Attachment 12

Technical Memorandum – Restoration Guidance for Delta Smelt. WRA, 2017

TECHNICAL MEMORANDUM

RESTORATION GUIDANCE FOR DELTA SMELT

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The purpose of this technical memorandum is to provide guidance for the conceptual development of habitat restoration for Delta smelt (*Hypomesus transpacificus*) at the Cache Slough Project Property in Solano County, California. Appended to this memorandum is for target protected fish species, which includes Delta smelt, to occur and benefit from proposed restoration activities at the Cache Slough Project Property.

SPECIES BACKGROUND

Delta Smelt (*Hypomesus transpacificus*).
Delta smelt is a member of the Osmeridae family (northern smelts) (Moyle 2002) and is one of six species currently recognized in the genus *Hypomesus* (Bennett 2005). Delta smelt is a California endemic species, found only within the San Francisco and Sacramento-San Joaquin Delta Estuary.

Delta smelt are a pelagic species and the majority of the population lives for only a single year and with a small portion living into the second year. Delta smelt are fast-growing and short-lived, with the majority of growth occurring in the first seven to nine months of life. Adult Delta smelt are slender body fish that generally reach 60 to 70 mm standard length (SL), though a few may reach 120 mm SL (USFWS 2003). While some aspects of this species' life history are known, certain key components of wild fish, such as spawning habitat requirements and locations, are less well known and often inferred by laboratory observations, trawl and sample catch locations of spent females and young larvae, and comparisons with similar species (USFWS 2008).

The US Fish and Wildlife Service (USFWS) proposed to list the Delta smelt as threatened with proposed critical habitat on October 3, 1991 (56 FR 50075). The USFWS listed the Delta smelt as threatened on March 5, 1993 (58 FR 12854), and designated critical habitat for this species on December 19, 1994 (59 FR 65256). Delta smelt was listed as Endangered under the California Endangered Species Act on January 20, 2010. The Delta smelt was one of eight fish species addressed in the Recovery Plan for the Sacramento–San Joaquin Delta Native Fishes

(USFWS 1995). A 5-year status review of the Delta smelt was completed on March 31, 2004; that review affirmed the need to retain the Delta smelt as a threatened species.

DESIGN PARAMETERS

The following table discusses key concepts for a range of parameters important to Delta smelt restoration. Each parameter is discussed in more detail in the sections below.

Parameter	Key Concepts – Guiding Principal
Location	Cache Slough – Liberty Island Complex is an important area for Delta smelt; a portion of the population is present in this location throughout the year
Location	In freshwater Delta smelt are commonly found in tidal channels and littoral zones (i.e. water column)
Depth	Shallow subtidal water habitat less than 4 meters (13.1 feet)
Channel Size	Channel size is variable; from widths of 15 meters (49.2 feet) to 280 meters (306.2 feet) used by the species
Spawning / Spawning Habitat	Adhesive eggs are believed to be laid on shallow sandy beaches or sloughs
Food / Feeding	Feed mainly on zooplankton; particularly calanoid copepods
Water Velocity	Delta smelt are not strong swimmers
Salinity	Delta smelt are most abundant in low salinity zones
Turbidity	Turbidity is an important habitat feature for this species
Water Temperature	Commonly observed in water temperature at 10-22°C

Guidance From Sommer and Meija 2013 : "*A given project will fail if the constructed habitat is subject to periodic water quality issues such as low dissolved oxygen, pesticide inputs, and toxic algal blooms, or high levels of predators and invasive species. In general, maintaining high levels of hydrologic and structural variability and complexity has been suggested as a key approach to promote native fishes (Moyle et al. 2010)*."

Location

Key concept geographic scale: Cache Slough – Liberty Island Complex is an important area for Delta smelt; a portion of the population is present in this location throughout the year.

Key concept: In freshwater Delta smelt are commonly found in tidal channels and littoral zones (i.e. water column).

The North Delta Habitat Arc concept has been championed by UC Davis as a core area with the best potential to benefit native fishes through an interconnected series of mostly tidal habitats (Fig 1). The Cache - Lindsey Slough – Liberty Island Complex features prominently in this recovery strategy, as it makes up a significant portion of the North Delta and one of the few remaining places Delta smelt have been found. A small portion of the Delta smelt population is believed to remain in the Cache Slough Complex year-round (IEP 2015).

Delta smelt are capable of completing their life cycle and remaining year-round in freshwater (Moyle *et al* 2016). In freshwater habitat, Delta smelt are commonly found in tidal channels and littoral zones (i.e. water column). They are rarely encountered in non-tidal or in/adjacent to

submerged aquatic vegetation (SAV). There has been little sampling in emergent marshes; however the species is not believed to use these areas with any frequency (Sommer and Meija 2013).

