Effects to Delta Smelt Critical Habitat from the Proposed Action

1.1 Background

The following are the delta smelt critical habitat Primary Constituent Elements (PCEs) as defined in the critical habitat rule (Service 1994):

Primary Constituent Element 1: “Physical habitat” is defined as the structural components of habitat. As reviewed in the [Status of Critical Habitat], physical habitat in the Bay-Delta has been substantially changed with many of the changes having occurred many decades ago (Andrews *et al.* 2017; Gross *et al.* 2018). Important physical habitat attributes include substrate, water depth variation and channel morphology for spawning adults, and potentially foraging habitat for rearing juveniles along marsh edges (Bever *et al.* 2016; Hammock *et al.* 2019).

Primary Constituent Element 2: “Water” is defined as water of suitable quality to support various delta smelt life stages with the abiotic elements that allow for survival and reproduction. Delta smelt inhabit open waters of the Delta and Suisun Bay. Certain conditions of temperature, turbidity, and food availability characterize suitable pelagic habitat for delta smelt. Factors such as high entrainment risk and contaminant exposure can degrade this PCE even when the basic water quality is consistent with suitable habitat.

Primary Constituent Element 3: “River flow” was originally believed to be critical as transport flow to facilitate adult dispersal and the transport of offspring to low-salinity zone rearing habitats (Service 1994). However, it has subsequently been learned that most transport and retention mechanisms for delta smelt (and their prey) involve the selective use of tidal currents rather than net flows (Kimmerer *et al.* 1998; 2002; Bennett *et al.* 2002; Kimmerer *et al.* 2014; Bennett and Burau 2015). River flow includes both “inflow to” and “outflow from” the Delta, both of which influence the net movements of water through the Delta (Kimmerer and Nobriga 2008) and exert some influence on the distribution of delta smelt (Sweetnam 1999; Dege and Brown 2004; Feyrer *et al.* 2007; Nobriga *et al.* 2008; Sommer *et al.* 2011; Manly *et al.* 2016; Polansky *et al.* 2018; Peterson and Barajas 2018; Simonis and Merz 2019).

Primary Constituent Element 4: “Salinity” is defined as the LSZ nursery habitat. The LSZ is where freshwater transitions into brackish water; the LSZ is defined as 0.5–6.0 ppt (Kimmerer 2004; MacWilliams *et al.* 2015). The LSZ expands and moves downstream when river flows into the estuary are high. Similarly, it contracts and moves upstream when river flows are low. The 2 ppt isohaline is a specific point within the LSZ where the average daily salinity at the bottom of the water is 2 ppt (Jassby *et al.*1995). By local convention, the location of the LSZ is described in terms of the distance from the 2 ppt isohaline to the Golden Gate Bridge (X2); X2 is an indicator of habitat suitability for many San Francisco Estuary organisms and is associated with variance in abundance of diverse components of the ecosystem (Jassby *et al.*1995; Kimmerer 2002b). During the past 40 years, monthly average X2 has varied from as far downstream as San Pablo Bay (45 km) to as far upstream as Rio Vista on the Sacramento River (95 km), but as reviewed in the [Status of Critical Habitat], this is a smaller range than under pre-development conditions (Andrews *et al.* 2017; Gross *et al.* 2018). At all times of the year, the location of X2 influences both the area and quality of habitat available for delta smelt to successfully complete its life cycle. In general, the abiotic elements of delta smelt habitat quality and habitat surface area are greater when X2 is located in Suisun Bay than when it is located in the Delta (Feyrer *et al.* 2011; 2016; Bever *et al.* 2016). The density of delta smelt's primary prey is related to X2 in the spring (Kimmerer 2002b), but not in the summer and fall (Kimmerer 2002b; Kimmerer *et al.* 2018). Nevertheless, one recent study reported better metrics of delta smelt feeding success for fish within the LSZ (Hammock *et al.* 2017).

Due to the interrelationship between the PCEs and the intended conservation role they serve for different delta smelt life stages, some effects are similar and overlap across the PCEs. For instance, Delta outflow determines the extent and location of the LSZ and the areas of physical habitat delta smelt are able to utilize at all times of year. Therefore, many of the effects described below for the PCEs are difficult to separate so some effects are repeated for multiple PCEs.

As discussed in the *Status of the Critical Habitat Within the Action Area*, it was originally believed that delta smelt adults needed access to spawning habitat during the adult migration period from December through July (Service 1994). The current paradigm is that maturing adults do not migrate as much as disperse in response to winter storms which bring pulses of freshwater and turbidity in to the estuary (Sommer *et al.* 2011; Murphy and Hamilton 2013; Polansky *et al.* 2018). Thus, we analyze the effects of the PA on "dispersing" adults instead of the original conceptual model of adult "spawning migration" described in the delta smelt Critical Habitat Rule (Service 1994).

Effects to each PCE were evaluated qualitatively and when appropriate using CalSim II modeling outputs. The CalSim II model is used by Reclamation and DWR to simulate the operation of the major CVP and SWP water facilities in the Central Valley and generates monthly estimates of river flows, exports, reservoir storage, deliveries, and other parameters (PA modeling). The following PA components are encompassed in the analysis below as part of water operations and are represented in the hydrologic modeling and no additional effects are anticipated: minimum export rate, DCC ops, ag barriers, Contra Costa Water District Rock Slough Operations, North Bay Aqueduct, and Water Transfers Table 1 shows where the effects to critical habitat from the PA are expected to occur for each PCE.

1.2 Effects to Delta Smelt Critical Habitat Related to PCE 2-Water

The PA will cause small changes in several components of water quality (PCE 2) needed to support delta smelt in all life stages, but which were either found to have small to negligible effects compared to the COS, either alone, or in combination with conservation measures proposed as part of the PA.

- **Sediment load:** Turbidity produced by suspended sediment provides cover for delta smelt to avoid predators and facilitates successful feeding by the larvae (Ferrari *et al.* 2014; Baskerville-Bridges *et al.* 2004; Hasenbein *et al.* 2016; Sullivan *et al.* 2016). The majority of suspended sediment entering the estuary comes from the Sacramento River and Yolo Bypass during high flows with a smaller proportion coming from the San Joaquin River at Vernalis and the Eastside tributaries. Previous studies have estimated that about 2% of the sediment discharge at Freeport was exported via the SWP (Schoellhamer *et al.* 2012) (Figure 1). The

BA did not provide an estimate of PA effects on suspended sediment. According to the PA modeling, Delta outflow would decrease by an annual average of 4% (633 TAF) with reductions in outflow occurring in all months except December, July and September. Outflow comparisons between the PA and COS show small differences during the months of December through March when precipitation-associated sediment loading would be the greatest. The highest reduction in Delta outflow during the winter was December with a 9% increase in TAF. January outflow decreased under the PA by 1.6% and the remaining winter months were 1% or less. Reducing outflow may alter critical habitat by reducing the contribution of suspended sediment to the Delta to a small degree in December and January compared to the COS.

