

2 Covered Species

This section contains species accounts for all listed species addressed in this document. The species habitat models described herein were initially developed for the Bay Delta Conservation Plan Public Draft (U.S. Bureau of Reclamation and California Department of Water Resources 2013) and carried forward for this analysis, except Mason’s lilaepsis, for which field surveys were conducted.

California Department of Fish and Wildlife (CDFW) incidental take permit (ITP) regulations (14 California Code of Regulations [CCR] 783.2(a)(2)) require identification of the common and scientific names of the species to be covered by the permit, including the species’ status under the California Endangered Species Act (CESA). The species for which California Department of Water Resources (DWR) seeks a CESA ITP are shown in Table 2-1. These species have the potential to occur in the area that could be affected by the project and could be subject to incidental take as a result of the project. A description of each of the covered species is provided below, including known population trends and known threats to the species.

Table 2-1. Species to be Covered by 2081(b) Incidental Take Permit

Common Name	Scientific Name	State Status
Delta Smelt	<i>Hypomesus transpacificus</i>	Endangered
Longfin Smelt	<i>Spirinchus thaleichthys</i>	Threatened
Sacramento River Winter-Run Chinook salmon	<i>Oncorhynchus tshawytscha</i>	Endangered
Central Valley Spring-Run Chinook salmon	<i>Oncorhynchus tshawytscha</i>	Threatened
California Tiger Salamander	<i>Ambystoma californiense</i>	Threatened
Giant Garter Snake	<i>Thamnophis gigas</i>	Threatened
Swainson’s Hawk	<i>Buteo swainsoni</i>	Threatened
Tricolored Blackbird	<i>Agelaius tricolor</i>	Proposed Endangered
Mason’s Lilaepsis	<i>Lilaepsis masonii</i>	Rare ¹

¹ Take of Mason’s lilaepsis is being requested through a rare plant permit, not through a 2081(b) permit. Information on this species is provided in this document to support the rare plant permit application.

GIS-based habitat models have used to estimate impacts to California tiger salamander, giant garter snake, Swainson’s hawk, and tricolored blackbird. These habitat models are described in the appropriate subsections, below. Impacts to fish species were based on the assumption of potential presence throughout fish-bearing waters in the project area, subject to timing constraints and habitat use as described for each species in the appropriate subsections, below. Impacts to Mason’s lilaepsis were based on surveys conducted in the project area as described in Section 2.9 *Mason’s Lilaepsis*.

2.1 Delta Smelt

The following discussion summarizes aspects of Delta Smelt biology relevant to this application. This description was adapted from the environmental baseline presented in the *Biological Assessment of Potential Effects on Listed Fishes from the West False River Emergency Drought Barrier Project* (ICF International 2015).

2.1.1 Geographic Distribution and Status

The Delta Smelt was listed as a threatened species under the CESA in 1993, and reclassified as an endangered species in 2009. It is also listed as a threatened species under the federal Endangered Species Act (ESA). Delta Smelt are endemic to the San Francisco Estuary, found nowhere else in the world (Bennett 2005). Genetic analysis has established that Delta Smelt is most closely related to surf smelt (*H. pretiosus*), a species common along the western coast of North America (Trenham et al. 1998; Fisch et al. 2013). The Delta functions as a migratory corridor, as rearing habitat, and as spawning habitat for Delta Smelt. A summary of the general spatial distribution of life stages was provided by Merz et al. (2011), and is shown in Table 2-2.

2.1.2 Life History and Habitat Requirements

Overall, the Delta Smelt life cycle is completed in the brackish and tidal freshwater reaches of the upper San Francisco Estuary. Salinity requirements vary by life stage. Apart from spawning and egg-embryo development, the distribution and movements of all life stages are influenced by transport processes associated with water flows in the estuary, which also affect the quality and location of suitable open water habitat (Dege and Brown 2004; Feyrer et al. 2007; Nobriga et al. 2008). Delta Smelt are weakly anadromous and undergo a spawning migration from the low salinity zone (LSZ; 1–6 parts per thousand [ppt]) to freshwater in most years (Grimaldo et al. 2009; Sommer et al. 2011). Spawning migrations occur between late December and late February, typically during “first flush” periods when inflow and turbidity increase on the Sacramento and San Joaquin Rivers (Grimaldo et al. 2009, Sommer et al. 2011). Adult smelt do not spawn immediately after migration to freshwater, but appear to stage in upstream habitats (Sommer et al. 2011). Spawning primarily occurs during April through mid-May (Moyle 2002). Fecundity of females ranges from about 1,200 to 2,600 eggs, and increases with size (Bennett 2005). Delta Smelt spawning behavior has only been directly observed in the laboratory, and eggs have not been found in the wild. In the laboratory, Delta Smelt have been observed to be broadcast spawners, spawning with greater frequency during nighttime periods (Baskerville-Bridges et al. 2004; Mager et al. 2004). It is believed that Delta Smelt spawn on sandy substrates (Bennett 2005).

Dege and Brown (2004) found that larvae less than 20 mm rear 3–12 miles (5–20 km) upstream of X2 (Dege and Brown 2004; Sommer and Mejia 2013). As larvae grow and water temperatures increase in the Delta (~73°F [23 °C]), their distribution shifts towards the low salinity zone (Dege and Brown 2004; Nobriga et al. 2008). By fall, the centroid of Delta Smelt distribution is tightly coupled with X2 (Sommer et al. 2011; Sommer and Mejia 2013).

2.1.3 Species Threats

A number of threats are thought to affect Delta Smelt. These are reviewed in recent syntheses of available information for the species (Interagency Ecological Program, Management, Analysis, and Synthesis Team 2015; Moyle et al. 2016). Although there is scientific debate about the relative importance of the threats, the following represents a list of those that are generally recognized:

- *Entrainment by Water Diversions*—Entrainment at the SWP/CVP south Delta export facilities was estimated to have been historically substantial in some years (Kimmerer 2008; see debate on the magnitude by Miller 2011, with response from Kimmerer 2011), with varying evidence presented as to the importance of entrainment in driving population trends (Mac Nally et al. 2010; Thomson et al. 2010; Maunder and Deriso 2011; Miller et al. 2012; Rose et al. 2013a,b). The restrictions on water exports during the winter-spring as a result of the USFWS (2008) BiOp have presumably lessened the magnitude of entrainment as a threat, although some entrainment does still occur and remains the subject of research undertaken as part of the CSAMP.
- *Reduction in Extent of Rearing Habitat*—Evidence exists that the availability and suitability of delta smelt rearing habitat varies with salinity and the location of the low salinity zone (Moyle et al. 1992; Hobbs et al. 2006; Feyrer et al. 2007; Kimmerer et al. 2009), although some Delta Smelt also occupy other areas for rearing (e.g., in the north Delta; Sommer and Mejia 2013). Outflow objectives in the State Water Resources Control Board Decision 1641 recognize the importance of the location of the LSZ, and are intended to protect beneficial uses for fish and wildlife, including for Delta Smelt. The USFWS (2008) BiOp included requirements for the position of the low salinity zone during fall months, reflecting concern over changes in rearing habitat as a threat to Delta Smelt (Feyrer et al. 2011). The importance to Delta Smelt of rearing habitat and its relationship to the low salinity zone remains a major subject of research (Interagency Ecological Program, Management, Analysis, and Synthesis Team 2015).
- *Reduction in Turbidity*—There are positive associations between Delta Smelt early life feeding success (Baskerville-Bridges et al. 2004), predation avoidance (Ferrari et al. 2014; Schreier et al. 2016), and spatial distribution (Feyrer et al. 2007, 2011; Nobriga et al. 2008; Sommer and Mejia 2013); turbidity is also an important cue for Delta Smelt spawning migrations (Grimaldo et al. 2009). Turbidity levels have declined in the Delta as a result of numerous factors such as upstream sediment trapping by dams, proliferation of invasive aquatic vegetation, changes in hydraulic residence time, and sediment flushing during stochastic events (Kimmerer 2004; Schoellhamer et al. 2012; Hestir et al. 2013, 2016).
- *Reduction in Food Resources*—Reduced food availability in the Bay-Delta estuary has been identified as a major threat to Delta Smelt, and is supported by various population dynamics analyses (Maunder and Deriso 2011; Miller et al. 2012; Rose et al. 2013b). Delta smelt feed primarily on calanoid copepods, cladocerans, amphipods, and, to a lesser extent, on insect larvae (Moyle et al. 1992; Lott 1998; Nobriga 2002; Slater and Baxter 2014). Heavy grazing by introduced clams has depleted phytoplankton standing stock, limiting food supplies for the zooplankton prey of Delta Smelt and other fish species (Lucas et al. 2002; Lopez et al. 2006; Kimmerer and Thompson 2014). Other factors thought to affect food availability include direct entrainment of lower food web materials (Jassby et al. 2002; Cloern and Jassby 2012), contaminants (Brooks et al. 2012), nutrient composition (Wilkerson et al. 2006; Dugdale et al. 2007; Glibert et al. 2011; Parker et al. 2012; Dugdale et al. 2012), and availability of areas with longer residence times (Sommer and Mejia 2013).

