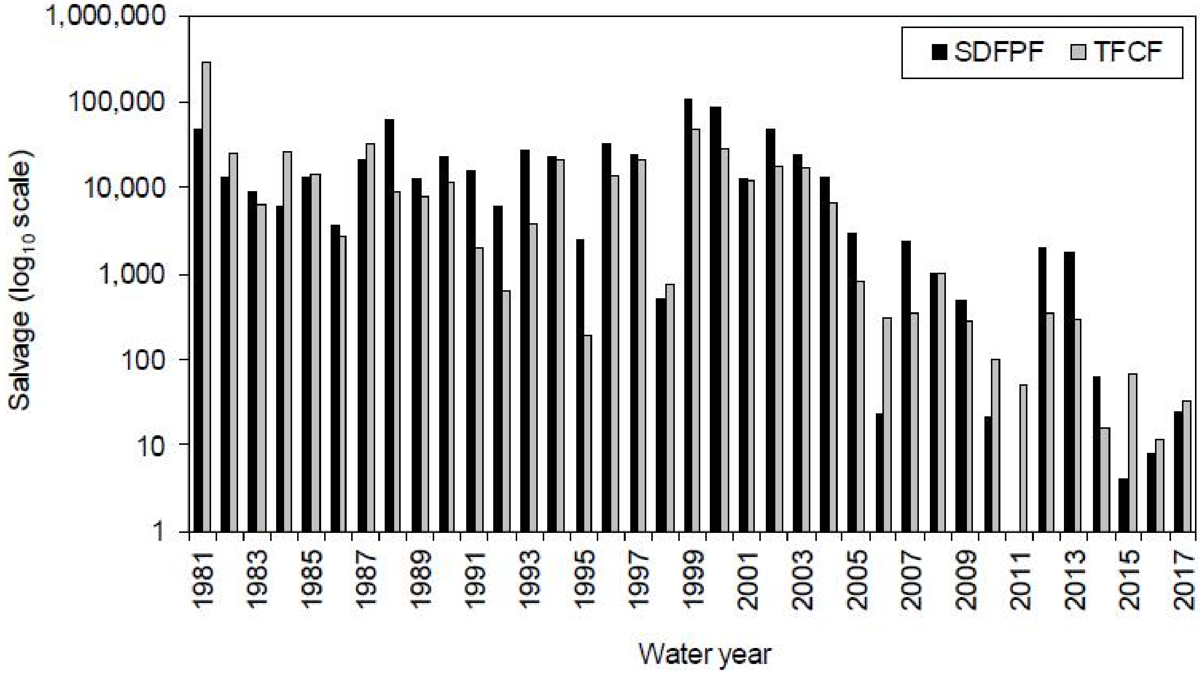


Figure 11. Annual salvage of delta smelt (all life stages) at the Skinner Fish Facility (SDFPF) and the TFCF. (Aasen and Morinaka 2018).

The salvage of delta smelt does not return meaningful numbers of delta smelt back into the Delta and current TFCF and Skinner Fish Facility protocols dictate that delta smelt that are subsampled for fish counts are euthanized and retained in order to determine gender and sexual maturation of each individual. The information provided by these analyses can offer additional evidence of delta smelt spawning activity or presence in the south Delta, meant to supplement regular surveys designed to monitor the status of delta smelt. However, most delta smelt that enter the south Delta via Old and Middle rivers are assumed to be eaten before they reach the fish facilities and salvaged individuals ultimately do not survive the salvage process. Therefore, there are no additional effects to delta smelt of any life stage from the operation of the salvage facilities.

1.1.2.2 Clifton Court Forebay Aquatic Weed Program

DWR will apply herbicides or will use mechanical harvesters on an as-needed basis to control aquatic weeds and algal blooms in CCF. Herbicides may include Komeen®, a chelated copper herbicide (copper-ethylenediamine complex and copper sulfate pentahydrate) and Nautique®, a copper carbonate compound. These products are used to control algal blooms that can degrade drinking water quality through tastes and odors and production of toxins. Because delta smelt within CCF are already entrained and have a nearly 100% mortality rate (Castillo *et al.* 2012), the application of herbicides does not change the overall impact to the species, though it could increase observed salvage if the fish receive acutely toxic doses of these chemicals.