- **Food availability:** Water exports directly entrain phytoplankton and zooplankton (Arthur *et al.* 1996; Jassby and Cloern 2000). Annual primary production in the estuary varies annually due to several factors including consumption by the invasive overbite clam, a long-term decline in total suspended solids, and river flow (Jassby *et al.* 2002). Delta smelt do occur where their food (*P. forbesi*, a copepod prey item of delta smelt) is at least in summer-fall as the salinity range occupied by this copepod is very similar to the salinity range that most delta smelt occupy. Exports do not meaningfully affect the subsidy of *P. forbesi* to the LSZ (Kimmerer *et al.* 2018). Thus, we would not expect delta smelt food availability to change as a result of reductions in Delta outflow.

The PA includes several actions including habitat restoration, water management, and food web subsidy studies which may provide information for food web adaptive management and/or contribute to delta smelt's food supply to a degree in which it may increase access to prey above current conditions.

- Habitat Restoration: Reclamation and DWR have proposed to complete construction of the remainder of the 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh by 2030 to increase estuary productivity including availability of delta smelt prey. 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. A monitoring program will evaluate the effectiveness of the restoration actions and adaptive management of delta smelt food web. Tidal habitat restoration of this magnitude, once complete, would be expected to improve, at unknown locations and to an unknown degree, the availability of food for delta smelt for all life stages. However, the net direction and magnitude of the effect of this proposed action is unknown at this time. Since this activity is being addressed programmatically in this consultation, subsequent consultation will address further effects to delta smelt critical habitat at the standard consultation level.

- Delta Smelt Summer-Fall Habitat: Reclamation and DWR have proposed combined operation of the SMSCG for up to 60 days (may be non-consecutive) in three of five water year types to direct more fresh water into Suisun Marsh and create and maintain low salinity habitat in Montezuma Slough and other channels within the Marsh. In Below Normal (BN) water years, the gates would be operated only in the summer. In Above Normal (AN) years, gate operation in the summer and fall and additional freshwater flows are proposed. Additional flows may be provided to increase the spatial overlap of food, turbidity, and water temperature from June through October. Gate operations in wet years are proposed in the September and October (and potentially in warm summers) to assist with this habitat overlap goal.

Delta smelt are hypothesized to experience food limitation in summer and fall (Bennett and Moyle 1996) and summer-to-fall survival has been associated with zooplankton biomass (Kimmerer 2008). Kimmerer (2008) suggested that delta smelt management should include improved habitat or food supply. The PA includes the operation of the Roaring River Distribution System to distribute "food web organisms" by flushing fresh water through the Distribution System to increase the low salinity habitat in Grizzly and Honker Bays. Combined gate operation and water distribution would, in June through October, direct Sacramento River water and its accompanying food web into Montezuma Slough and its tributaries and direct organic carbon from the Marsh into Grizzly and Honker Bays. The PA posits that these actions will make more food available for rearing juvenile delta smelt in Suisun Marsh in 3 of 5 water year types. If effective, this action may improve a suite of rearing habitat attributes for juvenile delta smelt from June through October in Suisun Marsh. The net direction and magnitude of the effect of this proposed action is unknown at this time.

- Sacramento Deepwater Ship Channel Study: The PA includes a partnership with the City of West Sacramento and West Sacramento Area Flood Control Agency to repair or replace the West Sacramento lock system to hydraulically reconnect the ship channel with the mainstem of the Sacramento River. The PA posits that the reconnected ship channel has the potential to flush phyto- and zooplankton into the north Delta to improve food availability in the Liberty Island/Cache Slough. All life stages of delta smelt are present at this location. The net direction and magnitude of the effect of this proposed action is unknown at this time. Since this activity is being addressed programmatically in this consultation, subsequent consultation will address further effects to delta smelt critical habitat at the standard consultation level.

- North Delta Food Subsidies/Colusa Basin Drain Study: DWR, Reclamation, and water users have proposed to locally stimulate a planktonic food web in the north Delta by flushing nutrient-rich water from the Colusa Basin Drain into the Yolo Bypass and north Delta (Frantzich *et al.* 2018). They propose to flush agricultural drainage (i.e., nutrients and perhaps phytoplankton) from the Colusa Basin Drain through Knight's Landing Ridge Cut and the Yolo Bypass Tule Canal/Toe Drain into Cache Slough where the PA posits it will stimulate a local zooplankton bloom. Reclamation has proposed to 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 stimulate phyto- and zooplankton production. All life stages of delta smelt may be present at this location, but the net direction and magnitude of the effect of this proposed action is unknown at this time. Since this activity is being addressed programmatically in this consultation, subsequent consultation will address further effects at the standard consultation level.