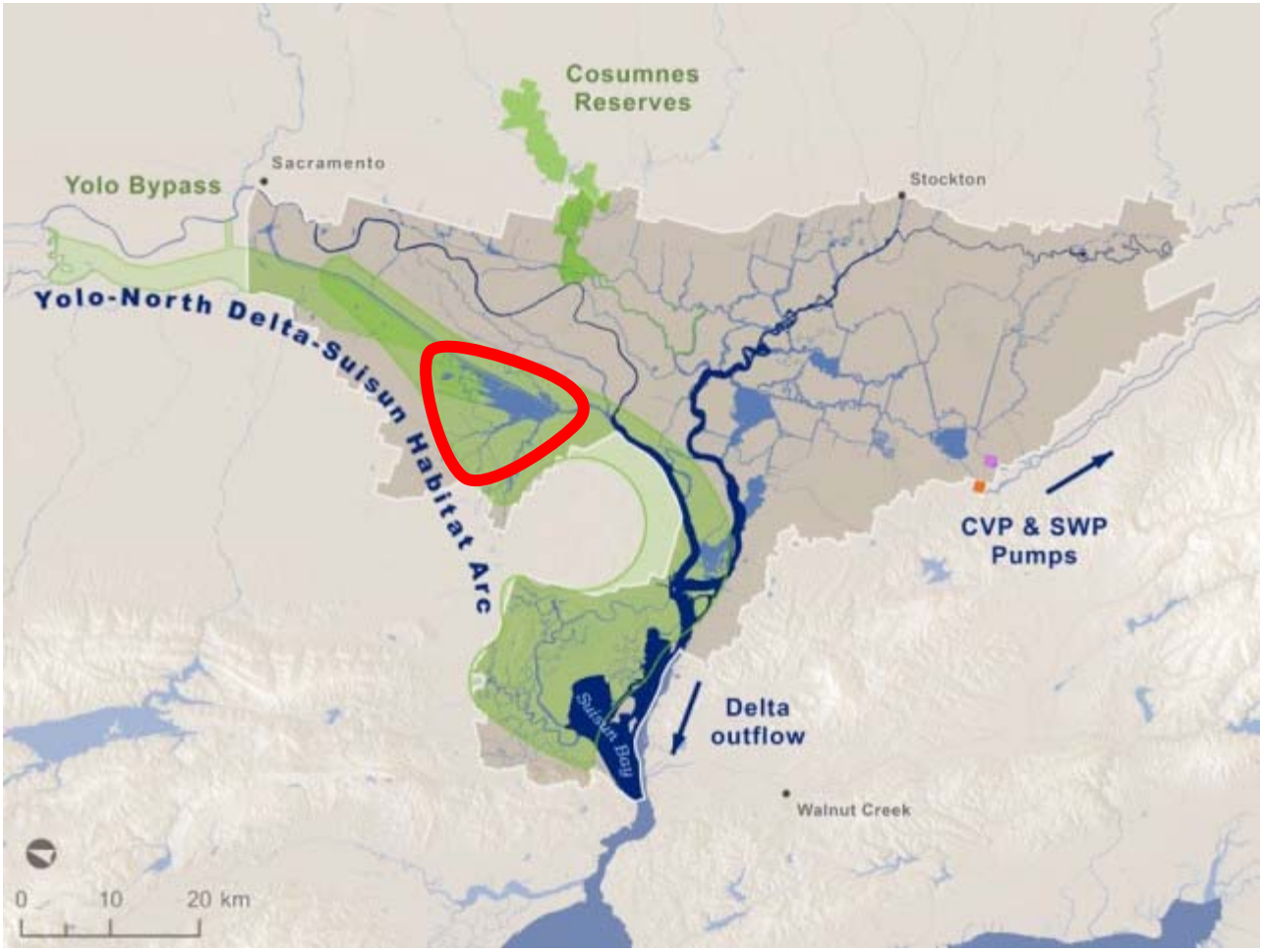

Figure 1. North Delta Habitat Arc; Cache - Lindsey Slough – Liberty Island Complex circled in red. Source: https://californiawaterblog.com/2016/11/06/the-north-delta-habitat-arc-an-ecosystem-strategy-for-saving-fish/

Depth

Key concept: Shallow subtidal water habitat less than 4 meters (13.1 feet) preferred by the species

While considered a pelagic species, Delta smelt will utilize much of the water column and have been caught in shoals and shallow water (Sommer and Meija 2013). USFWS considers shallow subtidal habitat less than 4 meters (13.1 feet) to be a core part of designated Critical Habitat (USFWS 1994). Shallow open water habitat is one of the few structural habitat components that this otherwise pelagic species has been linked to (USFWS 2008).

The species location throughout the water column can vary throughout the day, and can be driven by tidal conditions, turbidity, life stage, river stage, light, and food availability (IEP 2015).

Smelt rely on subtidal habitat for spawning and foraging, and are not believed to substantially use intertidal areas (Sommer and Meija 2013).