- *Exposure to Toxins*—Exposure of Delta Smelt to toxins can be the result of contaminant inputs from point and nonpoint sources associated with agricultural, urban, and industrial land uses. The recent reviews by Interagency Ecological Program, Management, Analysis, and Synthesis Team (2015) and Moyle et al. (2016) summarize what is known about pesticides, ammonia and ammonium, heavy metals, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs), contaminants of emerging concern, and contaminant mixtures. Brooks et al. (2012) presented a conceptual model of potential contaminant effects on Delta Smelt, including elements such as acute toxicity to larvae and juveniles, direct or indirect food limitation, impaired behavior and disease susceptibility, harmful algal blooms, migratory release of toxins from fat reserves, and temperature effects on toxic thresholds. Moyle et al. (2016) suggested that any threat to Delta Smelt from toxins is most likely through indirect effects. Exposure to toxins can also take the form of harmful algal blooms, particularly *Microcystis*, which produces toxic microcystins and is of concern as a direct or indirect threat to Delta Smelt (Lehman et al. 2010).
- *Predation and Competition*—Moyle et al. (2016) suggested that Mississippi silversides currently are the most important predators of Delta Smelt early life stages, as reflected in recent studies of Delta Smelt DNA in the prey consumed by silversides (Baerwald et al. 2012; Schreier et al. 2016). As reviewed by Interagency Ecological Program, Management, Analysis, and Synthesis Team (2015), there is no evidence for striped bass driving population trends in Delta Smelt, and inverse correlations of Delta Smelt abundance trends with indices of abundance of some predators could reflect inverse changes in habitat suitability for Delta Smelt and these predators. Silversides may also compete with Delta Smelt for prey and may be at an advantage over Delta Smelt because they spawn repeatedly throughout late spring, summer, and fall (Bennett 1998, 2005). The closely related smelt species wakasagi *Hypomesus nipponensis* occurs in Delta and has prompted concern because of its broader environmental tolerance than Delta Smelt (Swanson et al. 2000), which could lead it to outcompete Delta Smelt and hybridize. However, the most recent investigation of hybridization found it to be relatively limited (11 percent of morphologically ambiguous individuals in the Yolo Bypass, 0.1 percent of positively identified Delta Smelt in the Bay-Delta), although the presence of hybrids warranted continued monitoring. In the most recent good year of Delta Smelt recruitment (2011), the mean density of Delta Smelt in the Summer Towntnet survey was over 40 times as great as that of wakasagi, and Delta Smelt were collected at 30 percent of sampled stations, compared to 4 percent for wakasagi; in contrast, data for the first four surveys of the 2016 Summer Towntnet survey indicate the mean density of Delta Smelt to be just over three times that of wakasagi, with Delta Smelt occurring at 2 percent of stations and wakasagi at 1 percent of stations (California Department of Fish and Wildlife 2016a). This suggests that although both species are considerably less abundant in 2016 than 2011 (probably as a result of several years of drought), wakasagi have declined less than Delta Smelt. Whether this means that there is a relatively greater threat from wakasagi to Delta Smelt is uncertain.
- *Water Temperature and Climate Change*— During the late spring, summer, and early fall months water temperatures in the central and southern regions of the Delta typically exceed 25°C (77°F), which has been found to be close to the incipient lethal temperature

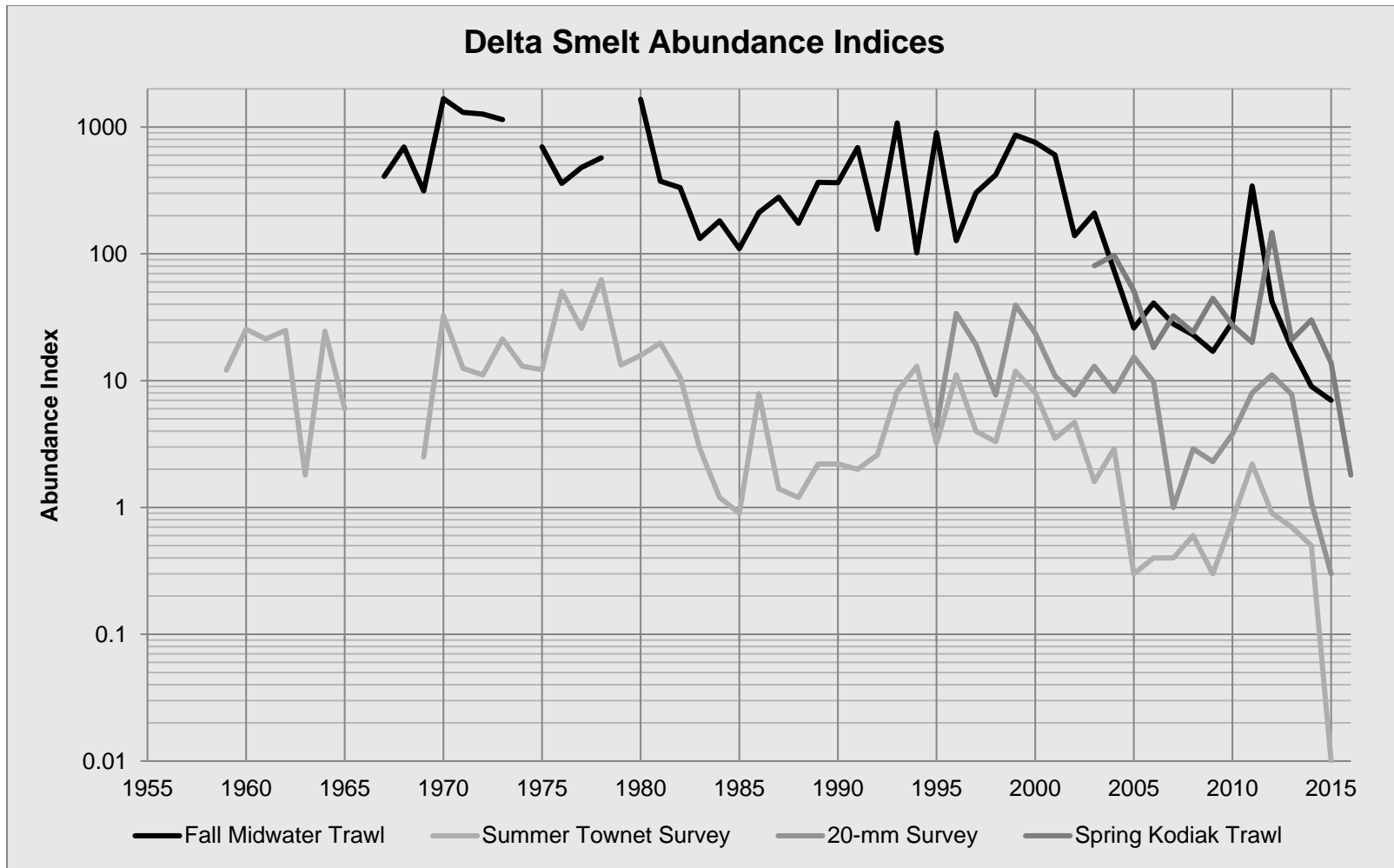
for Delta Smelt . During these warmer periods, results of monitoring surveys have shown that Delta Smelt avoid inhabiting the central and south Delta and are typically located downstream in Suisun Bay and Suisun Marsh (Nobriga et al. 2008). Although water temperatures are cooler in Suisun Bay during the summer months, water temperatures in excess of 20°C (68°F) are typical in July (Nobriga et al. 2008). Under these warm summer conditions, Delta Smelt rearing in Suisun Bay and Suisun Marsh would be stressed by exposure to elevated water temperatures and would experience higher metabolic demands and a greater demand for food supplies to maintain individual health and a positive growth rate. Stresses experienced by rearing delta smelt during the warmer summer months, which include the synergistic effects of salinity and seasonally elevated water temperatures, have been hypothesized to be a potentially significant factor affecting delta smelt survival, abundance, and subsequent reproductive success in the Bay-Delta estuary (Baxter et al. 2010), with quantitative evidence for this importance emerging from population dynamics models (Mac Nally et al. 2010; Maunder and Deriso 2011; Rose et al. 2013a,b). Recent climate change analyses have examined the potential implications of climate warming for delta smelt (Feyrer et al. 2011; Wagner et al. 2011; Brown et al. 2013; Brown et al. 2016). Modeling results projected increases in the number of days with lethal and stressful water temperatures (especially along the Sacramento River) and a shift in thermal conditions for spawning to earlier in the year, upstream movement of the low salinity zone, and decreasing habitat suitability.