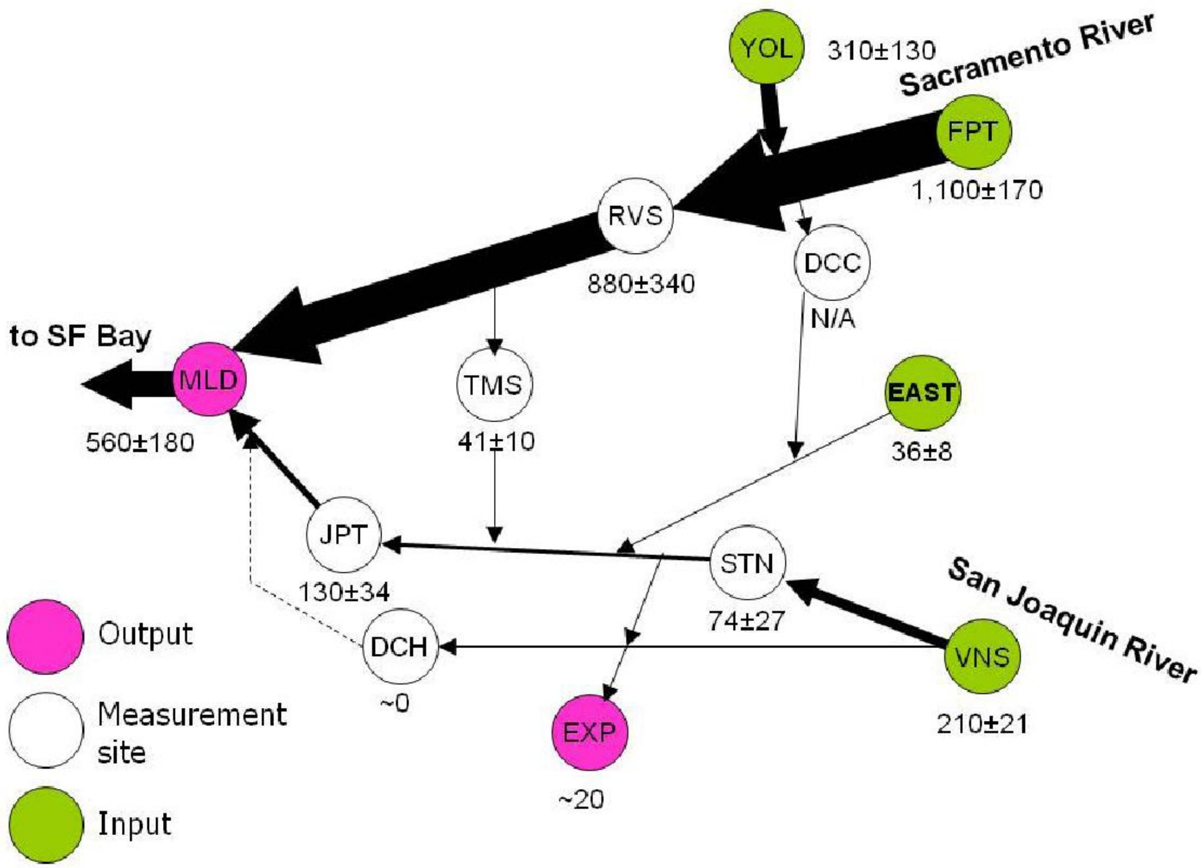

Figure 1. Average annual Delta sediment budget based on water years 1999–2002, except for Threemile Slough (TMS), which is based on water years 2001 and 2002 only. Numbers are the annual suspended-sediment flux and the estimated error in thousand metric tons. Arrow thickness indicates relative magnitude of the suspended-sediment flux. Sediment deposition accounts for the decreased sediment fluxes from east to west. Additional sites are Sacramento River at Freeport (FPT), Yolo Bypass (YOL), Delta Cross Channel (DCC), Sacramento River at Rio Vista (RVS), Mallard Island (MAL), Eastside tributaries (EAST), San Joaquin River at Vernalis (VNS), San Joaquin River at Stockton (STN), exports from the State and Federal water projects (EXP), Dutch Slough (DCH), and San Joaquin River at Jersey Point (JPT). Source: Wright and Schoellhamer 2005.

Table 1. Summary of effects of the PA on critical habitat by life stage. (Type of effect indicated by cell color: yellow [neutral], and red [negative], brown [mixed effects], grey [not applicable]).

Life stage	*PCE 1: Physical habitat*	*PCE 2: Water [quality]*	*PCE 3: River flow*	*PCE 4: Salinity [LSZ]*
Dispersing adults		Negligible loss of sediment due to exports. Small unquantifiable contributions to copepod production from restoration in unknown locations in the Delta and Suisun Marsh.	Increases in frequency of modeled OMR flows greater than -5000 cfs, OMR management may reduce frequency and duration of flows exceeding -5000 cfs.	No change in effect.
Spawning adults	No change in effect.	Negligible loss of sediment due to exports. Small contributions to food web from restoration in unknown locations in the Delta and Suisun.		No change in effect.
Dispersing larvae and juveniles		Negligible loss of sediment due to exports. Small contributions to food web from restoration in unknown locations in the Delta and Suisun.	Increases in frequency of modeled OMR flows greater than -5000 cfs, OMR management may reduce frequency and duration of flows exceeding -5000 cfs.	No change in effect.
Rearing larvae and juveniles	No change in water depth. Potential increase in marsh foraging from restoration and food enhancement in Suisun Marsh, Grizzly and Honker Bays.	Negligible loss of sediment due to exports. Small contributions to food web from restoration in unknown locations in the Delta and Suisun.	Lower outflow will increase salinity and lower the suitability of western parts of critical habitat by increasing the frequency of years in which the LSZ primarily encompasses deep channelized habitats.	Lower outflow will increase salinity and limit suitability of western parts of critical habitat and locate the LSZ upstream of COS. Potential improvement in Suisun salinity in Suisun Marsh from gate operation.

1.3 Effects to Delta Smelt Critical Habitat by Life Stage

1.3.1 Habitat Conditions supporting larval and juvenile transport

PCE 3 – River Flow

The operation of the CVP and SWP involves the storage, release and diversion of freshwater. Stored water is delivered to the Delta where some of it is exported, often along with runoff from other sources. These actions directly influence river flows in the Delta and Suisun Bay, which in turn affects aspects of habitat quality within the critical habitat boundaries (Service 1994; Bever *et al.* 2016). The PA provides a quantitatively modeled base condition and qualitative descriptions of real-time and seasonal management strategies that will be used to modify the modeled base condition to various degrees. The PA is expected to result in changes to river flows and net flows into and out of the Delta (ROC BA 2019), which will in turn affect PCE 3.

It was once thought that delta smelt needed to be transported from "upstream" spawning habitats to "downstream" rearing habitats (Service 1994). It is now recognized that delta smelt can begin feeding where they are spawned and often rear close to where they are believed to have been spawned. It is also recognized that larval fishes, including delta smelt, use swimming behavior changes timed to the tidal cycle and local bathymetry to maintain themselves in low-salinity zone habitats that often have large seaward net flows (Bennett *et al.* 2002). The primary remaining mechanism related to a transport flow for larvae and juveniles that is thought to be both pertinent to the critical habitat function, and under substantial CVP and SWP control, is the varying magnitudes of flood and ebb tidal flows in Old and Middle rivers that are indexed by OMR. The more negative the OMR flow, the greater the flood tide volume and velocity toward the south Delta pumping plants are relative to the ebb tide, and the more Sacramento River water 'back-fills' for the diverted San Joaquin/south Delta water. This tidal asymmetry indexed by OMR can be associated with net southward transport of larval delta smelt into unsuitable habitat and ultimately into water diversions where they may be salvaged and have an extremely low likelihood of survival (Kimmerer 2008; 2011).

The CALSIM II modeling in support of the PA caps OMR flow at -5,000 cfs during March-June. However, the modeling shows that OMR flow would typically be a little less negative than -5,000 cfs most of the time. During April and May, the frequency of occurrence of modeled OMR at -5,000 cfs is zero percent. In March, it is about 30%, and in June, about 35%. Although the CALSIM II modeling indicates that the projects are not anticipated to operate in a way that causes monthly mean OMR flow to reach as low as -5,000 cfs in April and May, negative OMR flows (any value) are modeled to occur more frequently in April and May relative to the COS. The frequency of negative OMR flows (any value) is modeled to be about the same in March and June as in the COS. Thus, the model results suggest that the PA will modify the larval transport flow indexed by OMR flow a little more relative to the COS.