1.1.2.3 Clifton Court Forebay Predator Removal

Predator control efforts under the proposed action to reduce predation on listed fish species following entrainment into Clifton Court Forebay could reduce pre-screen loss of delta smelt. Depending on the gear type of Clifton Court predator control efforts, predator control efforts may also catch or injure delta smelt. Because delta smelt within CCF are already entrained and have a nearly 100% mortality rate (Castillo *et al.* 2012), predator removal activities would not change the overall impact to the species discussed in the entrainment effects section above.

1.2 Delta Operations

1.2.1 Water Transfers

Reclamation's proposed action to expand the transfer window to July 1 to November 30 could result in additional pumping of approximately 50 TAF per year in most water year types (ROC BA 2019). During this time, most delta smelt are juveniles. During summer and early fall, much of the Delta is presently inhospitable for delta smelt due to the combination of high water temperature, low turbidity, high SAV infestation, and possibly toxic impacts of peak Microcystis bloom densities. Therefore, delta smelt are not anticipated to be present in this area. Typically, dispersal back into the San Joaquin River and associated channels does not begin until December or January, thus, effects to the sub-adult life stage are also not anticipated. However, an occasional delta smelt could potentially be exposed to increased pumping as result of water transfers. Effects would be the same as those discussed for entrainment effects above.

1.2.2 Delta Cross Channel

Under the proposed action, the DCC gates would usually be closed during delta smelt's reproductive season. The DCC gates may be operated during low inflow conditions to help Reclamation meet D-1641 salinity requirements. Reclamation would use modeling to predict when D-1641 salinity standards would be exceeded and open the DCC to avoid the exceedances.

It is unknown what, if any, impacts occur to delta smelt as a result of opening or closing the DCC gates. Delta smelt move into the area surrounding the DCC during the winter, but based on limited collections, the Service considers this region a transiently used habitat. It is possible that opening or closing the DCC gates changes the dispersal path of some delta smelt, but it is not known whether there is a consequence, such as a change in predation risk or likelihood of successful spawning. Given that the main effect of DCC operations would be to manage the quantity of Sacramento River flow entering the interior (central and south) Delta, there will be minimal effects to delta smelt due to the proposed gate closure schedule. Closures of the DCC for juvenile salmonid protection are likely to create more natural hydrodynamics in the Delta, by keeping Sacramento River flows in the Sacramento River and Georgiana Slough, which provide flow cues for dispersing adult delta smelt (Service 2008). Closure of the DCC would occur during most, if not all, of the December-March dispersal of adult delta smelt, and essentially would seldom differ between the PA and COS. Individual impacts to delta smelt are unknown, but since few delta smelt have been detected at the DCC according to historical survey data, it is expected that the population effect of occasional DCC gate operations will be minimal.

1.2.3 Agricultural Barriers

DWR will to continue to install three agricultural barriers at the Old River at Tracy, Middle River, and Grant Line Canal each year when necessary for water quality purposes. The barriers are installed between April and July and removed in November. The effects of installation of these three barriers are covered under a separate biological opinion with the Corps, where they are referred to as the Temporary Barrier Program (TBP) (Service file number: 08FBDT00-2018-F-0041). Installation activities under the TBP biological opinion are covered for a period of 5 years and expire after 2022. If section 7 coverage for the installation of the TBP lapses, reinitiation of consultation may be necessary to continue TBP operations.

Under the proposed action, the operation of the TBP would not include the Head of Old River Barrier and the three remaining barriers would be operated at their respective locations. It is possible that after TBP installation, adult delta smelt that have already been entrained into Old and Middle rivers may be trapped between the barriers and the fish facilities. The placement of the barriers would prevent these individuals from moving back downstream and they and any progeny spawned that far south would very likely not survive the summer. However, given that the barriers are in poor quality and channelized habitat, delta smelt that have dispersed or been drawn this far south are already assumed not to survive per our description of entrainment above. As discussed in the TBP installation biological opinion, delta smelt occurring in the vicinity of the barriers could be subjected to predation because of predator species congregating by the barriers. However, because very few delta smelt can successfully reproduce from as far into the south Delta as the location of these barriers, any effects of TBP operations above and beyond the entrainment effects related to the export of water from the Banks and Jones pumping plants are minimal.