Given the long list of stressors discussed in the USFWS (2008) OCAP BO, the range-wide status of the Delta Smelt is currently declining. Although there was a spike in the population in 2011, the declining abundance of Delta Smelt is clear (Figure 2-1). The 2014 fall midwater trawl index was the second lowest ever; the 2015 index was the lowest ever. The 2016 Spring Kodiak Trawl index is the lowest since the survey began in 2002, and the 2015 20-mm Survey Index is also the lowest since the survey began in 1995. The 2015 Summer Townet Survey age-0 Delta Smelt abundance index is 0.0, which is the lowest index reported in the history of this survey (implemented in 1959) and is consistent with the downward trend observed in recent years (Figure 2-1). This abundance trend has been influenced by multiple factors, some of which are affected or controlled by CVP and SWP operations and others that are not (U.S. Fish and Wildlife Service 2008:189). Although long-term decline of the Delta Smelt was strongly affected by ecosystem changes caused by non-indigenous species invasions and other factors influenced but not controlled by CVP and SWP operations, the CVP and SWP have played an important direct role in that decline, especially in terms of entrainment and habitat-related impacts that add

Table 2-2. Average Annual Frequency (Percent) of Delta Smelt Occurrence by Life Stage, Interagency Ecological Program Monitoring Program, and Region

Region Life Stage:	Average Annual Frequency (%)										
	Larvae (<15 mm)	Sub-Juvenile (≥15, <30 mm)		Juvenile (30–55 mm)			Sub-Adult (>55 mm)	Mature Adults (>55 mm)		Pre- Spawning ^a	Spawning ^a
Monitoring Program:	20-mm	20-mm	STN	20-mm	STN	FMWT	FMWT	BS	BMWT	KT	KT
Years of Data Used:	1995–2009	1995–2009	1995–2009	1995–2009	1995–2009	1995–2009	1995–2009	1995–2009	1995–2006	2002–2009	2002–2009
Time Period:	Apr–Jun	Apr–Jul	Jun–Aug	May–Jul	Jun–Aug	Sep–Dec	Sep–Dec	Dec–May	Jan–May	Jan–Apr	Jan–May
San Francisco Bay	NS	NS	NS	NS	NS	NS	NS	0.0	0.0	NS	NS
West San Pablo Bay	NS	NS	NS	NS	NS	0.2	0.0	0.0	1.2	NS	NS
East San Pablo Bay	0.0	1.0	0.0	2.8	3.6	0.7	0.6	NS	2.7	NS	NS
Lower Napa River	7.3	7.7	3.3	13.3	14.0	1.7	0.8	NS	NS	14.3	11.8
Upper Napa River	11.6	21.2	NS	12.0	NS	NS	NS	NS	NS	NS	NS
Carquinez Strait	5.7	9.3	1.1	24.4	33.7	1.9	3.3	NS	5.4	16.7	0.0
Suisun Bay (SW)	17.8	18.3	1.3	17.5	26.9	4.3	4.3	NS	4.3	23.3	5.6
Suisun Bay (NW)	2.2	8.9	1.1	21.7	34.8	7.3	10.0	NS	8.7	23.3	5.6
Suisun Bay (SE)	19.5	24.9	11.0	20.9	45.7	11.0	12.1	NS	6.5	28.3	6.9
Suisun Bay (NE)	17.8	19.2	33.6	29.7	66.7	20.3	29.3	NS	28.3	48.3	13.9
Grizzly Bay	16.3	27.6	17.9	42.9	72.8	15.0	19.6	NS	30.4	30.0	5.6
Suisun Marsh	21.4	33.6	14.2	18.5	19.2	22.8	27.2	NS	NS	62.0	23.1
Confluence	35.7	41.6	25.7	29.2	36.1	20.2	24.5	1.8	17.4	30.0	10.4
Lower Sacramento River	16.5	37.0	43.3	26.2	55.5	22.9	37.1	NS	18.8	54.4	17.8
Upper Sacramento River	10.8	8.2	1.3	0.0	0.0	2.7	8.0	5.8	16.7	21.7	15.3
Cache Slough and Ship Channel	17.2	47.3	NS	54.3	NS	9.8	26.7	NS	NS	33.9	21.1
Lower San Joaquin River	28.0	24.5	4.1	5.1	5.6	2.6	3.5	0.9	12.6	30.6	9.7
East Delta	14.6	8.8	0.0	1.2	0.0	0.0	0.0	1.6	NS	5.7	2.3
South Delta	18.4	10.8	0.0	1.4	0.3	0.0	0.0	0.3	NS	7.1	1.1

Region Life Stage:	Average Annual Frequency (%)										
	Larvae (<15 mm)	Sub-Juvenile (≥15, <30 mm)		Juvenile (30–55 mm)			Sub-Adult (>55 mm)	Mature Adults (>55 mm)		Pre- Spawning ^a	Spawning ^a
Monitoring Program:	20-mm	20-mm	STN	20-mm	STN	FMWT	FMWT	BS	BMWT	KT	KT
Years of Data Used:	1995–2009	1995–2009	1995–2009	1995–2009	1995–2009	1995–2009	1995–2009	1995–2009	1995–2006	2002–2009	2002–2009
Time Period:	Apr–Jun	Apr–Jul	Jun–Aug	May–Jul	Jun–Aug	Sep–Dec	Sep–Dec	Dec–May	Jan–May	Jan–Apr	Jan–May
Upper San Joaquin River	NS	NS	NS	NS	NS	NS	NS	0.2	NS	NS	NS
Sacramento Valley	NS	NS	NS	NS	NS	NS	NS	0.2	NS	NS	NS
^a Gonadal stages of male and female Delta Smelt found in Spring Kodiak Trawl database were classified by California Department of Fish and Wildlife following Mager (1996). Descriptions of these reproduction stages are available at: < http://www.dfg.ca.gov/delta/data/skt/eggstages.asp >. Mature adults, pre-spawning: Reproductive stages ^a : females 1–3; males 1–4. Mature adults: spawning: Reproductive stages ^a : females 4; males 5.											
20-mm = 20-millimeter Towntnet		KT = Kodiak Trawl.									
BMWT = Bay Midwater Trawl.		NS = indicates no survey conducted in the given life stage and region.									
BS = Beach Seine.		SKT = Spring Kodiak Trawl.									
FMWT = Fall Midwater Trawl.		STM = Summer Tow-Net.									
Source: Merz et al. 2011											



Source: <ftp://ftp.delta.dfg.ca.gov/Delta%20Smelt/>, <https://www.wildlife.ca.gov/Regions/3>, and <http://www.dfg.ca.gov/delta/data/skt/bibliography.asp> Accessed: 10/27/2015 and 6/29/2016 .Note: The Summer Townet Survey index for 2015 is 0.0, but is shown as 0.01 to allow plotting on the logarithmic scale.

Figure 2-1. Delta Smelt Abundance Indices

increments of additional mortality to the stressed Delta Smelt population (U.S. Fish and Wildlife Service 2008: 189). Past CVP and SWP operations have been one of the factors influencing Delta Smelt abiotic and biotic habitat suitability, health, and mortality (U.S. Fish and Wildlife Service 2008: 189).

While CVP and SWP operations and introduction of non-native species into the Delta have contributed to the long-term decline in Delta Smelt abundance, other factors may be influencing trends in abundance as well. Climate change has become an ever-growing concern as it relates to potential effects to listed fish species. Increasing air temperature, sea level rise, and increased variability in hydrology are predicted to occur under future climatic conditions. Changes in each of these can influence the extent, availability, and quality of Delta Smelt habitat, which may affect the distribution of Delta Smelt in the estuary and other biological characteristics such as the timing of the spawning window (Brown et al. 2013). In particular, drought conditions, which can amplify various Delta Smelt stressors in the Delta, are expected to occur more frequently in the future. Some of these effects have already been observed during the current drought.