1.3.2 Habitat conditions supporting rearing

PCE 1-Physical habitat

Habitat restoration and food supply enhancement via Roaring River Distribution System operations may provide additional tidal wetland marsh edge for foraging for rearing juveniles in

Suisun Marsh, Grizzly and Honker Bays (Hammock *et al.* 2019). The magnitude of the effect of these activities are unknown at this time.

PCE 4 – Salinity

The LSZ expands and moves downstream when river flows are high (Jassby *et al.* 1995; Kimmerer *et al.* 2013; MacWilliams *et al.* 2015). By exporting river inflows, the PA can contribute to upstream movement and contraction of the LSZ into the Delta shipping channels. Ideal rearing conditions for juvenile delta smelt occur when the location of the LSZ maximizes habitat quantity and quality by providing appropriate salinity, turbidity, water quality, temperature, and food availability. The location of the LSZ is important in determining the quality, both extent and suitability, of juvenile rearing habitat. When X2 is located at or above 85 km, the entire LSZ is upstream of Chipps Island, east of the turbid shoals in Suisun Bay (i.e., Grizzly Bay and Honker Bay) and the more suitable habitat conditions that occur when the LSZ overlaps these embayments (Bever *et al.* 2016). Figure 2 shows the predicted difference in expanse and location of the LSZ under steady-state Delta outflow conditions when X2 is located at 84 km vs 85 km.

It is important to note that when X2 is at 81 km or above, the upstream extent of the LSZ differs between the Sacramento and San Joaquin rivers. However, the portion of the LSZ that extends up the San Joaquin River in late summer and fall is poor quality due to high water clarity and temperature, thus the Service uses X2 on the Sacramento River (Hutton *et al.* 2015) as the habitat indicator. Figure 3 through Figure 9 show the difference between scenarios in kilometers over 82 years of modeling during the rearing months of June through December. Note that a positive difference indicates an X2 upstream or eastward of the location predicted by the CalSim II-modeled COS. Based on 82 years of CalSim II modeling, for the summer months of June, July and August, PA conditions are the same as the COS (Figures 3 through 5). For the months of September, October, November and December, X2 under the PA is upstream compared to the COS to varying degrees (Figure 6 through Figure 8). Additionally, for the months of September through December the LSZ is consistently predicted to be upstream by as much as 17 km when compared to the COS. In these months, under the PA, it is estimated that X2 will be located upstream of 85 km 94% of the time in September, 90% of the time in October, 80% of the time in November, and 50% of the time in December (Figure 10).

The PA includes a Delta Smelt Summer-Fall habitat component which may lower the salinity in a larger fraction of the critical habitat than what is predicted from the CalSim II modeling by SMSCG operation and outflow augmentation. Reclamation and DWR have proposed to operate the SMSCG for up to 60 days (may be non-consecutive) in BN, AN, and Wet water year types potentially from June through October to direct more fresh water into the Marsh and create and maintain low salinity habitat there and in adjacent shoals in Grizzly Bay. The summer-fall habitat component also includes flow augmentation in AN years, and possibly in Wet years, which may result in X2 locations in September and October more eastward than conditions modeled in CalSim II. The goals of the habitat action relevant to critical habitat are to manage the overlap of low-salinity water with localized turbid areas and copepod production that may be less affected by the overbite clam (Hammock *et al.* 2015; Baumsteiger *et al.* 2017) and establish contiguous low salinity habitat from the Cache Slough Complex to the Suisun Marsh (Moyle *et* *al.* 2010; 2016). Specific actions will be informed each year by the use of Structured Decision Making to achieve habitat goals which will try to overlap low salinity water (0 to 6 ppt at Belden's Landing from June to October), with turbid water (targeting at least 12 NTU) and highest available food supplies. The proposed management actions are described in Table 2.

Table 2. Proposed management actions for the Summer-Fall Habitat component by Water Year Type (WYT).

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.

The effects of these management actions will likely provide better salinity conditions for rearing delta smelt than those modeled in CalSim II, but the magnitude of effect is uncertain. The Summer-Fall Habitat component does not include actions to improve salinity for rearing delta smelt in November or December where modeling shows degraded conditions compared to the COS. Improved conditions beyond those modeled are likely to occur primarily in Suisun Marsh. The PA, including water operations and the Summer-Fall habitat component in combination would contribute to appropriate salinity during juvenile rearing, including suitable water quality (turbidity and food availability) in Suisun Marsh and Grizzly Bay.