Channel Size

Key concept: Channel size variable; from widths of 15 meters (49.2 feet) to 280 meters (306.2 feet)

Channel width is not believed to be a constraint for the species. Delta smelt have been captured in a wide range of channel widths; including the Cache Slough (up to 280 meters [306.2 feet]) down to Spring Branch Slough in Suisun Marsh (15 meters wide [49.2 feet]) (Sommer and Meija 2013).

Spawning / Spawning Habitat

Key concept: Adhesive eggs are believed to be laid on shallow sandy beaches or sloughs

Adults migrate to more freshwater environments of the upper Delta, where they seek out sloughs and shallow edge areas. Delta Smelt spawning locations are dependent upon fresh water flow conditions and can vary in locality yearly. While most spawning occurs within the upper Delta and the Sacramento River above Rio Vista, spawning has occurred within the Montezuma Slough near Suisun Marsh and during years with high rainfall may occur as far west as the Napa River "estuary" (Moyle 2002). Spawning locations are inferred by the locations of captured gravid females, spent females and larvae in trawl samples. Wet years, in which higher levels of freshwater are moving through the Delta system, appear to cause a greater abundance and distribution of smelt in the following year (USFWS 2003). Larvae hatch in 10 to 14 days, are planktonic (float with the water currents), and are washed downstream until they reach areas near X2.

The only known important physical habitat for Delta Smelt occurs during spawning, when suitable spawning substrate is required. Spawning has not been observed in the wild, and what is known about Delta smelt spawning and related habitat is inferred from the location of captured post hatch larvae and laboratory culture. Suitable spawning habitat is comprised of open, unvegetated, shallow subtidal (less than three meters) waters with sand or pebble sized substrate found within freshwater sloughs, beaches or shoals (USFWS 2008, Moyle 2002, EIP 2015). Sand is believed to be the preferred spawning substrate for the species. Submerged aquatic vegetation (SAV) is not thought to be used for spawning by Delta smelt, and the expansion the invasive Brazilian waterweed (*Egeria densa*) has likely reduced the availability of suitable spawning site within the Delta (Moyle et al 2016).

Spawning can occur January through June, with peak spawning activity occurring in April and May (EIP 2015, Moyle 2002). Most spawning is believed to take place within seven to 15 degrees Celsius (C), though temperatures as high as 22 C may be suitable for reproduction (USFWS 2003). Smelt are broadcast spawners with demersal, or bottom-sinking, fertilized eggs that adhere to pebble or sand substrate to keep them from washing away and to allow them to "tumble incubate" with wave movement (USFWS 2008). In laboratory experiments, females demonstrated the ability to produce multiple clutches when spawning conditions were favorable (Moyle et al 2016).

Water Velocity

Key concept: Delta smelt are not strong swimmers

Delta smelt juveniles and adults are not strong swimmers and have a hard time sustaining themselves in elevated water velocities and therefore subject to involuntary transport in river flows and tidal exchange (IEP 2015). Delta smelt are believed to move up or down in the water column under different tidal conditions (referred to as 'tidal surfing') as a way to reduce energetic cost (IEP 2015).

Delta smelt can swim at a sustained stroke glide at less than 10 cm/s and sustained swimming occurs above 15 cm/s. Fish will normally not swim above water velocity of 10-15 cm/s (Moyle *et al* 2016). Adult fish have a critical swimming ability (top speed) near 28 cm/s (Sommer and Meija 2013). Larval Delta smelt have comparatively little swimming ability and are transported to downstream low salinity mixing areas once they hatch out (IEP 2015).

Salinity

Key concept: Delta smelt are most abundant in low salinity zones

Delta smelt distribution typically tracks with salinity distribution within the Delta Estuary, and salinity is considered a key environmental parameter for habitat suitability. The species is generally found in low salinity zones; ranging from 0 to 7 ppt (Moyle *et al* 2016). The species has been found to tolerate salinity in the field up to 19 ppt, and has been shown to survive sea water conditions for short periods of time in the laboratory (IEP 2015, Komoroske *et al* 2014).

Adult Delta smelt spawn in freshwater with larvae subsequently being washed downstream to low salinity mixing zones where they rear. The low salinity mixing zone corresponds to the point in the estuary where the average daily salinity at the bottom of the water is two ppt. This location is referred to as "X2," which is the distance from this low salinity zone (about 0.6 to 3.0 ppt) to the Golden Gate Bridge, measured in kilometers (USFWS 2008). This distance changes over the course of the year based on freshwater inflow through the Delta (USFWS 2008). Periods when the X2 gradient is located within western Suisun Bay have been found to have a positive effect on Delta smelt abundance (Moyle *et al* 2016).