As described in DWR and Reclamation's March 2015 Biological Review for Endangered Species Act Compliance with the WY 2015 Drought Contingency Plan April through September Project Description, written as part of the March 24 Temporary Urgency Change Petition to SWRCB¹, research presented at the Interagency Ecological Program (IEP) workshop (March 18–20, 2015) showed that the current drought impacts Delta Smelt in a number of ways.

The following is adapted from the summary in the Biological Review, which provides references to the specific presentations providing the information presented below.² The drought can reduce the area of habitat to which Delta Smelt migrate or disperse for spawning and reduce food availability for adults and for juveniles moving there to rear. Drought can indirectly impact reproductive potential by lowering the number of oocytes females produce. This is brought about by a link between dryer hydrological conditions and elevated water temperature, which may increase metabolic needs, resulting in less energy available for oocyte production.

Generally, water temperatures in the Delta are driven by ambient atmospheric conditions (e.g., air temperature and insolation), although water temperatures at shorter time and smaller spatial scales can also be influenced by riverine flow (Wagner et al. 2011). Warming water temperature shortens the spawning window, which causes fewer clutches to be produced per female. Both of these mechanisms combine with low adult abundance to impair population fecundity. Lower outflow also tends to reduce turbidity. Delta smelt use turbid water to avoid predators and they also use it as foraging habitat. Otolith analysis has revealed that since 1999, Delta Smelt experienced an 8-percent decline in growth between dry and wet years and spawning is more successful in the north Delta during drought.

The quality of Delta Smelt habitat is further compromised by concentrations of herbicides such as diuron and hexazinone, which may be present in higher concentrations during low outflow

¹ Available at:

http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/docs/tucp/2015/biorev2_aprsep.pdf. Accessed: 10/27/2015. The sources of the specific statements are provided in that document.

² Additional information to that presented in the Biological Review is provided, with appropriate citation as necessary.

conditions (due to a limited dilution effect) and have synergistic effects that reduce food availability for juveniles. Furthermore, warm, slow moving water characterized by drought promotes conditions in which parasites like Ich (*Ichthyophthirius multifiliis*) and cyanobacteria like *Microcystis* thrive. Ich causes skin lesions to form on a variety of fish and has an increased prevalence among captive Delta Smelt above 17°C. *Microcystis* is a cyanobacterium that can produce toxic hepatotoxins that became established throughout the Delta in 2000; it thrives in water above 17°C with low turbulence. This highly toxic cyanobacterium is known to kill phytoplankton, zooplankton and compromise fish health. *Microcystis* is typically observed during the late summer and is found in the south Delta, east Delta, and lower San Joaquin River subregions. However, *Microcystis* blooms extended into December of 2014, presumably due to higher water temperatures associated with the drought. Finally, the abundance of non-native Delta Smelt predators, such as black bass, increased in the Delta in response to the drought in 2014, mainly because it expanded their preferred habitat. The same pattern was found for non-native competitors, such as clams like *Corbicula*, which seem to be expanding throughout the Delta despite the drought.

2.2 Longfin Smelt

The following discussion briefly summarizes aspects of Longfin Smelt biology relevant to this application. A more detailed and complete account of the species is presented in Appendix 2.A *Longfin Smelt*.

2.2.1 Geographic Distribution and Status

Populations of Longfin Smelt occur along the Pacific Coast of North America, from Hinchinbrook Island, Prince William Sound, Alaska to the San Francisco Bay estuary (Lee et al. 1980). Although individual Longfin Smelt have been caught in Monterey Bay (Moyle 2002), there is no evidence of a spawning population south of the Golden Gate. The San Francisco Bay/Sacramento–San Joaquin River Delta (Bay-Delta) population is the southernmost and largest spawning population in California. Longfin Smelt occur throughout the San Francisco Bay and the Delta. The population has shown extremely low abundance in recent years, as measured by the Fall Midwater Trawl, as part of the pelagic organism decline (POD) (Sommer 2007; Baxter et al. 2010).

The Bay-Delta population of Longfin Smelt is designated as a candidate for listing under the ESA (77 *Federal Register* [FR] 19755) and, since June 26, 2009, the Longfin Smelt has been listed as threatened under the CESA.

2.2.2 Life History and Habitat Requirements

Longfin Smelt are anadromous and semelparous, moving from saline to brackish or freshwater for spawning from November to May (Moyle 2002; Rosenfield and Baxter 2007) Longfin Smelt usually live for 2 years, spawn, and then die (Rosenfield 2010). Peak spawning takes place in January and February of most years, and appears to be centered in brackish water (1–8 ppt); their habitat typically extends from San Pablo Bay to the confluence of the Sacramento River and San Joaquin River.

Newly hatched Longfin Smelt larvae are planktonic and probably do not control their position in the water column before they develop an air bladder. Once their air bladder is developed (~12 mm standard length) they are capable of controlling their position in the water column by undergoing reverse diel vertical migrations, which allows them to maintain position on the axis of the estuary (Bennett et al. 2002).

The geographic distribution of larval and early juvenile life stages of Longfin Smelt may be influenced by freshwater inflows to the Delta during late winter and spring, although the mechanisms are complicated and not fully understood (Hieb and Baxter 1993; Baxter 1999; Dege and Brown 2004).

Juvenile Longfin Smelt move seaward, mostly west of Carquinez Bridge, by late summer and fall. Rosenfield and Baxter (2007) suggest that juvenile Longfin Smelt seek cooler and deeper water in the summer months. Their diets shift to large prey, such as mysids and amphipods, as they transform from early juveniles to sub-adults (Moyle 2002). Little is known about the biology of sub-adult Longfin Smelt upon entry into their Age-1 life stage. Rosenfield and Baxter (2007) noted a sharp decline in their abundance during this life stage but also acknowledged that some individuals may be moving outside the sampling range of the CDFW sampling programs (i.e., to the ocean). It appears that some individuals move upstream with Age-2 spawners. Overall, ocean rearing of Age-1 and some Age-2 fish is not well understood, in part for a lack of ocean monitoring information. Longfin Smelt have been captured periodically in sampling programs outside the Golden Gate Bridge and in some tributaries to the north, including the Russian River, Eel River, and Klamath River (California Department of Fish and Game 2009).

The habitats used by adult Longfin Smelt can be inferred from CDFW surveys and a few other special studies (Merz et al. 2013). As previously mentioned, some proportion of the adult Longfin Smelt population likely enters the ocean. Adults that occupy the San Francisco Bay are often found in turbid, pelagic habitats, though information on their vertical distribution remains elusive (Rosenfield and Baxter 2007). Similar to adults, information about habitats used by juvenile Longfin Smelt is limited to CDFW Monitoring Survey data. Juvenile Longfin Smelt are collected in shallow and deep habitats throughout the Suisun Bay region.

2.2.3 Species Threats

A number of threats may affect Longfin Smelt, and were reviewed by California Department of Fish and Game (2009) and in the USFWS 12-month finding on the petition to list Longfin Smelt under the ESA (77 FR 19756). Threats include the following, which are discussed further in Section 2.A.2.5 *Threats of Appendix 2.A Evaluation of Species Considered for Coverage*.

- Entrainment by water diversions
- Reduced freshwater flow
- Reduction in turbidity
- Reduction in food resources

- Exposure to toxins
- Predation and competition
- Water temperature and climate change
- Bycatch in bay shrimp fishery

2.3 Chinook Salmon – Winter-run

The following discussion briefly summarizes aspects of winter-run Chinook salmon biology relevant to this application. A more detailed and complete account of the species is presented in ICF International (2016), Appendix 4.A *Status of the Species and Critical Habitat Accounts*, Section 4.A.1 *Chinook Salmon, Sacramento River Winter-Run (Oncorhynchus tshawytscha)*.

2.3.1 Geographic Distribution and Status

Winter-run Chinook salmon were listed as endangered under the CESA on September 22, 1989. As the Sacramento River winter-run Chinook salmon evolutionary significant unit (ESU), they are also listed as endangered under the ESA.

The Sacramento River winter-run Chinook salmon ESU currently consists of only one population that is confined to the upper Sacramento River, spawning downstream of Shasta and Keswick Dams in California's Central Valley. In addition, an artificial propagation program at the Livingston Stone National Fish Hatchery (LSNFH) produces winter-run Chinook salmon that are part of this ESU (June 28, 2005, 70 FR 37160). In addition USFWS has applied for a permit for a Winter-run Chinook captive broodstock program under ESA section 10(a)(1)(A) permit 16477 (August 22, 2016, 81 FR 56603). This permit does not allow the stocking of captive broodstock, which will require a separate permit. All historical spawning and rearing habitats have been blocked since the construction of Shasta Dam in 1943. Most components of the winter-run Chinook salmon life history (e.g., spawning, incubation, freshwater rearing) have been compromised by this habitat blockage. Remaining spawning and rearing areas are completely dependent on cold-water releases from Shasta Dam in order to sustain the remnant population.