1.2.4 Contra Costa Water District Rock Slough Intake

The CCWD water system includes the Mallard Slough, Rock Slough, Old River, and Middle River (on Victoria Canal) intakes; the Rock Slough Fish Screen (constructed in 2011 under the authority of CVPIA 3406(b)(5)); the Contra Costa Canal and shortcut pipeline; and the Los Vaqueros Reservoir. All CCWD facilities are subject to no-fill and no-diversion periods identified as March 15 through May 31 and April 1 through April 30, respectively, for fisheries protection. CCWD diverts approximately 127 TAF per year in total. Approximately 110 TAF is CVP contract supply. No changes in operation criteria are proposed for the facilities. CCWD's operation of the diversion, storage, and conveyance facilities to divert water under CCWD's water rights are covered under a separate biological opinion (Service file number: 1-1-93-F-35). The intakes at Old River and Middle River have a maximum pumping capacity of 250 cfs and are screened in accordance with delta smelt fish screening criteria (approach velocity of 0.2 ft/sec). The Rock Slough intake, which has a maximum pumping capacity of 350 cfs, is screened to the same specifications. Rock Slough is a dead-end slough with poor habitat for delta smelt. Numbers of delta smelt collected at Rock Slough during sampling at the intake are usually low and no delta smelt have been collected since 2012. Except when flows are very high, few if any delta smelt can successfully reproduce from as far into the south Delta as the Rock Slough intake. This, combined with relatively small diversions that are similar between the PA and current conditions suggests that any individual or population-level effect of the Rock Slough intake on delta smelt would be minimal.

1.2.5 North Bay Aqueduct

No changes in operational criteria between the PA and COS are proposed. Current operations will continue subject to existing regulatory requirements. The Barker Slough Pumping Plant diverts water from the Cache Slough Complex, which is one of several key delta smelt spawning regions. Adult and larval fish densities in the greater area are among the highest observed. The NBA intakes are screened in accordance with delta smelt fish screening criteria (approach velocity of 0.2 ft/sec). The fish screens should preclude 100% of adult delta smelt from being entrained, but it is not known how well they protect individuals < 25 mm in length.

NBA diversions do not appear to have had a substantial effect on delta smelt (Service 2008). It is expected that the effects to delta smelt will continue to be minimal under the PA on an individual and population level.

1.3 Delta Smelt Summer-Fall Habitat

1.3.1 Suisun Marsh Salinity Control Gate Operations, Outflow Augmentation, and Food Enhancement Actions

SMSCG Operation

Reclamation proposes October – May SMSCG operations as necessary to meet D-1641 water quality requirements that protect the management of waterfowl habitats in Suisun Marsh's wetlands. The SMSCG can be opened on ebb tides to divert Sacramento River water into Montezuma Slough from which it is subsequently diverted onto numerous hunting clubs and other managed wetlands in the marsh to grow freshwater and low salinity forage for various waterfowl species. The SMSCG are closed on flood tides to limit the influx of saltier water.

Reclamation proposes additional operations of the gates for up to 60 days (may be non-consecutive). This action is intended to continue a recently proposed experimental approach to managing delta smelt habitat quality by using the SMSCG to lower salinity in the summer months or to maintain longer periods of low salinity conditions in the marsh in years where salinity is already low in the early summer. Table 3 describes the operations of this action for Below Normal, Above Normal, and Wet water year types. There is no action proposed to operate the SMSCG during the summer in Dry or Critically Dry water year types.

Water Year Type	SMSCG action	Delta outflow operation
Below Normal	Operate up to 60 days June-August	D-1641 compliance
Above Normal	Operate up to 60 days June-October	D-1641 compliance plus a volume of outflow that under steady-state conditions would meet a monthly average X2 at 80 km during September and October. Each time the

		SMSCG is operated, the volume of additional Delta outflow needed to stay in compliance with D-1641 would be subtracted from the total. Any outflow augmentations provided by Reclamation or DWR during June-October, would likewise be subtracted from the allotted water volume. Actions would no longer be taken (1) once the allotted water volume is used or (2) after October 31. Delta outflow will be made available with allotted water volume.
Wet	Operate up to 60 days September-October May operate gates in warm summers.	D-1641 compliance plus a volume of outflow that under steady-state conditions would meet a monthly average X2 at 80 km during September and October. Any water costs associated with the operation of the SMSCG will not be subtracted from the available water volume. Actions would no longer be taken (1) once the allotted water volume is used or (2) after October 31. Delta outflow will be made available with allotted water volume.

Table 3. Proposed management actions for the Summer-Fall Habitat component by Water Year Type (WYT).