Turbidity

Key concept: Turbidity is an important habitat feature for this species

Delta smelt distribution is strongly associated with turbid water from spring through fall (Moyle et al 2016). Catch rates and entrainment rates have been found to be higher at higher turbidity levels (IEP 2015). For Delta smelt, turbidity is believed to be important for increasing foraging efficiency and decreasing the predation threat (IEP 2015). In laboratory experiments, Delta smelt feeding was highest at 12 Nephelometric Turbidity Units (NTUs) and was stable in the turbidity range of 12 – 120 NTU (Hasenbein et al. 2013). Laboratory results have also found that larval Delta smelt vertical position within the water column shifts upward (i.e. higher/shallower), which is believed to put them in more food rich surface waters (IEP 2015). Within the Delta, turbidity is generally between 20-40 NTUs, and can increase to 250-500 NTUs

during higher river flows (CDWR 2013). Turbidity at or above 250 NTUs is believed to impair feeding (IEP 2015).

Water Temperature

Key concept: Commonly observed in water temperature at 10-22°C

Water temperature plays an important role in determining Delta smelt distribution and habitat suitability. The species is typically observed in water temperatures ranging from 10-22°C (Moyle *et al* 2016). Delta smelt are sensitive to warm temperatures, as the upper thermal tolerance of the species is at 25°C (IEP 2015). In laboratory conditions, juvenile Delta smelt have been found to have slightly elevated upper thermal tolerance (up to 29°C); however, are rarely found in the field in locations that reach 25°C (Komoroske *et al* 2014, IEP 2015). Thermal related stress is believed to begin in fish exposed to water 20 to 21°C; which while not fatal, could result in the species allocating energy to stress response and away from growth or reproductive output (Moyle *et al* 2016).

Food / Foraging

Key concept: Feed mainly on zooplankton; particularly calanoid copepods.

Delta smelt feed on small crustacean, called zooplankton, which fill part of the base levels of the food web. Food production for Delta smelt is largely driven by bottom-up dynamics, where nutrient availability and favorable abiotic conditions combine to stimulate phytoplankton and subsequent zooplankton development. In addition to food production, the type of zooplankton available (i.e. food quality) is important for Delta smelt. The primary zooplankton consumed by the species include calanoid (*Eurytemora affinis*, *Pseudodiaptomus forbesi*, *Acartiella sinensis*, *Sinocalanus doerri*), copepods, cladocerans, with larger adult smelt are capable of consuming mysid shrimp (*Neomysis mercedis*) (Moyle *et al* 2016, IEP 2015). Delta smelt distribution has been correlated with turbidity which can help increase foraging efficiency and decrease predation threat (IEP 2015).

Food web support and improving primary and secondary productivity in the Delta has been identified as critical part of the effort to recover Delta smelt. Marsh and floodplain habitat generate primary productivity, but these habitats have been significantly decreased by the establishment of levees throughout the Delta system. Historically, there were over 3,000 km of marsh and floodplain habitat connected to water; however, this number is now estimated to have been reduced to only 31 km (Cloern *et al* 2016).

In addition to reconnecting tidal habitat, food web enhancements flows have been used in the Yolo Bypass to stimulate plankton blooms within the Delta (CNRA 2016b). Using seasonal pulse flows, targeted applications of water are transported through wetland and tidal slough complexes and have been shown to create beneficial downstream phytoplankton blooms (CNRA 2016a). Directional water flow through tidal systems, increased residence time in dendritic channels, and targeted use of managed wetlands are believed to promote phytoplankton blooms which support zooplankton development and improved food web conditions for Delta smelt (CNRA 2016a, Brown *et al* 2016).

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SUPPLEMENTAL TECHNICAL MEMORANDUM

FISH HABITAT RESTORATION PROGRAM TARGET SPECIES

Potential for Occurrence

and

Benefit of Habitat Restoration

FISH HABITAT RESTORATION PROGRAM TARGET SPECIES

This section will discuss the potential for target protected fish species identified in the Department of Water Resources Biological Opinion from the US Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) and the California Department of Fish and Wildlife Service (CDFW) Incidental Take Permit to occur within the Cache Slough Project Property in Solano County, California (Study Area). "Target protected fish species" covered under these respective documents include Delta smelt (*Hypomesus transpacificus*), steelhead (*Oncorhynchus mykiss)*, winter and spring-run Chinook salmon (*O. tshawytscha)*, green sturgeon (*Acipenser medirostris*), and longfin smelt (*Spirinchus thaleichthys*). Table 1 discusses key components of each species life history and provides an evaluation of the potential for each to take place at, and subsequently benefit from, the potential tidal reconnection and habitat restoration associated with the Study Area. Life history components discussed include adult and juvenile rearing, migration, and spawning habitat. Additionally, the presence of federal designated critical habitat for each species is addressed. Finally, a narrative of potential benefits the restoration of the Study Area would provide to these species is provided.