2.3.2 Life History and Habitat Requirements

Winter-run Chinook salmon adults enter fresh water in an immature reproductive state in winter or early spring, and then move upstream to hold in the cool waters below Keswick Dam for an extended period until spawning in spring or early summer. Fry begin to emerge from the gravel in late June to early July and continue through October. Juvenile winter-run Chinook salmon then migrate to sea after 5 to 9 months rearing in-river; their occurrence in the project area is primarily in December and January, though some fish are seen as early as August and as late as May. This life-history pattern differentiates winter-run from all other runs in the Sacramento River (Hallock and Fisher 1985; Vogel 1985).

2.3.3 Species Threats

While CVP and SWP operations and introduction of non-native species into the Delta have contributed to the long term decline in Winter-run abundance, other factors may be influencing trends in abundance as well. Good *et al.* (2005) described the threats to the winter-run Chinook salmon ESU as follows: That there is only a single extant population that is spawning outside of its historical range within an artificial habitat that is vulnerable to drought and other catastrophic conditions such as loss of cold-water pool and temperature control.

As described in more detail in ICF International (2016), Appendix 4.A *Status of the Species and Critical Habitat Accounts*, Section 4.A.1 *Chinook Salmon, Sacramento River Winter-Run (*Oncorhynchus tshawytscha*)*, estimates of the winter-run Chinook salmon population reached nearly 120,000 adult fish in the late 1960s before declining to under 200 fish in the 1990s (Fisher 1994; California Department of Fish and Wildlife 2014). Adult abundance remained very low through the mid-1990s, and was less than 500 fish in some years (CDFW 2014). From the mid-1990s through 2006, adult escapement showed a trend of increasing abundance, up to around 20,000 fish in 2005 and 2006. However, recent population estimates have declined since the 2006 peak, with escapement estimates for 2007 through 2014 ranging from 738 adults (2011) to 5,959 (2013). The 2011 estimate of 738 was the lowest since the all-time low of 144 in 1994. Poor ocean productivity (Lindley *et al.* 2009), drought conditions during 2007–2009, and low in-river survival (National Marine Fisheries Service 2011a) are suspected to have contributed to the recent decline in escapement of adult winter-run Chinook salmon.

Lindley *et al.* (2007) assessed that the Sacramento River winter-run Chinook salmon ESU was at moderate risk of extinction based on a population viability analysis criterion (>5 percent risk of extinction within 100 years) and at low risk of extinction based on other criteria, including population size, population decline, rate and effect of catastrophe on population, and hatchery influence. However, Lindley *et al.* (2007: 13) noted that “an ESU represented by a single population at moderate risk of extinction is at high risk of extinction over the long run. A single catastrophe could extirpate the entire Sacramento River winter-run Chinook salmon ESU, if its effects persisted for four or more years. The entire stretch of the Sacramento River used by winter-run Chinook salmon is within the zone of influence of Mt. Lassen. Some other possible catastrophes include a prolonged drought that depletes the cold water storage of Lake Shasta or some related failure to manage cold water storage, a spill of toxic materials with effects that persist for four years, or a disease outbreak.” Trends in the criteria described by Lindley *et al.* (2007) include continued low abundance, a negative growth rate within the population over the last two generations (6 years), and an increased risk from catastrophic events (wildfires, oil spills, extended drought conditions, poor ocean rearing conditions) as the population has declined. Hatchery influence on wild stocks, although not a problem with present stocks, could become a problem if cohorts of wild fish were to experience lowered survival, similar to the loss of eggs and alevins as the result of temperature control failure in the upper Sacramento River in 2014, or other reductions in overall population. During times when the ESU is in decline due to marine and freshwater conditions, naturally reproducing winter-run Chinook salmon are less able to withstand high harvest rates (California Hatchery Scientific Review Group 2012). Impacts from the salmon ocean fishery, consistent with the fishery operation since 2000, would not be expected to negatively affect the abundance during periods of positive population growth, but during times of negative population growth the impacts of the fishery at levels over the last

decade would appreciably increase the risk of extinction. Therefore, NMFS, which addresses the ocean harvest impacts on this ESU from commercial and recreational ocean salmon fisheries managed under the Pacific Coast Salmon Fishery Management Plan, concluded the fisheries were likely to jeopardize the continued existence of the ESU, and included a reasonable and prudent alternative (RPA) that required NMFS to implement an interim RPA for the 2010 and 2011 fishing years and develop and implement a new management framework for the ocean fishery addressing impacts to Sacramento River winter-run Chinook salmon before the 2012 ocean salmon fishery season (National Marine Fisheries Service April 30, 2012 memo).

The most recent 5-year status review (National Marine Fisheries Service 2011b) on winter-run Chinook salmon concluded that the ESU continues to be at high risk of extinction. Williams *et al.* (2011) concluded that the ESU status remains the same as when it was examined by Good *et al.* (2005), *i.e.*, “in danger of extinction” and will remain so until another low-risk population is established within its historical spawning range. The most recent biological information suggests that the extinction risk for the winter-run Chinook salmon ESU has not decreased since 2005 (previous status review), and that several listing factors have contributed to the recent decline in abundance, including drought and poor ocean conditions (National Marine Fisheries Service 2011b).

Extreme drought conditions in California are causing increased stress to winter-run Chinook in the form of low flows reducing rearing and migratory habitats, higher water temperatures affecting survival, and likely higher-than-normal predation rates (State Water Resources Control Board 2015). Limited cold water storage and loss of temperature control out of Keswick Dam from mid-August through the fall, resulting in an increased potential for incubation mortality over the 15 year average of 73 percent (e.g., mortality of 95 percent of winter-run Chinook salmon eggs and fry) occurred in 2014 (SWRCB 2015; Rea pers. comm.). Additionally, the Net Delta Outflow Index (NDOI) was modified from an outflow 7,100 cfs to no less than 4,000 cfs during the months of April through June and no less than 3,000 cfs in July (SWRCB 2015). Reductions in outflow in an effort to preserve the cold-water pool may have the potential to reduce survival of out-migrating winter-run Chinook salmon during their migration through the North Delta, through via increased predation mediated by hydrodynamic and habitat mechanisms (State Water Resources Control Board 2015). Reduced outflow increases tidal excursion upstream (reduced daily proportion of positive velocities) into the waterways in the North Delta region, leading to a reduction in the proportion of positive daily flows passing Georgiana Slough and/or an open Delta Cross Channel, which may increase juvenile entrainment into Georgiana Slough and, if open, the Delta Cross Channel (State Water Resources Control Board 2015). Survival of migrating juvenile salmonids has been shown to be lower when salmon are entrained into these two migration routes as compared to the Sacramento River and Steamboat Slough (Singer *et al.* 2013; Perry *et al.* 2010).

The following conditions have been identified as important threats and stressors to winter-run Chinook salmon:

- Reduced access, quantity and quality of staging, spawning, and egg incubation habitat
- Reduced rearing and out-migration habitat

- Predation
- Harvest
- Reduced genetic diversity and integrity
- Entrainment
- Exposure to toxins
- Increased water temperature

2.4 Chinook Salmon—Spring-Run

The following discussion briefly summarizes aspects of spring-run Chinook salmon biology relevant to this application. A more detailed and complete account of the species is presented in ICF International (2016), Appendix 4.A *Status of the Species and Critical Habitat Accounts*, Section 4.A.2 *Chinook Salmon, Central Valley Spring-Run (*Oncorhynchus tshawytscha*)*.