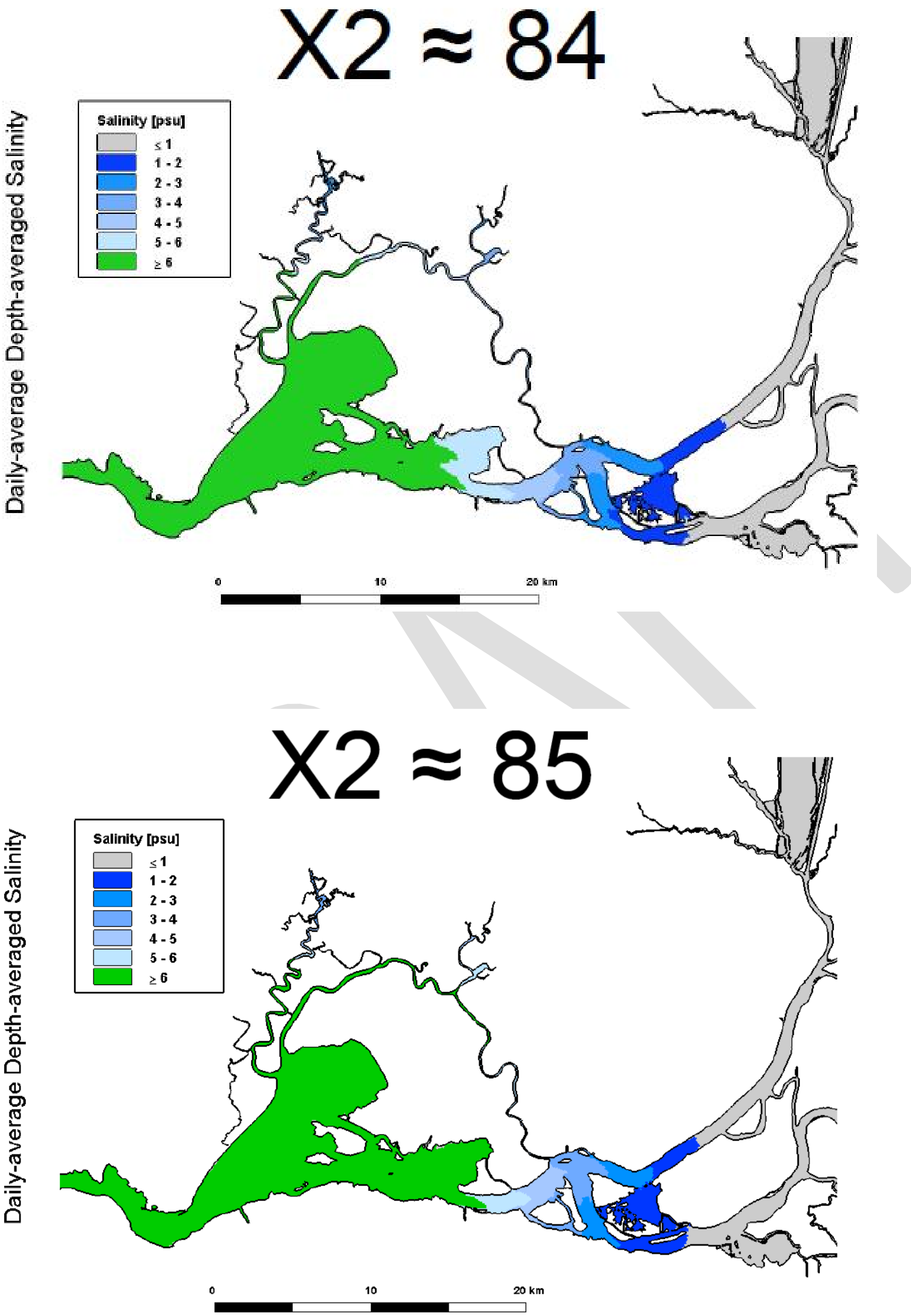

Figure 2. Daily-averaged depth-average salinity in psu (practical salinity units) between Carquinez Strait and the western Delta for X2 located at 84 and 85 km (Delta Modeling Associates 2012).

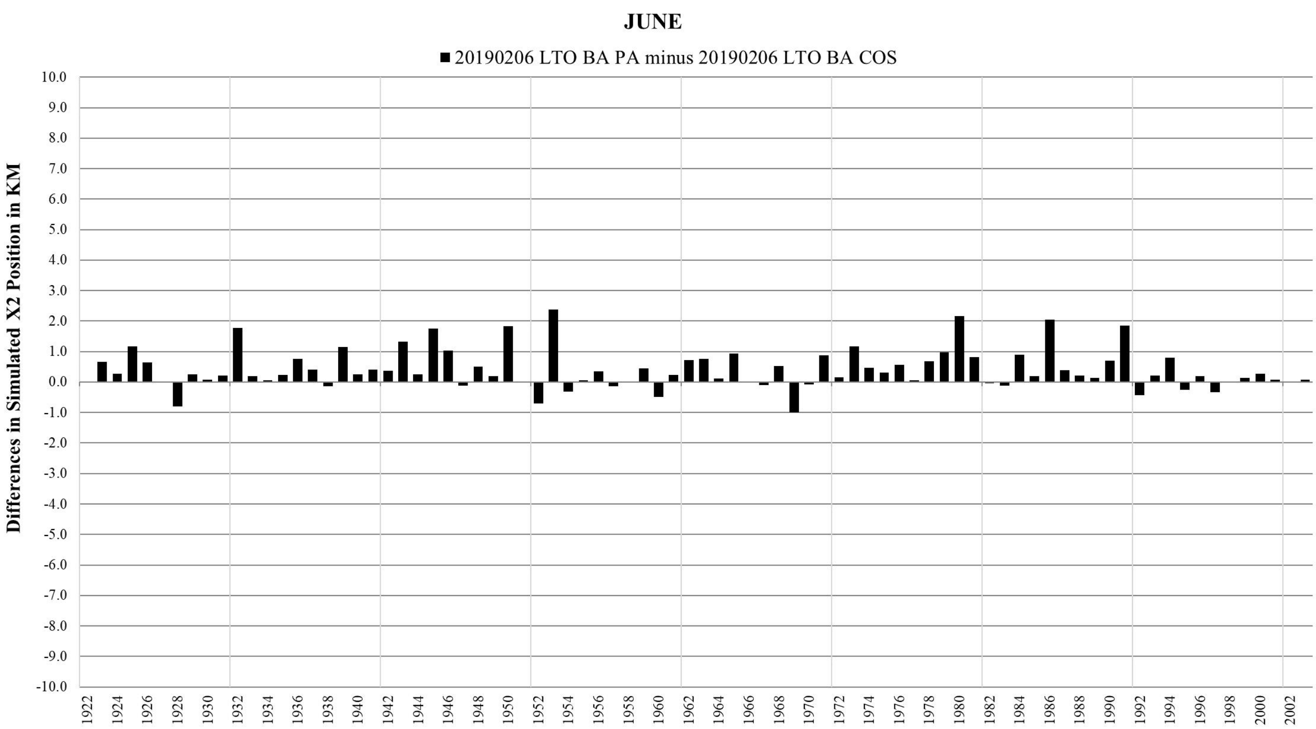

Figure 3. Difference in the position of X2 in kilometer between the PA and the COS for all Augusts based on 82 years of CalSim II modeling.

Figure 4. Difference in the position of X2 in kilometer between the PA and the COS for all Augusts based on 82 years of CalSim II modeling.