The Study Area is located within the North Delta Habitat Arc, which provides the best potential for habitat restoration and recovery actions for target protected species. Located in the Cache Slough Complex and adjacent to important and well studied Delta regions such as Liberty Island, the Yolo Bypass, and the lower Sacramento River; the Study Area is well positioned to provide habitat for the target protected fish species. Long term monitoring stations positioned near the Study Area provides a basis for the frequency of each species life stage occurring in the area, and supports the vital role the Cache Slough Complex provides for each species. As portions of the Delta have become unusable for these protected species, the Cache Slough Complex has remained one of the few locations where these species consistently occur (Sommer and Meija 2013, IEP 2015, Young et al 2015, Moyle *et al* 2016, Morris and Damon 2016, CDFW 2017).

Habitat within the Study Area is currently inaccessible to the target species, with the exception of elevated winter flows which result in Cache Slough flooding the very southern portion of the Study Area (i.e. the Vogel property). Once waters recede, the low lying levees that serve to keep water out of the Vogel property then act to trap water and fish within what becomes a temporary 65 acre lake. The majority of the Study Area is blocked by US Army Corps of Engineers levees, and while there is a small network of screw gate culverts, these provide only a small amount of managed water movement into or out of the Study Area. The levee protected irrigated agricultural land that comprises the Study Area is emblematic of the habitat loss that has occurred for the target protected fish species. Only a small fraction of the historic tidal wetlands, sloughs, and floodplain habitat of the Delta remain, and the loss of these key nursery and breeding grounds have significantly affected the target protected species.

Proposed restoration of the Study Area will serve to reverse this trend by reconnecting historic habitat and creating new high quality habitat in a important location for the target protected fish species. Restoration activities will look to excavate a network of dendritic channels, reestablish an extensive wetland complex, provide transitional floodplain habitat to account for sea level rise, and breach levees to reestablish tidal exchange throughout the Study Area. Fundamental benefits for target species are anticipated to occur with:

- **Improved and new created rearing habitat.** The restoration of approximately 1,600 acres of habitat will provide important nursery habitat for juvenile fish. Subtidal dendritic channels boarded by tidal wetlands will provide foraging habitat and cover for Delta smelt, juvenile salmonids, and green sturgeon. Under elevated winter flows, much of the Study Area will be submerged, providing increased foraging habitat for outmigrating salmonids that significantly benefit from access to high quality floodplain habitat (Jeffres et al 2008). The restoration will also breech the levee surrounding the Vogel property, which currently acts to trap fish after high flows recede and impounded water forms a temporary lake. Restored tidal channel connection in this portion of the Study Area will correct a potential stranding area for native fish that were using Vogel for foraging habitat.
- **Improved and new created spawning habitat.** The Cache Slough Complex contains suitable spawning habitat for Delta smelt and longfin smelt and the detection of larval smelt indicate these species use the area as a core portion of their remaining spawning grounds (Sommer and Meija 2013, Young et al 2015, Morris and Damon 2016, CDFW 2017). The creation of subtidal channels tidally connected to the Cache Slough Complex is anticipated to provide potentially suitable spawning habitat for Delta smelt and longfin smelt. While specific spawning habitat requirements for these two species are unknown, the restoration design will incorporate the current understanding of suitable spawning habitat. An approach with heterogenous subtidal habitat, with seasonally deeper elevations occurring in the southern portion of the Study Area and shallower subtidal and intertidal channels occurring in the northern portion, is anticipated to provide a range of spawning sites under different flows conditions. Seasonal inundation of freshwater marsh habitat is also anticipated to provide habitat for other native fish species, including the California species of special concern Sacramento splittail (*Pogonichthys macrolepidotus*).
- **Added food web support.** Improved access to primary productivity and zooplankton, particularly during the summer and fall months, have been identified as a necessity to recovering the Delta smelt (IEP 2015). Marsh and floodplain habitat drive primary productivity, but these habitats have been significantly decreased by the establishment of levees throughout the Delta system. Historically, there were over 3,000 km of marsh and floodplain habitat connected to water; however, this number is now estimated to have been reduced to only 31 km (Cloern *et al* 2016). Reconnecting and establishing over 1,600 acres of hetergenous subtidal, intertidal, wetland, and floodplain habitats will result in nutrient availability and varied water residence times anticipated to stimulate primary productivity. The Study Area is anticipated to provide food web support to species within the Cache Slough Complex, and serve as an exporter of nutrients and basal trophic level support during seasonal pulse flows and more extreme tidal periods. Restoration of the Study Area is anticipated to benefit all target protected fish species, and is likely to a particular benefit to Delta smelt as a portion of population is believed to remain in the Cache Slough Complex year-round (IEP 2015).