Because the specific goals and actions of this project element are to be determined annually by a Delta Coordination Team through a structured decision making process, the specific actions taken in each water year may be unique based on conditions for that year and the recommendation of the team. Additionally, modeling conducted for the BA does not reflect additional Delta outflow that may be needed to meet D-1641 salinity standards in the western Delta when the SMSCG are being operated. Thus, this effects analysis is largely qualitative because the BA modeling does not likely reflect the actual action that will be implemented due to variable conditions of future applicable years and the multiple scenarios that the team would be considering for development of the recommendation. The analysis focuses on possible effects to individuals and the population using available data from the 2018 SMSCG pilot study, BA modeling, and a discussion of the modeling results from the 2017 Fall X2 reinitiation package from Reclamation to the Service.

In 2017, Reclamation reinitiated consultation proposing to modify the Fall X2 action provided for in the 2008 BiOp. The BiOp required X2 to be maintained at 74 km in a wet year for the months of September and October. Reclamation proposed to maintain X2 at 74 km in September, but at 81 km for the month of October. To support the reinitation, Reclamation provided an analysis of the effects of moving X2 to 81 km in October 2017. Based on the large inflection point in habitat between X2 at 80 versus 81 km demonstrated in the model results, Reclamation amended its request to maintain X2 at 80 km. The Service amended the 2008 BiOp to allow Reclamation to operate its facilities to achieve an average X2 location of no greater than 80 km in the month of October 2017. (Service, 2017. Memo to Area Manager, Bureau of Reclamation, Mid-Pacific Region, Bay Delta Office, from Regional Director, US Fish and Wildlife Service, Pacific Southwest Regional Office, Subject: Proposed Change to Action 4 of the 2008 Biological Opinion for the Coordinated Long-Term Operation of the Central Valley Water Project and State Water Project.)

Figure 11 from the modeling shows the difference between the PA and the COS during the summer months at Belden's Landing, identified as one possible compliance point among other stations and averaging periods yet to be identified.