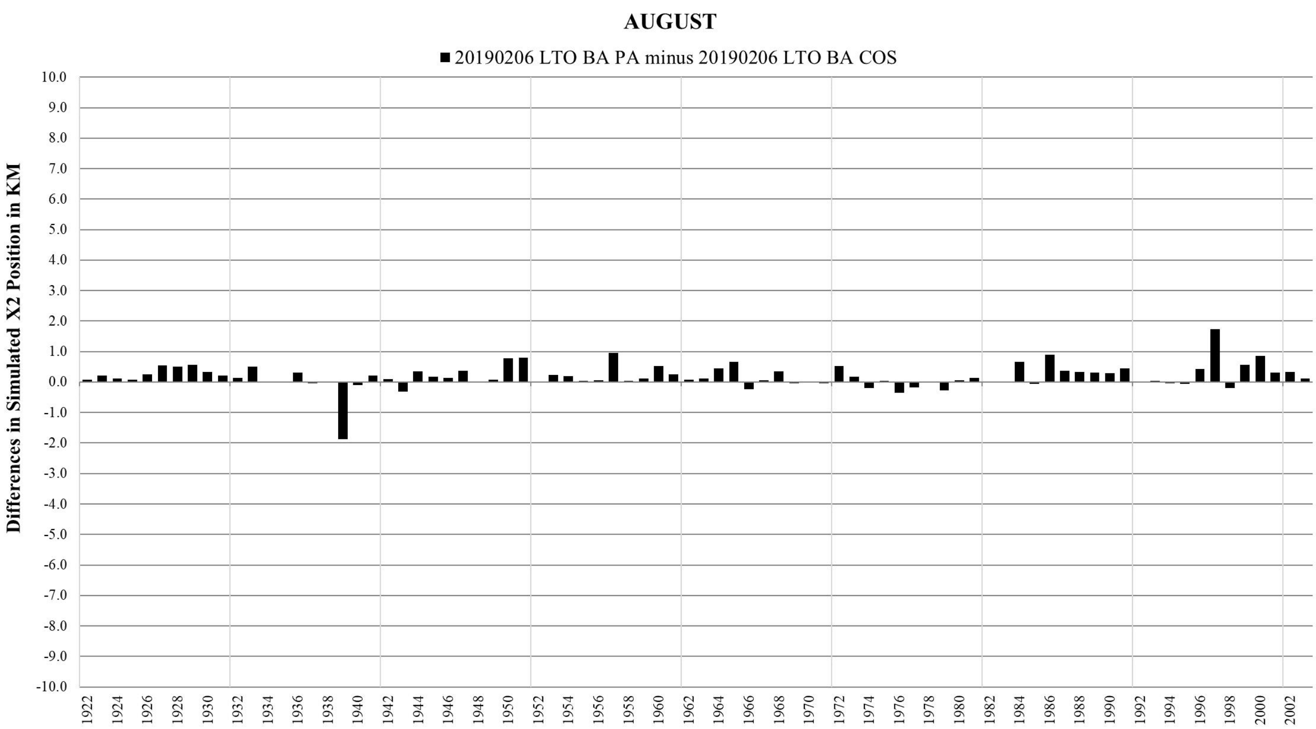

Figure 5. Difference in the position of X2 in kilometer between the PA and the COS for all Augusts based on 82 years of CalSim II modeling.

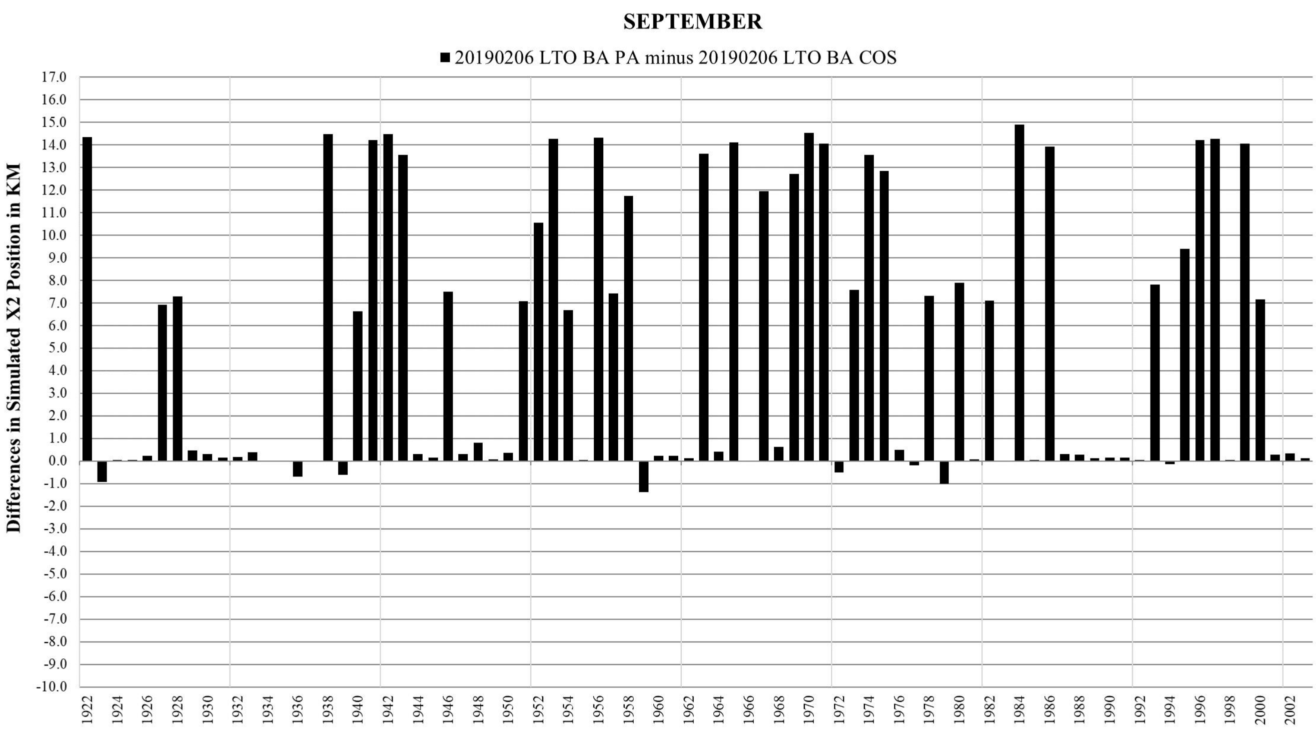

Figure 6. Difference in the position of X2 in kilometer between the PA and the COS for all Septembers based on 82 years of CalSim II modeling.