2.4.1 Geographic Distribution and Status

Central Valley spring-run Chinook salmon were listed as a threatened species under the CESA on February 5, 1999. The Central Valley spring-run Chinook salmon ESU is also listed as a threatened species under the ESA. This ESU consists of spring-run Chinook salmon occurring in the Sacramento River basin. The Feather River Fish Hatchery (FRFH) spring-run Chinook salmon program has been included as part of the Central Valley spring-run Chinook salmon ESU in the most recent Central Valley spring-run Chinook salmon listing decision (70 FR 37160, June 28, 2005). Although there have been observations of springtime running Chinook salmon returning to the San Joaquin tributaries in recent years, there is insufficient information to determine the specific origin of these fish, and whether or not they are straying into the basin or returning to natal streams (NMFS 2016: 8). More information is needed when considering whether or not the presence of these fish would warrant a change to the ESU boundary (NMFS 2016: 8-9). Additionally, there may be interest in modifying the ESU boundary in the future when spring-run Chinook salmon are successfully reintroduced into the San Joaquin River Basin and/or into Central Valley habitats upstream of currently impassable barriers (NMFS 2016: 9; 78 FR 79622; NMFS 2014). Based on the most recent 5-year status review, NMFS (2016: 9) is not recommending a change to the boundary of this ESU at present (2016). Note that the analyses presented in Chapter 4 *Take Analysis* consider potential effects of the Proposed Project (PP) on San Joaquin River spring-run Chinook salmon, which are considered to represent both the reintroduced population as part of the San Joaquin River Restoration Program, and springtime running Chinook salmon mentioned above.

2.4.2 Life History and Habitat Requirements

Spring-run Chinook salmon tend to enter fresh water as immature fish, migrate far upriver, hold in cool-water pools for a period of months during the spring and summer, and delay spawning for several months until early fall. Pools in the holding areas need to be sufficiently deep, cool (about 61°F or less), and oxygenated to allow over-summer survival. Adults tend to hold in pools

near quality spawning gravel. Spring-run Chinook salmon are thus present in the project area as adults primarily in May and June. Spawning occurs well upstream of the project area, so juveniles are primarily present during their outmigration, emigration timing is highly variable, as spring-run Chinook juveniles may migrate downstream as young-of-the-year, or as juveniles, or yearlings, with Butte Creek juveniles having peaks from early November through late January, but may extend through March in lower water years in the project area, although some juveniles are found in the Delta into late August. Peak catches at Knights Landing are from February through May.

Habitat functions provided in the project area are primarily those associated with freshwater migration corridors and the transition to estuarine habitat. Freshwater migration corridors should be free from obstructions (passage barriers and impediments to migration), have favorable water quantity (instream flows) and quality conditions (seasonal water temperatures), and contain natural cover such as submerged and overhanging woody debris, native aquatic vegetation, large rocks and boulders, side channels, and undercut banks for juvenile foraging habitat and cover from predators. Estuarine habitat should be free of obstructions and provide suitable water quality, water quantity (river and tidal flows), and salinity conditions to support juvenile and adult physiological transitions between fresh and salt water. Tidal wetlands and seasonally inundated floodplains have been identified as high-value foraging and rearing habitats for juvenile salmon migrating downstream through the estuary. Estuarine areas have a high conservation value because they are nutrient-rich and support juvenile Chinook salmon growth, smoltification, and protection from predators before they transition to the ocean environment.

2.4.3 Species Threats

Good et al. (2005) described the threats to the Central Valley spring-run Chinook salmon ESU as falling into three broad categories:

- Loss of historical spawning habitat
- Degradation of remaining habitat
- Genetic threats from the Feather River Hatchery spring-run Chinook salmon program

Other likely important threats and stressors include:

- Nonnative predators
- Commercial and recreational harvest
- Entrainment at water withdrawal facilities
- Increased water temperatures

While CVP and SWP operations and introduction of non-native species into the Delta have contributed to the long-term decline in spring-run Chinook salmon abundance, other factors may be influencing trends in abundance as well. Good et al. (2005) described the threats to the Central Valley spring-run Chinook salmon ESU as falling into three broad categories: loss of

historical spawning habitat, degradation of remaining habitat, and genetic threats from the Feather River Fish Hatchery spring-run Chinook salmon program. Other likely important threats and stressors include nonnative predators, commercial and recreational harvest, entrainment at water withdrawal facilities, toxin exposure, increased water temperatures, and loss of rearing habitat in the Sacramento River and Delta. ICF International (2016), Appendix 4.A *Status of the Species and Critical Habitat Accounts*, Section 4.A.2.5 *Threats and Stressors*, discusses these issues in more detail.

The Central Valley spring-run Chinook salmon ESU has displayed broad fluctuations in adult abundance between 1960 and recent years (Figure 4.A.2-4 in ICF International 2016, Appendix 4.A *Status of the Species and Critical Habitat Accounts*). The total spring-run Chinook salmon escapement count for Feather River Fish Hatchery, Butte Creek, Mill Creek, Deer Creek, Antelope Creek, Cottonwood Creek, Clear Creek, and Battle Creek in 2013 was 23,697 adults, which was the highest count since 2005 (23,093 adults) and over three times that of 2011 (7,408 adults) (CDFW 2014). However, abundance declined considerably in 2014 (9,901 adults) and even more so in 2015 (5,635 adults) (CDFW 2016b). Sacramento River tributary populations in Mill, Deer, and Butte Creeks are probably the best trend indicators for the Central Valley spring-run Chinook ESU as a whole because these streams contain the primary independent populations in the ESU. Generally, there was a positive trend in escapement in these waterways between 1992 and 2005, after which there was a steep decline until 2010 (Figure 4.A.2-5 in ICF International 2016, Appendix 4.A *Status of the Species and Critical Habitat Accounts*). Adult spring-run salmon escapement to Mill, Deer, and Butte Creeks in was estimated to be 18,135 fish in 2013; 6,592 fish in 2014 and only 964 fish in 2015 (CDFW 2016b). Escapement numbers are dominated by Butte Creek returns, with the contribution of Butte Creek fish to total numbers in these three creeks being >90 percent in 2013, 77 percent in 2014, and ~60 percent in 2015 (CDFW 2016b). In 2012, Battle Creek saw the highest number of returns in recent history (799 fish), with declines to 608 fish in 2013, 429 fish in 2014, and 181 fish in 2015 (CDFW 2014). Individuals have only recently begun spawning in Battle Creek, where they spawned historically, and greater access upstream for spawning and rearing has been facilitated by some of the initial actions from the Battle Creek Salmon and Steelhead Restoration Project, scheduled for full completion in 2020 (NMFS 2016: 19).

The most recent viability assessment of Central Valley spring-run Chinook salmon was conducted during NMFS's 2016 status review (NMFS 2016). This review found that on balance the biological status of the ESU had probably improved since the last status review (2010) through 2014, with two of the three extant independent populations improving from high extinction risks to moderate extinction risks. The third extant independent population, Butte Creek, has remained at low risk, and all viability metrics had been trending in a positive direction, up until 2015 (NMFS 2016: 17). The Butte Creek spring-run Chinook salmon population has increased in part due to extensive habitat restoration and the accessibility of floodplain habitat in the Sutter-Butte Bypass for juvenile rearing in the majority of years. Additionally, spring-run Chinook salmon in both Battle Creek and Clear Creek continue to repopulate those watersheds, and now fall into the moderate extinction risk category for abundance. In contrast, most dependent spring-run populations have been experiencing continued and somewhat drastic declines (NMFS 2016: 17).

Extreme drought conditions are causing increased stress to spring-run Chinook salmon populations in the form of low flows reducing rearing and migratory habitats, higher water temperatures affecting survival, and likely higher-than-normal predation rates. Modification to flow and operational criteria may reduce through-Delta survival of juvenile migrating spring-run Chinook salmon and may modify their designated critical habitat during April and May (SWRCB 2015). Changes in Sacramento River outflow during April and May can possibly delay adult spring-run Chinook salmon migration. Low export levels are not expected to appreciably affect survival of juvenile spring-run Chinook salmon emigrating through the Delta (SWRCB 2015). Drought conditions and current reservoir storage levels have been forecasted to impact suitable water temperatures in the Upper Sacramento River and Clear Creek. Temperature effects on Clear Creek and in the Upper Sacramento may lead to higher pre-spawn mortality of adult spring-run Chinook salmon and reduced egg viability if temperatures exceed 60°F during August and early September, as well as greater mortality of incubating eggs and pre-emergent fry if temperatures exceed 56°F after September 15 (SWRCB 2015).

As described by NMFS (2016: 18), the Central Valley spring-run Chinook salmon ESU has experienced two drought periods over the past decade. From 2007 to 2009, and now 2012 to 2015, the Central Valley experienced drought conditions and low river and stream discharges, which are generally associated with lower survival of Chinook salmon. The impacts of the recent drought years and warm ocean conditions on the juvenile life stage will not be fully realized by the viability metrics until they manifest in potential low run size returns in 2015 through 2018. This is already being realized with very low returns in 2015 (NMFS 2016: 18).

2.5 California Tiger Salamander

The Central Valley distinct population segment (DPS), the Santa Barbara County DPS, and the Sonoma County DPS of California tiger salamander are state listed as threatened as of August 2010.