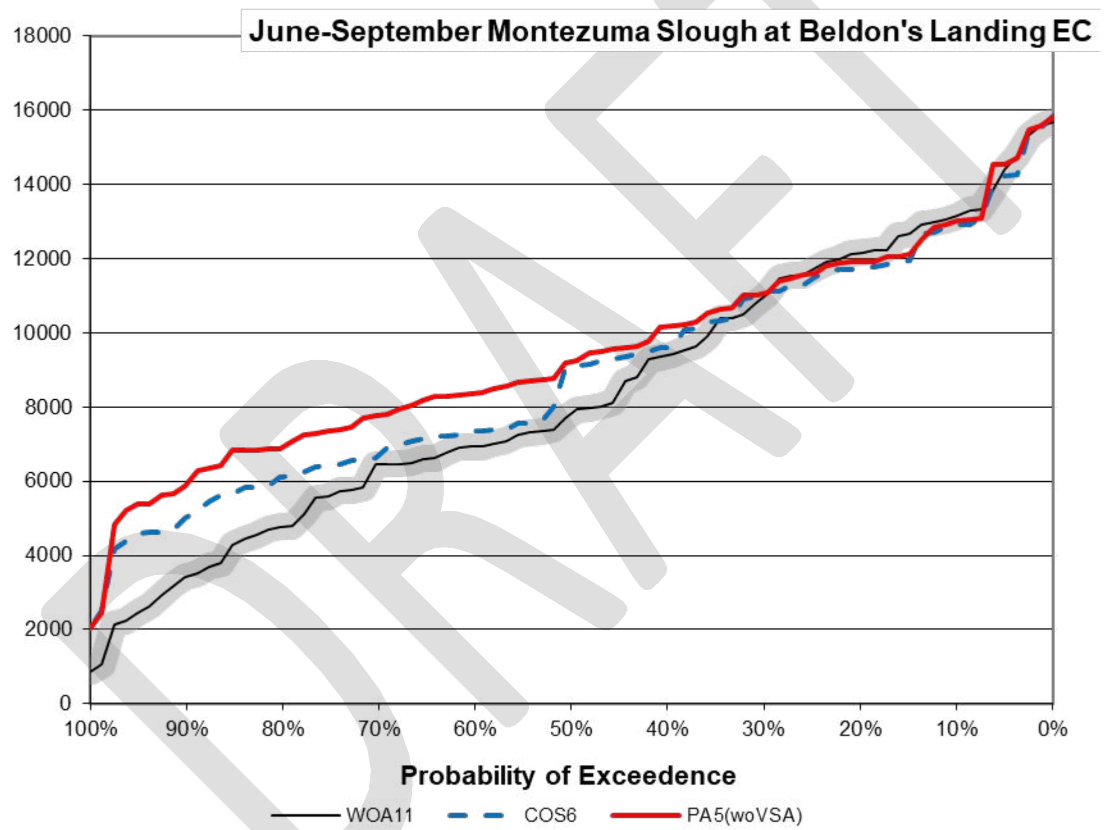
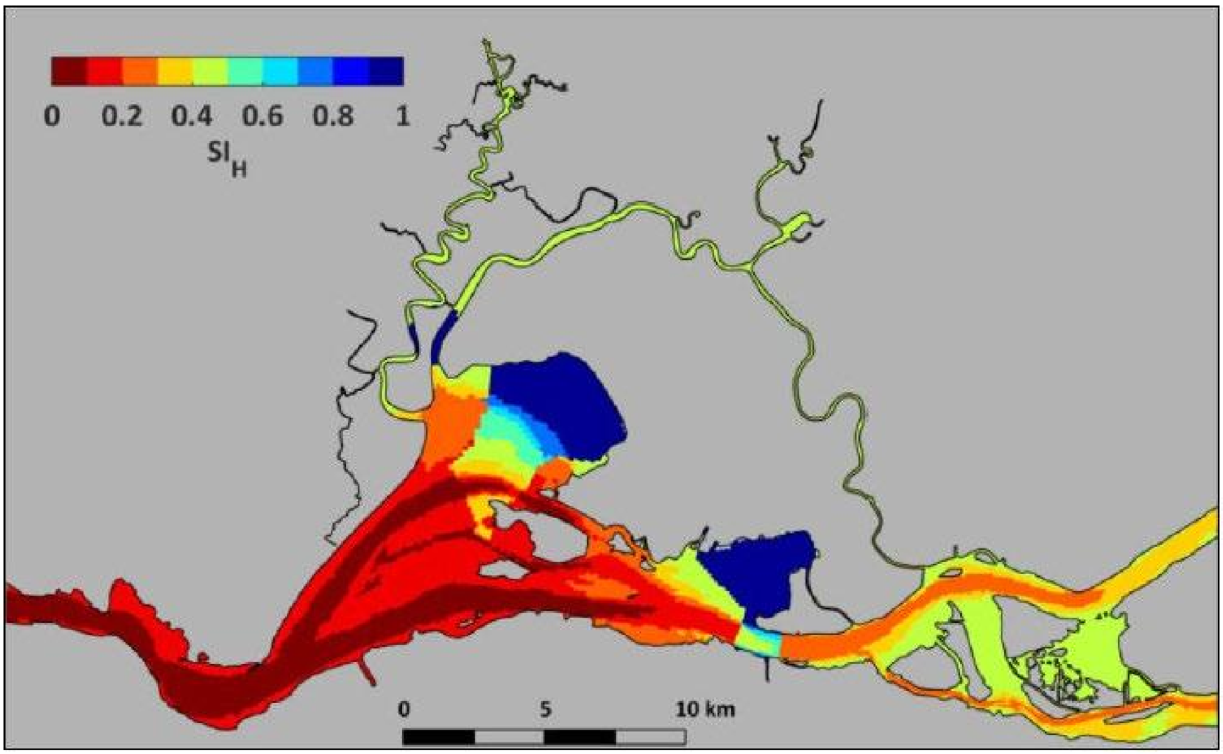


Figure 12. Summer Electrical Conductivity at Belden's Landing. (Source: ROC BA 2019)

Generally, higher summer salinities are expected in the PA modeling when compared with current operations. However, the Delta Smelt Summer-Habitat Action was not included in the modeling and is posited to improve conditions to an unknown degree. In Below Normal years, no additional outflow beyond that which is required to meet D-1641 water quality standards is proposed. It is unknown at this time what the Delta Coordination Team may recommend due to the variability in conditions from year to year. However, without additional flow as a tool in Below Normal years, it is difficult to determine whether there will be a benefit beyond the PA modeling.

In the case of Above Normal year types, the PA modeling does not reflect the additional water volume that would be required to support a 2ppt isohaline at 80 km from the Golden Gate Bridge in September and October, minus the volume which would be used for gate operations to comply with D-1641. In wet years, however, the full volume of water to meet 80 km could be made available. Maintaining X2 at 80 km in September and October would offset some of the impact demonstrated in the modeling of moving X2 eastward in the fall of most years because the low-salinity zone would frequently still occur in association with the comparatively turbid, low-velocity shoals of Grizzly and Honker bays, as well as throughout the Suisun Marsh. These pockets of high suitability habitat apparently become abruptly unavailable at X2 ≥ 81 km.