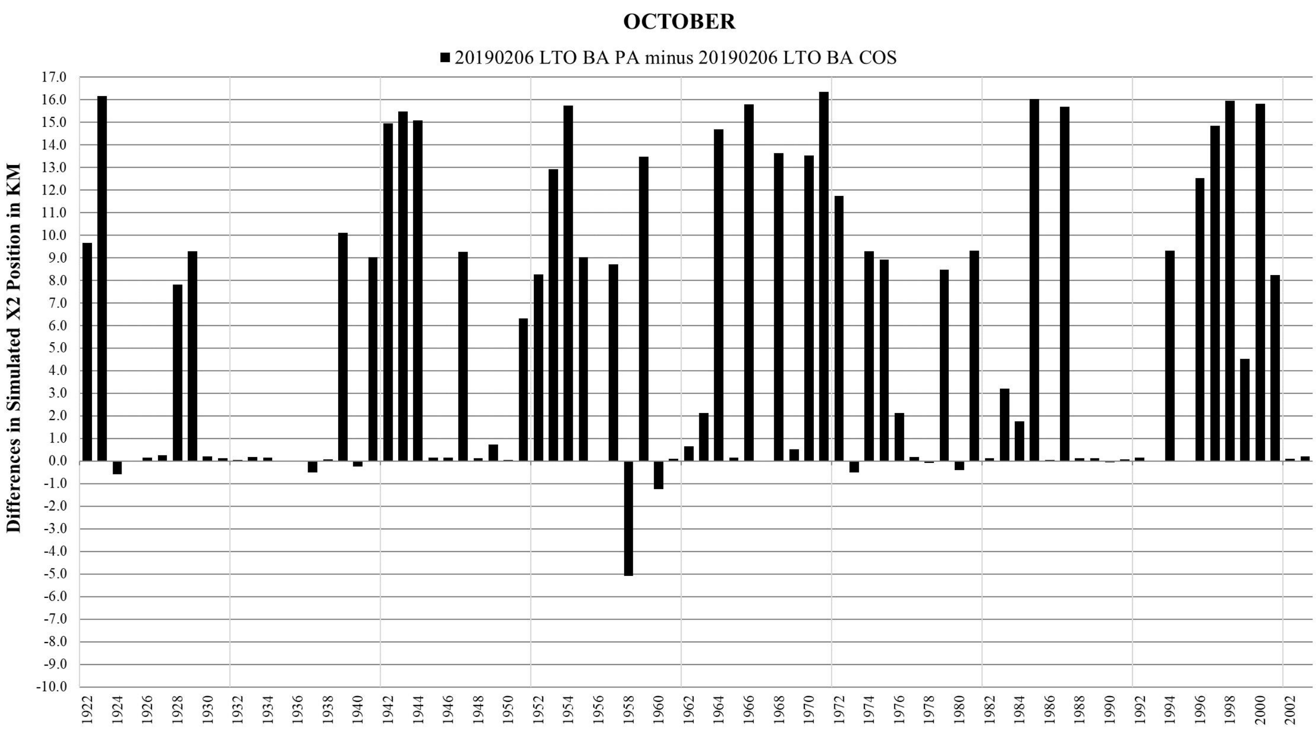

Figure 7. Difference in the position of X2 in kilometer between the PA and the COS for all Octobers based on 82 years of CalSim II modeling.

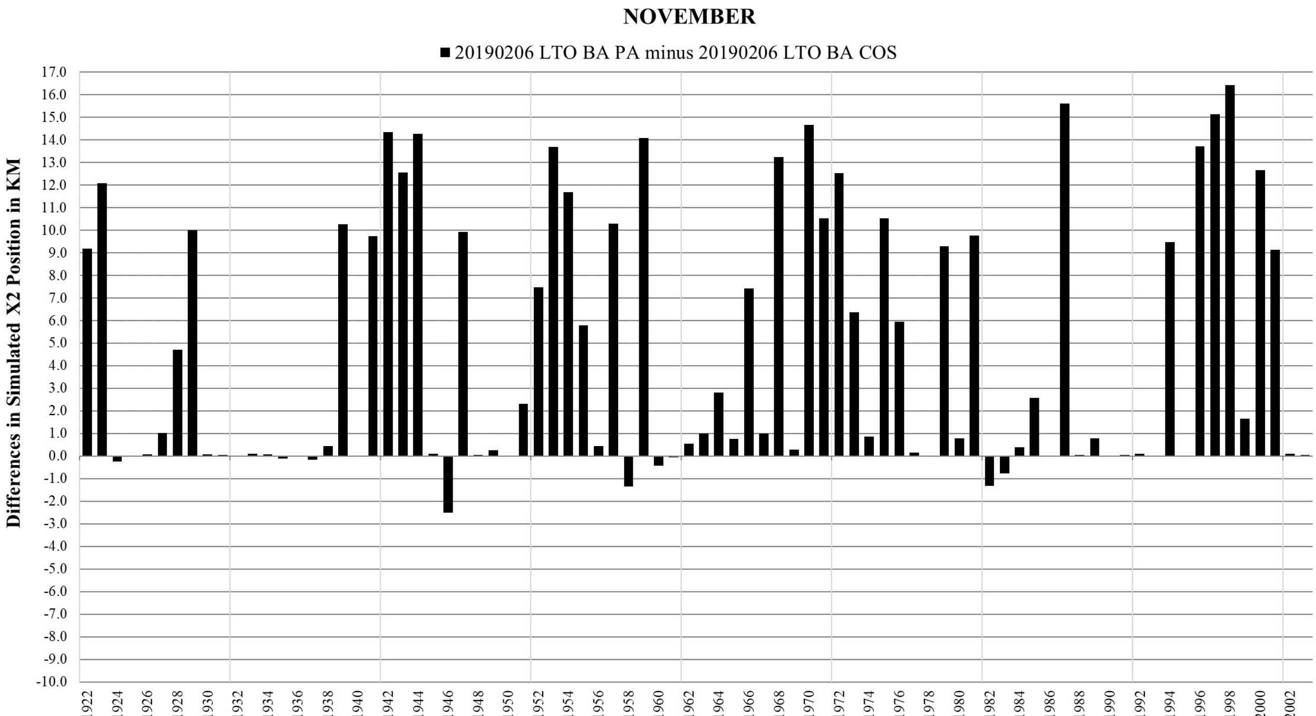

Figure 8. Difference in the position of X2 in kilometer between the PA and the COS for all Novembers based on 82 years of CalSim II modeling.