The habitat benefits of restoring the Study Area for target protected fish species are anticipated to be numerous and dynamic. Seasonal changes and annual variability in flows will change the amount and duration various portions of the Study Area are accessible and alter the roles these habitats can play. Restoring and reconnecting hetergenous habitats within the Cache Slough Complex provide the target protected fish species a better chance of completing their life cycles through

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Table 1. Life stages of Fish Habitat Restoration Program Target Species and critical habitat for Cache Slough Complex within the vicinity of the Study Area

SPECIES	STATUS*	HABITAT	LIFE STAGE	POTENTIAL FOR OCCURRENCE
Delta smelt *Hypomesus transpacificus*	FT, SE	Endemic to the Sacramento Delta, where it is distributed from the Suisun Bay upstream through the Delta in Contra Costa, Sacramento, San Joaquin, Solano and Yolo counties. The delta smelt is a pelagic and euryhaline species.	**ADULT (REARING/MIGRATION)**	**High Potential.** The Cache Slough Complex is known to support Delta smelt adult rearing habitat and serves as a portion of the Delta the species seasonally migrates through (DWR 2015, Bennett 2005, USFWS 1996). A small portion of the Delta smelt population is believed to inhabit the Cache Slough Complex year round (IEP 2015). Data from CDFW trawls confirms that adult smelt have been consistently detected in this area (CDFW 2017). Tidally reconnected habitat in the Study Area would create and increase adult rearing and migratory habitat for this species.
			JUVENILE (REARING/MIGRATION)	**High Potential.** The Cache Slough Complex is known to support Delta smelt juvenile rearing habitat and serves as a portion of the Delta the species seasonally migrates through (DWR 2015, Bennett 2005, USFWS 1996). A small portion of the Delta smelt population is believed to inhabit the Cache Slough Complex year round (IEP 2015). Data from CDFW trawls confirms that juvenile and larval smelt have been consistently detected in this area (CDFW 2017). Tidally reconnected habitat in the Study Area would create and increase juvenile rearing and migratory habitat for this species.

SPECIES	STATUS*	HABITAT	LIFE STAGE	POTENTIAL FOR OCCURRENCE
Delta smelt cont.			**SPAWNING**	**High Potential.** The only known important physical habitat for Delta smelt occurs during spawning, when suitable spawning substrate is required. Suitable spawning habitat is comprised of open, unvegetated, shallow subtidal (less than three meters) waters with sand or pebble sized substrate found within freshwater sloughs (USFWS 2008, Moyle 2002). The Cache Slough Complex contains suitable spawning habitat for the species and the detection of larval smelt indicate the species uses these areas as a core portion of their remaining spawning grounds (Sommer and Meija 2013, Young et al 2015, Morris and Damon 2016, CDFW 2017). Tidally reconnected habitat in the Study Area would create potential spawning habitat for this species.
			CRITICAL HABITAT	**Present.** The entire Study Area falls within designated critical habitat for the species. Tidally reconnected habitat in the Study Area would benefit the species critical habitat.

SPECIES	STATUS*	HABITAT	LIFE STAGE	POTENTIAL FOR OCCURRENCE
steelhead - Central Valley Distinct Population Segment *Oncorhynchus mykiss*	FT, NMFS	Anadromous, spending most of life cycle in the ocean. Occurs in the Sacramento and San Joaquin Rivers and their tributaries, excluding San Francisco and San Pablo bays and their tributaries. Adults migrate upstream to spawn in cool, clear, well-oxygenated streams. Juveniles remain in fresh water for 2 or more years before migrating downstream to the ocean. Resident form known of the species, called rainwater trout, are protected in anadromous streams and waterways.	**ADULT (REARING/MIGRATION)**	**Moderate Potential.** The Sacramento River serves as a major migratory corridor. The close proximity of the Cache Slough Complex to the Sacramento River and Yolo Bypass make it likely that migrating adults may periodically utilize the areas adjacent to the Study Area. Tidally reconnected habitat in the Study Area may create and increase opportunistic rearing habitat for adult steelhead; however, would not serve as a migratory corridor for the species.
			JUVENILE (REARING/MIGRATION)	**High Potential.** Juvenile steelhead can spend several years rearing in freshwater before migrating to the ocean. Sloughs, marshes, and off-channel habitats like those found throughout the Cache Slough Complex provide important rearing habitat and cover during migration (NMFS 2016a). Juvenile steelhead have been regularly encountered by CDFW within the area (DWR 2015). Tidally reconnected habitat in the Study Area would create and increase rearing habitat for juvenile steelhead.
			SPAWNING	**No Potential.** The Cache Slough Complex does not provide suitable stream habitat for spawning. Tidally reconnected habitat in the Study Area would not provide spawning habitat for steelhead.
			CRITICAL HABITAT	**Present.** The southern portion of the Study Area, along Cache Slough, falls within designated critical habitat for the species. Tidally reconnected habitat in the Study Area would benefit the species critical habitat.