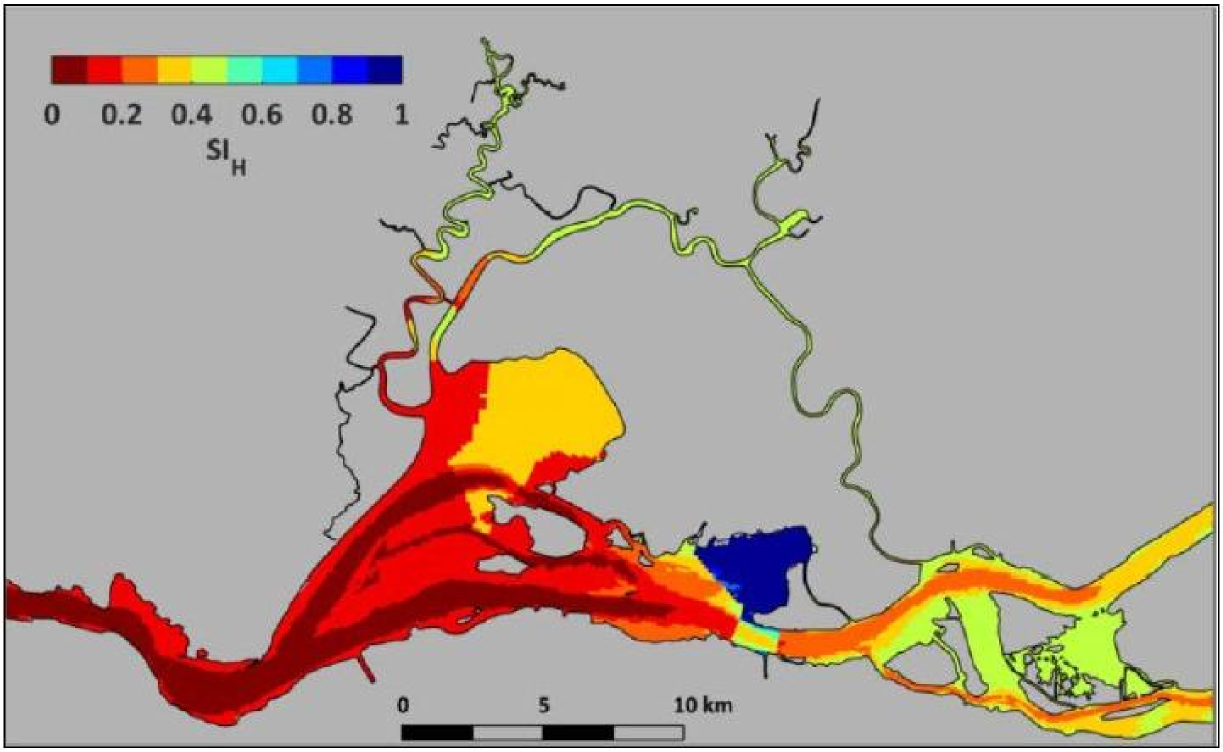


Figure 12. The delta smelt station-based habitat index proposed by Bever et al. (2016) in the Suisun Bay region at an X2 of 80 km (top panel) and at 81 km (bottom panel). Source: Effects Analysis in support of 2017 Fall X2 modification request.

In the 2018 SMSCG pilot study, an additional estimated 37,000 acre-feet of water was necessary to meet the D-1641 standards with operations of the gate. Preliminary results of this pilot study, which occurred during a Below Normal year, showed potential benefits for delta smelt. The EDSM survey observed modest numbers of rearing delta smelt in Suisun Marsh during the 30-day study period, though this is not unusual when compared with historical Summer Townet Survey results (CDFW 2019). It was posited that the 2018 gate operations would generate habitat conditions that were similar to Wet year conditions and allow delta smelt to access habitat within the marsh (ROC BA 2019). Preliminary results were mixed with regard to the hypotheses. Further results are forthcoming from the pilot project and may be able to guide the Delta Coordination Team in crafting future habitat actions.