2.5.1 Geographic Distribution and Status

Historically, the California tiger salamander occurred throughout the grassland and woodland areas of the Sacramento and San Joaquin River Valleys and surrounding foothills, and in the lower elevations of the central Coast Ranges (Barry and Shaffer 1994). The species' range is limited by its aestivation and winter breeding habitat requirements, which are generally defined as open grassland landscapes with highly seasonal precipitation patterns of a Mediterranean climate; ephemeral pools; and underground burrows made by burrowing squirrels or pocket gophers (Barry and Shaffer 1994).

Within its coastal range, the species currently occurs from southern San Mateo County south to San Luis Obispo County, with isolated populations in Sonoma and northwestern Santa Barbara Counties (California Department of Fish and Wildlife 2013). In the Central Valley and surrounding Sierra Nevada foothills, the species occurs from northern Yolo County southward to northwestern Kern County and northern Tulare and Kings Counties (California Department of Fish and Wildlife 2013).

Several occurrences have been reported in the vicinity of the Project Area, immediately west and southwest of Clifton Court Forebay (CDFW 2013). Occupancy of some of these sites was confirmed by larval surveys conducted between 2009 and 2011 by the DWR. There are many additional occurrences in vernal pool and pond habitats in the grassland foothills west of the Project Area and south of Antioch. Potential habitat exists in vernal pool habitats in Yolo and Solano Counties west of Liberty Island and in the vicinity of Stone Lakes in Sacramento County.

2.5.2 Life History and Habitat Requirements

The California tiger salamander is found in annual grasslands and open woodland communities in lowland and foothill regions of central California where aquatic sites are available for breeding (USFWS 2003). The species is typically found at elevations below 1,509 feet (460 meters) (68 FR 13498), although the known elevational range extends up to 3,455 feet (1,053 meters) (Jennings and Hayes 1994). Ecological characteristics of this area include seasonally dry soils, needlegrass grasslands, valley oaks, coast live oaks, and ephemeral flooded claypan vernal pools (USFWS 2003).

Adult California tiger salamanders are terrestrial and, for 6 to 9 months of the year, occur in grassland and open woodland habitats where they find cover and aestivation sites in the underground burrows of small mammals such as California ground squirrels (*Spermophilus beecheyi*) and Botta's pocket gopher (*Thomomys bottae*) (Storer 1925; Loredo and van Vuren 1996; Petranksa 1998; Trenham 1998). Active rodent burrow systems are an important component of California tiger salamander upland habitat (Loredo et al. 1996; U.S. Fish and Wildlife Service 2013). In a 2-year radiotelemetry project in Monterey County, Trenham (2001) found that salamanders preferentially used open grassland and isolated oaks; salamanders present in continuous woody vegetation were never more than 10 feet (3 meters) from open grassland, perhaps because ground squirrels primarily burrow in open habitats (Jameson and Peeters 1988 in Trenham 2001).

Vernal pools and other seasonal rain pools are the primary breeding habitat of California tiger salamanders (Barry and Shaffer 1994; 68 FR 13498). Since the species requires at least 10 weeks of pool inundation in order to complete metamorphosis of larvae (Anderson 1968; East Contra Costa County Habitat Conservancy 2006), California tiger salamanders are usually only found in the largest vernal pools (Laabs et al. 2001). The species is also known to successfully reproduce in ponds (Barry and Shaffer 1994; 69 FR 47212). In the East Bay Regional Park District in Contra Costa and Alameda Counties, California tiger salamanders breed almost exclusively in seasonal and perennial stock ponds (Bobzien and DiDonato 2007). However, the presence of predatory fish, barred tiger salamander (*Ambystoma tigrinum mavortium*), and bullfrogs (*Rana catesbeiana*) can diminish the habitat suitability of perennial ponds (Holomuzki 1986; Fitzpatrick and Shaffer 2004). Barry and Shaffer (1994) note that stock ponds can be productive breeding sites if they are drained annually, which can prevent predatory species from establishing.

The distance between occupied upland habitat and breeding sites depends on local topography and vegetation, and the distribution of rodent burrows (WRA Environmental 2005; Cook et al. 2006). While juvenile California tiger salamanders have been observed to disperse up to 1.6 miles (2.6 kilometers) from breeding pools to upland areas (Austin and Shaffer 1992) and adults

have been observed up to 1.2 miles (2 kilometers) from breeding ponds, most movements are closer to the breeding pond. Trenham et al. (2001) observed California tiger salamanders moving up to 670 meters (0.42 mile) between breeding ponds in Monterey County. Shaffer and Trenham (2005) found that 95 percent of California tiger salamanders resided within 0.4 mile (640 meters) of their breeding pond at Jepson Prairie in Solano County.

Connectivity between breeding sites may be an important factor in long-term conservation of this species. This would sustain the species' metapopulation structure, since local extinction and recolonization by migrants from other subpopulations are probably common events (69 FR 47212). Thus, providing movement corridors between potential breeding sites and avoiding isolation of these sites may counterbalance the effects of normal ecological processes (e.g., drought) that may result in local extinctions by allowing for movements to new sites and facilitating recolonization (Semlitsch et al. 1996).

2.5.3 Species Threats

Land conversion to residential, commercial, and agricultural uses is the principal threat to California tiger salamanders, resulting in destruction and fragmentation of upland and/or aquatic breeding habitat, and killing of individual California tiger salamanders (Twitty 1941; Shaffer et al. 1993; Jennings and Hayes 1994; Fisher and Shaffer 1996; Loredó et al. 1996; Davidson et al. 2002; CDFG 2010). Roads that traverse occupied habitat can fragment breeding and dispersal migratory routes. Features of road construction, such as solid road dividers, can further impede migration, as can other potential barriers such as berms, pipelines, and fences. Nonnative species that live in perennial ponds, such as bullfrog, mosquitofish (*Gambusia affinis*), centrarchids (e.g., largemouth bass [*Micropterus salmoides*] and bluegill [*Lepomis macrochirus*]), catfish (*Ictalurus* spp.), and fathead minnows (*Pimephales promelas*), have negatively affected California tiger salamander populations by preying on larval salamanders (Anderson 1968; Shaffer et al. 1993; Fisher and Shaffer 1996; Lawler et al. 1999; Laabs et al. 2001; Leyse 2005; USFWS 2013). Hybridization with the barred tiger salamander is also a threat to this species. Although no documentation has been found of hybridization or nonnative alleles occurring in California tiger salamander populations found in the Delta (U.S. Bureau of Reclamation and California Department of Water Resources 2013, Riley et al. 2003, Fitzpatrick et al. 2009), recent research has demonstrated the rapid spread of hybrid genes well outside the boundary of previously understood hybrid swarms. It is also possible that invasive super alleles are responsible for phenotypic and life history anomalies observed in populations adjacent to the Delta (Fitzpatrick et al. 2010, Wilcox et al. 2015). Pesticides, hydrocarbons, and other pollutants negatively affect breeding habitat, while rodenticides used in burrowing mammal control (e.g., chlorophacinone, diphacinone, strychnine, aluminum phosphide, carbon monoxide, and methyl bromide) are toxic to adult salamanders (Salmon and Schmidt 1984). California ground squirrel and pocket gopher control operations may have the indirect effect of reducing the availability of upland burrows for use by California tiger salamanders (Loredó-Prendeville et al. 1994).

2.5.4 Species Habitat Suitability Model

2.5.4.1 Terrestrial Cover and Aestivation Habitat Model

California tiger salamander habitat was modeled for the entire Delta. Modeled terrestrial cover and aestivation habitat in the Delta is defined as all grassland types with a minimum patch size of 100 acres (40.5 hectares) located west of the Yolo Basin but including the Tule Ranch Unit of the CDFW Yolo Basin Wildlife Area; east of the Sacramento River between Freeport and Hood-Franklin Road; east of Interstate 5 (I-5) between Twin Cities Road and the Mokelumne River; and in the area south and west of State Route (SR) 4 from Antioch (Bypass Road to Balfour Road to Brentwood Boulevard) to Byron Highway; then south and west along the county line to Byron Highway; then west of Byron Highway to Interstate 205 (I-205), north of I-205 to Interstate 580 (I-580), and west of I-580. These geographically described areas were developed into a habitat constraint GIS layer to limit the qualifying terrestrial habitat extents. Grasslands associated with south Montezuma Hills and Potrero Hills were also included. Grassland strips solely occurring atop levees and not adjacent to grassland areas were excluded. The excluded grassland strips were manually selected and developed into a GIS layer by visually reviewing grassland strips that occurred atop the levees, and comparing them to 2005 aerial photographs (U.S. Department of Agriculture 2005). These identified locations were removed from the habitat model. Patches of grassland that were below the 100-acre minimum patch size but were contiguous with grasslands outside of the Delta boundary were included.