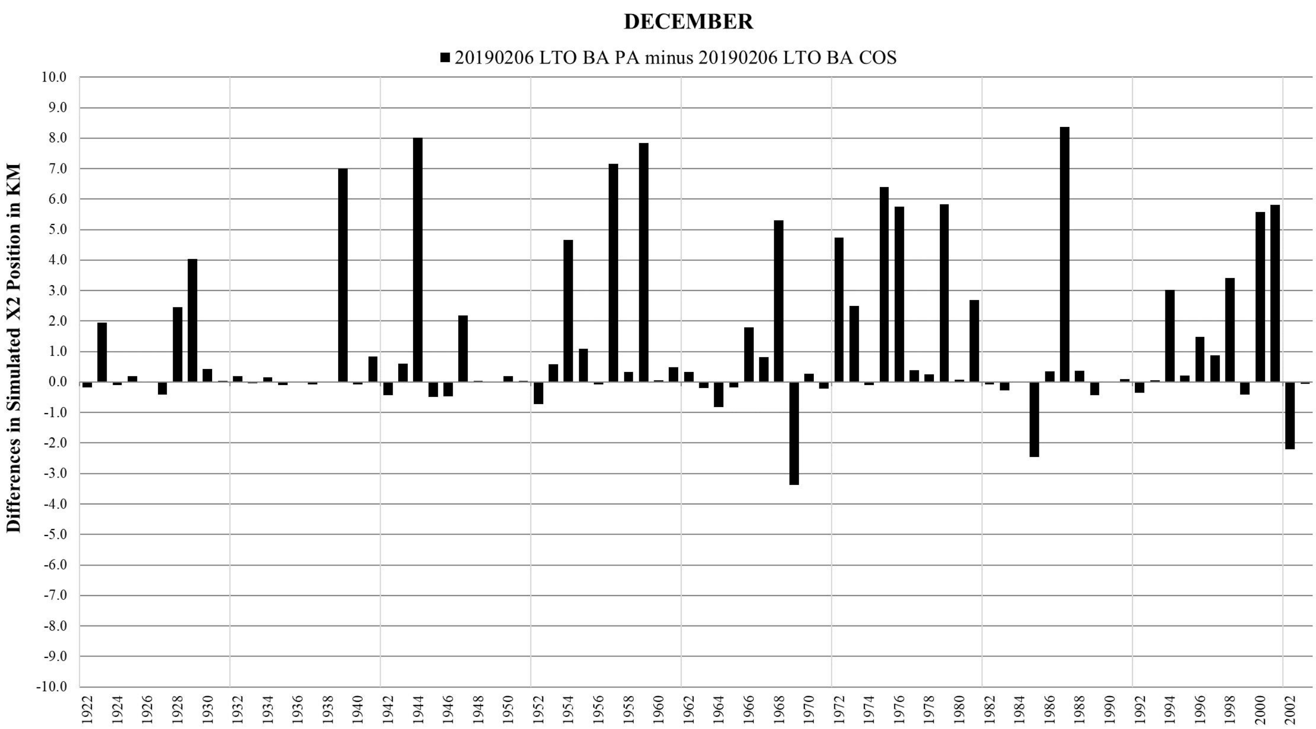

Figure 9. Difference in the position of X2 in kilometer between the PA and the COS for all Decembers based on 82 years of CalSim II modeling.

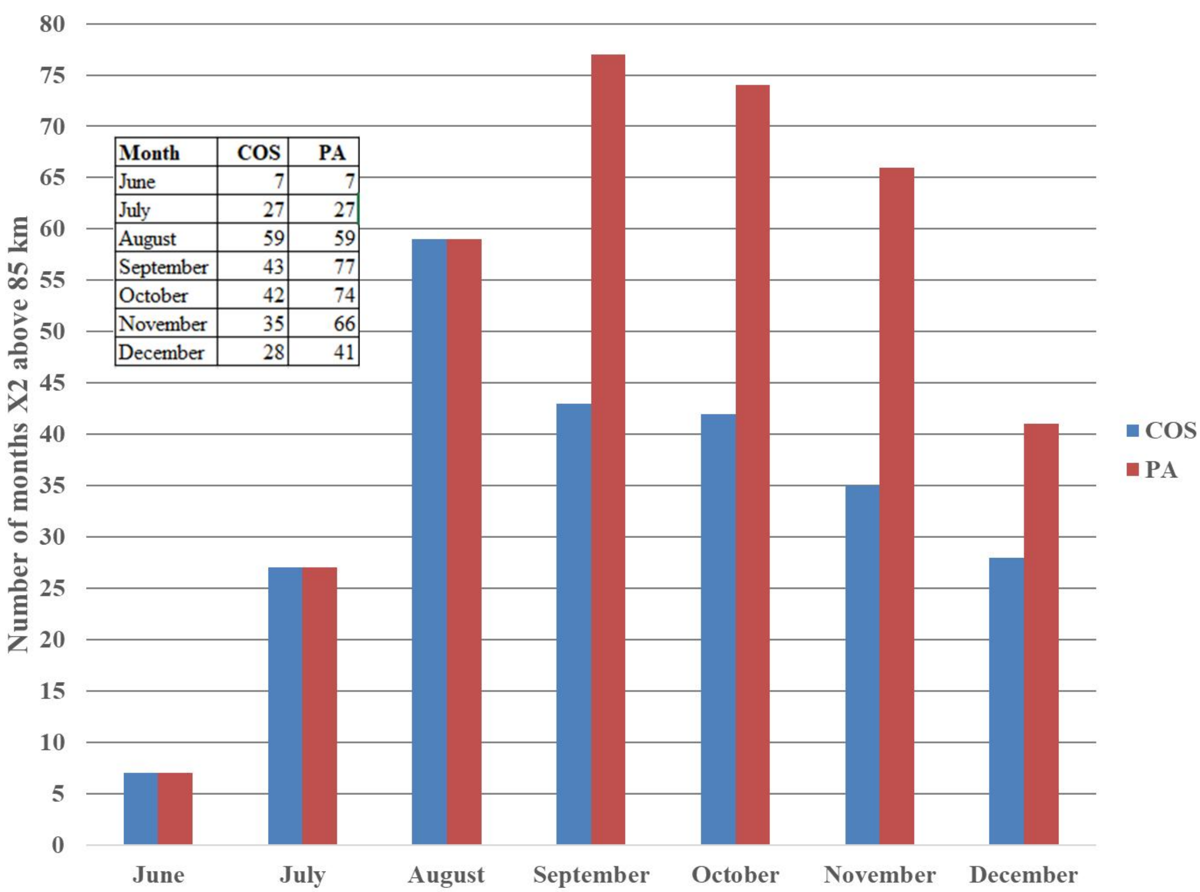

Figure 10. Comparison of the frequency of months (June-December) for the COS and PA that CalSim II modeling (n=82) indicates that X2 is at or above 85 km from the Golden Gate Bridge (no overlap of the low-salinity zone with Suisun Bay).

1.3.3 Habitat conditions supporting adult dispersal

PCE 3 – River Flow

Adult delta smelt need unrestricted access to suitable spawning habitat from December to March. Adequate flow must be maintained to attract migrating adults within the Delta and Suisun Marsh. These areas also should be protected from physical disturbance and flow disruption during adult dispersal. River flows includes inflow and outflow from the Delta, both of which influence the movement of migrating adult, larval, and juvenile delta smelt. Inflow, outflow, and OMR river flow influence the vulnerability of delta smelt adults to entrainment at Banks and Jones Pumping Plants. As discussed in the *Status of the Species Within the Action Area* and *Status of the Critical Habitat Within the Action Area* sections, new scientific understanding of factors affecting entrainment risk suggest that turbidity (PCE 2) in addition to river flow plays an important role in attracting migrating adults to spawning habitat.

Freshwater flows in combination with increasing turbidity are cues for adult delta smelt to disperse to spawning habitat in December through March (Sommer *et al.* 2011). South Delta water exports can alter critical habitat by drawing turbid Sacramento River water into the central and south Delta, encouraging the dispersal of adult delta smelt further south and east, making them and their offspring vulnerable to entrainment. For the south Delta, OMR flows more positive than -5000 cfs are expected to be protective of a high fraction of migrating adults because Sacramento River water flowing into the mainstem of the San Joaquin River is not being rapidly drawn into Old and Middle river under those conditions bringing the turbidity with it. This would indicate that more negative OMR flow conditions in critical habitat during adult spawning could result in disruption of turbidity cues for dispersing adults, altered transport flows, increased risk of entrainment into Old and Middle Rivers, and potentially into the Banks and Jones pumping facilities.

OMR Management is proposed as part of the PA and includes potential short-term restrictions as part of a real-time decision process to limit the dispersal of turbid water into the south Delta and pumping facilities during the adult dispersal period in December through March. These real-time management actions were not included in the CalSim II hydrologic modeling but if implemented, they could reduce the intensity and duration of disruptions to hydrodynamic and water quality-based dispersal cues during adult dispersal.