Under current operations, it is possible for a delta smelt to be entrained into Montezuma Slough when the SMSCG is opened and then closed. It is unknown whether this harms those entrained delta smelt. It is also possible that delta smelt face an increased risk of entrainment into the managed marshes where they would be unlikely to survive (Culberson *et al.* 2004; Service 2008). However, one recent study found that the body condition of delta smelt collected from Suisun Marsh was better than at other locations (Hammock *et al.* 2015). The degree to which movement of delta smelt around the LSZ is constrained by opening and closing the SMSCG is unknown.

If implementation of this action cannot meet the goals and objectives of this program then reinitiation of consultation will be necessary.

Food Enhancement Actions

Reclamation proposes to implement several food subsidy projects in conjunction with the Delta Smelt Summer-Fall Habitat Action. The integrated timing of these projects is expected to provide food benefits to delta smelt that may be attracted to the fresher and more turbid conditions generated in the vicinity of Suisun Marsh. These actions are addressed programmatically in this consultation, so further detail about expected benefits will be addressed in subsequent consultation prior to implementation (see section 1.4.5 Food Subsidy Projects).

Suisun Marsh Food Subsidies: Roaring River Distribution System

Infrastructure in the Roaring River Distribution System may help drain food-rich water from the canal into Grizzly Bay to augment delta smelt food supplies in that area. In addition, managed wetland flood and drain operations can potentially promote food export from the managed wetlands to adjacent tidal sloughs and bays.

Sacramento Deepwater Ship Channel

When combined with an ongoing foodweb study, the reconnected Sacramento Deepwater Ship Channel has the potential to flush food production into the north Delta. An increase in food supply has the potential to benefit Delta Smelt and their habitat.

North Delta Food Subsidies: Colusa Basin Drain

DWR, Reclamation, and water users propose to increase food entering the north Delta through flushing nutrients from the Colusa Basin into the Yolo Bypass and north Delta. DWR, Reclamation, and water users would work with partners to flush agricultural drainage (i.e., nutrients) from the Colusa Basin Drain through Knight's Landing Ridge Cut and the Tule Canal to Cache Slough, potentially supplementing the aquatic foodweb in the north Delta for fish species. Reclamation would work with DWR and partners to augment flow in the Yolo Bypass in July and/or September by closing Knights Landing Outfall Gates and routing water from Colusa Basin into Yolo Bypass to promote fish food production.

1.3.2 Delta Smelt Habitat Action Summary

Altogether, the population effect of the Delta Smelt Habitat Action cannot be quantified. With only partial results from one year of a SMSCG summer pilot study to draw conclusions from, it is difficult to predict whether these proposed habitat benefits can be realized in different water year types under different conditions. The structured decision making process called for under this action will help to refine the potential benefits that may be realized.

1.4 Non-Operational Actions

1.4.1 Supplementation efforts from Fish Conservation and Culture Laboratory (FCCL)

As discussed in the *Status of the Species Within the Action Area* and *Status of the Critical Habitat Within the Action Area*, the delta smelt faces a high risk of continued decline and extirpation by 2030 if the population is not supplemented. Reclamation proposes to support efforts to develop a supplementation program, focusing on capturing existing genetic diversity and expansion of FCCL to produce maximum numbers of delta smelt, and to begin supplementation prior to the construction of the conservation hatchery. This includes development of a strategy within one year of the issuance of this BiOp with a goal of increasing production by 2025 to a number and the life stages necessary to effectively augment the population as determined by the Service. The Service will work with partners to use this expanded delta smelt production to determine how a successful reintroduction program can be developed. The effects of scientific research activities for use of cultured delta smelt in contained environments are addressed in the framework programmatic biological opinion on our issuance of a section 10(a)(1)(A) permit to FCCL (Service file number 08FBDT00-2018-F-0360).

No effects to delta smelt are anticipated from expansion of FCCL because the expansion is not expected to be in delta smelt habitat. All other applicable regulatory requirements for FCCL's permit amendment will be met prior to wild population supplementation.

1.4.2 Delta Fish Species Conservation Hatchery

Reclamation proposes to partner with DWR to construct and operate a conservation hatchery for Delta Smelt by 2030. The conservation hatchery would breed and propagate delta smelt with equivalent genetic resources as the contemporary stock and with the goal of raising delta smelt in sufficient numbers to effectively augment the existing wild population. The scale on which the hatchery will be able to propagate delta smelt is unknown and there are other regulatory considerations that must be addressed prior to establishing a propagation and release program. Potential negative effects of releasing hatchery produced fish into the wild could include reduced fitness through domestication of hatchery fish that may breed with wild delta smelt. To address possible negative impacts, Reclamation proposes to fund and support the process to develop a functional and sustainable hatchery program for delta smelt. Once operational, this action would be expected to augment the population to a point where the species can withstand the effects of the CVP and SWP. Since this activity is being addressed programmatically in this consultation, subsequent consultation will address further effects at the standard consultation level.