SPECIES	STATUS*	HABITAT	LIFE STAGE	POTENTIAL FOR OCCURRENCE
Chinook salmon, Central Valley spring-run Evolutionary Significant Unit (ESU) *Oncorhynchus tshawytscha*	FT, ST, NMFS	Anadromous, spending most of life cycle in the ocean. Federal listing includes populations spawning in the Sacramento River and its tributaries. Adults migrate upstream typically February though June to spawn in cool, clear, well-oxygenated spring fed streams. Juveniles remain in fresh water for one or more years before migrating downstream to the ocean.	**ADULT (REARING/MIGRATION)**	**Unlikely.** The Sacramento River serves as the primary migratory corridor for this species. The close proximity of the Study Area to the Yolo Bypass makes it possible for the species to migrate past the Study Area; however, the Cache Slough Complex does not provide a migratory route for the species. Furthermore, adults do not feed after entering freshwater so rearing habitat is not required. Tidally reconnected habitat in the Study Area would not provide adult rearing or migratory habitat for this species.
			JUVENILE (REARING/MIGRATION)	**Moderate Potential.** Juvenile spring-run Chinook salmon typically emigrate January through April. Migration generally occurs at night within the deeper portions of rivers; however, day time rearing habitat is often in shallow vegetative covered locations where food and shelter are more abundant. Sloughs, marshes, and off-channel habitats like those found throughout the Cache Slough Complex provide important rearing habitat and cover during outmigration (NMFS 2016a). Spring Kodiak trawl data from CDFW operations south of Liberty Island, as well as fish rescue operations in the Yolo Bypass have confirmed the presence of the species throughout the local area (CDFW 2017, Acierto et al 2014). Tidally reconnected habitat in the Study Area would create and increase rearing habitat for juvenile spring-run Chinook salmon.

SPECIES	STATUS*	HABITAT	LIFE STAGE	POTENTIAL FOR OCCURRENCE
Chinook salmon, Central Valley spring-run ESU			**SPAWNING**	**No Potential.** The Cache Slough Complex does not provide suitable spring fed stream habitat for spawning. Tidally reconnected habitat in the Study Area would not provide spawning habitat for the species.
			CRITICAL HABITAT	**Present.** The southern portion of the Study Area, along Cache Slough, falls within designated critical habitat for the species. Tidally reconnected habitat in the Study Area would benefit the species critical habitat.

SPECIES	STATUS*	HABITAT	LIFE STAGE	POTENTIAL FOR OCCURRENCE
Chinook salmon, Sacramento River winter-run ESU *Oncorhynchus tshawytscha*	FE, SE, NMFS	Occurs in the Sacramento River below Keswick Dam. Spawns in the Sacramento River but not in tributary streams. Requires clean, cold water over gravel beds with water temperatures between 6 and 14 degrees C for spawning. Adults migrate upstream to spawn in cool, clear, well-oxygenated streams. Juveniles typically migrate to the ocean soon after emergence from the gravel.	**ADULT (REARING/MIGRATION)**	**Unlikely.** The Sacramento River serves as the primary migratory corridor for this species. The close proximity of the Study Area to the Yolo Bypass makes it possible for the species to migrate past the Study Area; however, the Cache Slough Complex does not provide a migratory route for the species. Furthermore, adults do not feed after entering freshwater so rearing habitat is not required. Tidally reconnected habitat in the Study Area would not provide adult rearing or migratory habitat for this species.
			JUVENILE (REARING/MIGRATION)	**Moderate Potential.** Juveniles typically emigrate September – January. The Study Area provides suitable rearing habitat for emigrating juveniles, and may be used seasonally by the species. Spring Kodiak trawl data from CDFW operations south of Liberty Island, as well as fish rescue operations in the Yolo Bypass have confirmed the presence of the species throughout the local area (CDFW 2017, Acierto et al 2014). Tidally reconnected habitat in the Study Area would create and increase rearing habitat for juvenile spring-run Chinook salmon.
			SPAWNING	**No Potential.** The Cache Slough Complex does not provide suitable stream habitat for spawning. Tidally reconnected habitat in the Study Area would not provide spawning habitat for the species.
			CRITICAL HABITAT	**Not Present.** The Study Area does not fall within designated critical habitat for the species.