1.4.3 Tidal Habitat Restoration (8,000 acres)

Reclamation and DWR propose to complete construction of the remainder of the 8,000 acres of intertidal and associated subtidal habitat restoration in the Delta and Suisun Marsh by 2030. The objective of this activity as stated is to "improve habitat conditions for delta smelt by enhancing food production and availability" (Service 2008). The Fishery Agency Strategy Team (FAST), which includes Reclamation, CDFW, NMFS, and the Service, coordinates on the design and crediting of proposed restoration projects to ensure they meet the objective stated above.

As described in the Consultation Approach section of this BiOp, subsequent consultations will occur for each tidal habitat restoration project, which will address effects at the site-specific level and will include Incidental Take Statements, as appropriate. Tidal restoration projects within the Suisun Marsh Plan Programmatic Biological Opinion coverage area could tier to this BiOp. Based on consultations on previous tidal habitat restoration projects, we expect that the following types of activities are likely to affect delta smelt, but this list does not include all possible effect mechanisms: vegetation removal for site preparation, access routes, construction staging, earthwork, breaching of berms or levees, new berm construction, tidal network creation, pond creation, in-water construction activities, dredging, water quality and biological monitoring, and long-term management activities. The nature and magnitude of adverse effects of tidal habitat restoration will vary depending on project design, site location, and construction timing, magnitude, and duration.

Tidal restoration projects will be sited and designed to increase available food web production for delta smelt. Reclamation and DWR commit to funding and ensuring that monitoring, operation, maintenance, adaptive management, and permanent protection occur on these restored lands. An overall monitoring program developed to focus on the effectiveness of the restoration actions will inform the evaluation of results from actions undertaken and adaptive management for the intended foodweb benefit of delta smelt.

1.4.4 Predator Hotspot Removal

It is generally believed that predation on delta smelt is related to macroscopic drivers like water temperature, water turbidity, and the degree of SAV infestation. Thus, predation losses of delta smelt are not likely to be greatly changed by removing predator hot spots as described in the PA. Predator hot spot removal under the proposed action is primarily focused on providing positive effects to juvenile salmonids. The PA did not provide much information about when, where, and how predator hotspot removal will be implemented. This project element is programmatic and will be addressed under future consultation when Reclamation identifies specific actions to be taken to reduce predator hot spots. Possible actions may include removal of structures and minimization of lighting near fish screens, bridges, and other infrastructure where predators congregate. While not expected to negatively impact delta smelt habitat, predator hot spot removal is not expected to have an appreciable positive effect on delta smelt of any life stage. The hot spots identified in Grossman *et al.* 2013 are mostly located in the south Delta, where the macroscopic conditions mentioned above likely are the dominant contributors to high rates of pre-screen loss. The scale of implementation for this project element would likely make little difference on predation rates of delta smelt and effects are expected to be minimal. Subsequent consultation will address effects at the site-specific level.

1.4.5 Food Subsidy projects (Sacramento DWSC, Colusa Basin Drain, Roaring River distribution system)

Reclamation proposes to pursue a series of food subsidy projects that may lead to overall increases in prey availability for delta smelt. This project element is intended to address the concept that limited food supply is negatively impacting delta smelt population numbers, which has been a common finding in quantitative studies of delta smelt population dynamics (Mac Nally *et al.* 2010; Maunder and Deriso 2011; Miller *et al.* 2012; Rose *et al.* 2013b; Hamilton and Murphy 2018; Kimmerer and Rose 2018). While there are no details on timing or frequency, it is possible that an increase in food supply from the Sacramento Deepwater Ship Channel, Colusa Basin Drain, and the Roaring River Distribution System will benefit rearing juvenile delta smelt and sub-adult delta smelt. Based on the locations of these projects, the influx of food would occur in desirable locations where delta smelt are typically found. The magnitude of benefits cannot be estimated at this time without additional details. Since this activity is being addressed programmatically in this consultation, subsequent consultation will address further effects at the standard consultation site-specific level.