SPECIES	STATUS*	HABITAT	LIFE STAGE	POTENTIAL FOR OCCURRENCE
Chinook salmon, Central Valley fall/late fall-run ESU *Oncorhynchus tshawytscha*	SSC, NMFS	Populations spawning in the Sacramento and San Joaquin Rivers and their tributaries. Adults migrate upstream to spawn in cool, clear, well-oxygenated streams. Juveniles may remain in fresh water for 1 or more years before migrating downstream to the ocean	**ADULT (REARING/MIGRATION)**	**Unlikely.** The Sacramento River serves as the major migratory corridor for this species. The close proximity of the Study Area to the Yolo Bypass makes it possible for the species to migrate past the Study Area; however, the Cache Slough Complex does not provide a migratory route for the species. Furthermore, adults do not feed after entering freshwater so rearing habitat is not required. Tidally reconnected habitat in the Study Area would not provide adult rearing or migratory habitat for these species.
			JUVENILE (REARING/MIGRATION)	**High Potential.** Juvenile fall-run Chinook salmon typically emigrate March – April, and late fall-run juveniles generally emigrate April - October. Sloughs, marshes, and off-channel habitats like those found throughout the Cache Slough Complex provide important rearing habitat and cover during outmigration (NMFS 2016a). Spring Kodiak trawl data from CDFW, as well as fish rescue operations in the Yolo Bypass have confirmed the presence of the species near the Study Area (CDFW 2017, Acierto et al 2014). Tidally reconnected habitat in the Study Area would create and increase rearing habitat for these species.
			SPAWNING	**No Potential.** The Cache Slough Complex does not provide suitable spawning habitat. Tidally reconnected habitat in the Study Area would not provide spawning habitat for the species.
			CRITICAL HABITAT	**Not designated for these species.**

SPECIES	STATUS*	HABITAT	LIFE STAGE	POTENTIAL FOR OCCURRENCE
green sturgeon, southern Distinct Population Segment (DPS) *Acipenser medirostris*	FT, SSC NMFS	Spawn in the Sacramento River and the Klamath River. Spawn at temperatures between 8-14 degrees C. Preferred spawning substrate is large cobble, but can range from clean sand to bedrock. Spawn in deep pools or "holes" in large, turbulent, freshwater river mainstems. Adults live in oceanic waters, bays, and estuaries when not spawning. Species is known to forage in estuaries and bays.	**ADULT (REARING/MIGRATION)**	**Moderate Potential.** Adult green sturgeon occur within the Sacramento River and Yolo Bypass. The Study Area is located adjacent to core habitat for the species, and Cache Slough Complex provides suitable adult foraging habitat. Adult sturgeon may forage and migrate past the Study Area during elevated flows when the Yolo Bypass is inundated. Tidally reconnected habitat in the Study Area would create and increase potential rearing habitat for adult green sturgeon.
			JUVENILE (REARING/MIGRATION)	**Moderate Potential.** Juvenile sturgeon distribution during their freshwater rearing period is not well known; however, the Cache Slough Complex provides suitable rearing habitat for this life stage. Tidally reconnected habitat in the Study Area would create and increase potential rearing habitat for juvenile green sturgeon.
			SPAWNING	**No Potential.** The Cache Slough Complex does not provide deep-water mainstem riverine areas typically used by the species for spawning. Tidally reconnected habitat in the Study Area would not provide spawning habitat for green sturgeon.
			CRITICAL HABITAT	**Not Present.** The Study Area is located immediately adjacent to designated critical habitat for the species. Shag Slough is the western boundary of critical habitat in the vicinity of the Study Area.

SPECIES	STATUS*	HABITAT	LIFE STAGE	POTENTIAL FOR OCCURRENCE
longfin smelt *Spirinchus thaleichthys*	ST, FC	Euryhaline, nektonic and anadromous. Found in open waters of estuaries, mostly in middle or bottom of water column. Prefer salinities of 15 to 30 ppt, but can be found in completely freshwater to almost pure seawater. Migrate to freshwater Adults move into freshwater streams in the winter to spawn. Juveniles and larvae rear for a period of time in low salinity zones.	**ADULT (REARING/MIGRATION)**	**High Potential.** The Cache Slough Complex is known to be important and seasonally support adult lognfin smelt as they migrate to spawning habitat (La Luz and Baxter 2015, CDFW 2017). During these periods, it's likely that opportunistic rearing takes place. Tidally reconnected habitat in the Study Area would create and increase adult rearing and migratory habitat for this species.
			JUVENILE (REARING/MIGRATION)	**High Potential.** The Cache Slough Complex is known to be important and seasonally support juvenile lognfin smelt as they rear in freshwater before migrating to more marine conditions (La Luz and Baxter 2015, CDFW 2017, Morris and Damon 2016). Data from CDFW trawls confirms that juvenile and larval smelt have been consistently detected in this area (CDFW 2017). Tidally reconnected habitat in the Study Area would create and increase juvenile rearing and migratory habitat for this species.
			SPAWNING	**High Potential.** The Cache Slough Complex contains suitable spawning habitat for the species and the detection of larval smelt indicate the species uses these areas as an important portion of their spawning grounds (Young et al 2015, Morris and Damon 2016, CDFW 2017). Tidally reconnected habitat in the Study Area would create potential spawning habitat for this species.
			CRITICAL HABITAT	**Not designated for the species.**

*** Key to status codes:**

FE	Federal Endangered
FT	Federal Threatened
FC	Federal Candidate
NMFS	Species under the Jurisdiction of the National Marine Fisheries Service
SE	State Endangered
ST	State Threatened
SSC	CDFW Species of Special Concern