Terrestrial covered and aestivation habitat includes the following types from the composite vegetation layer.

- Grassland
 - Ruderal herbaceous grasses and forbs
 - California annual grasslands–herbaceous
 - *Bromus diandrus*–*Bromus hordeaceus*
 - Italian ryegrass (*Lolium multiflorum*)
 - *Lolium multiflorum*–*Convolvulus arvensis*
 - Degraded vernal pool complex–California annual grasslands
 - Degraded vernal pool complex–ruderal herbaceous grasses and forbs
 - Degraded vernal pool complex–Italian ryegrass (*Lolium multiflorum*)
 - Degraded vernal pool complex–vernal pools
 - Annual grasses generic
 - Annual grasses/weeds

- *Bromus* spp./*Hordeum*
- *Hordeum/Lolium*
- Lolium (generic)
- *Lotus corniculatus*
- Medium upland graminoids
- Medium upland herbs
- Perennial grass
- Short upland graminoids
- Upland annual grasslands and forbs formation
- Upland herbs
- Alkali seasonal wetland complex
 - *Distichlis spicata*–annual grasses

In 2011, and again in 2012, the species habitat models were updated to include previously unmapped portions of the Delta. For most areas newly mapped, vegetation data were not available at the alliance level as in the rest of the Delta and so most of the new analysis areas were mapped at the natural community level. For California tiger salamander, in the new analysis areas, the following natural communities were assumed to provide terrestrial cover and aestivation habitat.

- Alkali seasonal wetland complex
- Grasslands
- Upland annual grasslands & forbs formation

2.5.4.2 Assumptions

- **Assumption:** California tiger salamander terrestrial cover and aestivation habitat in the Delta is geographically constrained to areas described in Section 2.5.4.1 *Terrestrial Cover and Aestivation Habitat Model*.
- **Rationale:** Habitat for the California tiger salamander includes vernal pools and seasonal and perennial ponds including artificial stock ponds in a grassland landscape (Barry and Shaffer 1994; 69 FR 47212; Bobzien and DiDonato 2007). Because the mapping of aquatic breeding habitats in the Delta is incomplete, this element cannot be effectively used to model the extent of suitable habitat for this species. Thus, grasslands are used to

more generally describe the extent of suitable habitat. Minimum patch size is 100 acres, which corresponds with the minimum conservation patch size identified by Trenham (2009). Grasslands located along the narrow eastern edge of Suisun Marsh that were contiguous with the larger grassland/agricultural landscape of the Montezuma Hills were reviewed and removed from the terrestrial cover and aestivation habitat component of the model because most appeared transitional to the tidal marsh wetlands that are not suitable for the California tiger salamander. The model is further constrained geographically by eliminating grasslands that are not within seasonal pool or pond/grassland landscapes, such as the central Delta. These areas are mapped as alkali seasonal wetland complex (*Distichlis spicata*-annual grasses); however, they have a substantial grassland component. The model overestimates suitable habitat by assuming there are sufficient aquatic breeding habitats within the grassland landscape as defined.

2.5.4.3 Aquatic Breeding Habitat Model

Modeled aquatic breeding habitat for the California tiger salamander in the Delta includes vernal pools and seasonal and perennial ponds. Aquatic breeding habitat includes the following land cover types and conditions that are within the grassland landscape as defined above.

- Vernal pool complex
 - *Allenrolfea occidentalis* mapping unit
 - Annual grasses generic
 - Annual grasses/weeds
 - California annual grasslands–herbaceous
 - *Distichlis* (generic)
 - *Distichlis*/annual grasses
 - *Distichlis*/*S. maritimus*
 - *Distichlis spicata*
 - *Distichlis spicata*–annual grasses
 - Italian ryegrass (*Lolium multiflorum*)
 - Mix *Schoenoplectus* (formerly *Scirpus*) mapping unit
 - Ruderal herbaceous grasses and forbs
 - *Salicornia virginica* (formerly *Sarcocornia*)
 - *Salicornia*/annual grasses

- Salt scalds and associated sparse vegetation
- Saltgrass (*Distichlis spicata*)
- Seasonally flooded grasslands
- *Suaeda moquinii*–(*Lasthenia californica*) mapping unit
- Vernal pools

In 2011, and again in 2012, the species habitat models were updated to include previously unmapped portions of the Delta. For most areas newly mapped, vegetation data were not available at the alliance level as in the rest of the Delta and so most of the new analysis areas were mapped at the natural community level. In the new analysis areas, the following natural community was assumed to provide terrestrial cover and aestivation habitat for the California tiger salamander.

- Vernal pool complex

2.5.4.4 Assumptions

- **Assumption:** California tiger salamander breeding habitat in the Delta is geographically constrained to areas described in Section 2.5.4.3 *Aquatic Breeding Habitat Model*.

Rationale: Aquatic breeding habitats are mapped to the extent data are available, but not used as a model attribute. The data for vernal pools and other seasonal wetlands and stock ponds are insufficient to effectively model California tiger salamander habitat on the basis of aquatic breeding habitat. Vernal pools and other seasonal rain pools are the primary breeding habitat of California tiger salamanders (Barry and Shaffer 1994; 68 FR 13498). California tiger salamander is also known to successfully reproduce in ponds, including artificial stock ponds (Barry and Shaffer 1994; 69 FR 47212). Stock pond habitats are used almost exclusively at occupied sites on the western edge of the Delta and in the hills immediately west of the Delta (Bobzien and DiDonato 2007). Mapping of vernal pools and other isolated seasonal wetlands and stock ponds is incomplete.

In lieu of this, the vernal pool complex natural community was used to represent aquatic breeding habitat, which comprises a combination of aquatic and upland habitat that is considered suitable for the California tiger salamander. Potential habitat included within the vernal complex natural community not having concave surfaces or land uses that are incompatible with the species' habitat requirements was removed from the vernal pool complex and aquatic breeding habitat components of the model. For example, polygons falling on lands that did not have characteristic vernal pool/swale signatures that would demonstrate seasonal inundation did not qualify for this habitat type. In other instances, some other vernal pool aquatic features were located in areas that had unsuitable land uses. These features were removed by developing a GIS layer that excluded habitat from these locations. This element of the model overestimates the extent of potential breeding habitat.

2.5.5 Suitable Habitat Definition

Although habitat for California tiger salamander was modeled for the entire Delta, minimization and mitigation will be based on suitable habitat identified by a Qualified Biologist within the Project Area. If the amount of habitat impacted or mitigated is expected to differ from what is addressed in the 2081 for this project, based on results of the suitable habitat evaluation, then DWR will seek a permit amendment. Based on the known distribution of the species, suitable habitat is confined to the geographic area described above for the habitat model and shown on Figure 4.5-1. Within this area, suitable terrestrial cover and aestivation habitat is defined as grassland with a minimum patch size of 100 acres (40.5 hectares), and suitable aquatic habitat is defined to consist of vernal pools, alkali seasonal wetlands, and stock ponds.

2.6 Giant Garter Snake

The giant garter snake (*Thamnophis gigas*) is listed as threatened under the CESA and ESA. The *Draft Recovery Plan for the Giant Garter Snake* was completed in 1999 (U.S. Fish and Wildlife Service 1999a) and a 5-year review was completed in 2012 (U.S. Fish and Wildlife Service 2012). The U.S. Fish and Wildlife Service (USFWS) prepared a revised draft recovery plan for the giant garter snake, published in 2015 (USFWS 2015).

2.6.1 Geographic Distribution and Status

Occurrence records indicated that giant garter snakes were distributed in 13 populations coinciding with historical flood basins, marshes, wetlands, and tributary streams of the Central Valley, at the time of the species' listing (U.S. Fish and Wildlife Service 1999a). Since the time of the species' listing, two populations were extirpated and genetic research resulted in grouping of other populations, leading to nine populations being recognized in the 2015 revised draft recovery plan for the species (U.S. Fish and Wildlife Service 2015). The nine extant populations include Butte Basin, Colusa Basin, Sutter Basin, American Basin, Yolo Basin, Cosumnes-Mokelumne Basin, Delta Basin, San Joaquin Basin, and Tulare Basin. These populations extend from Fresno north to Chico and include portions of 11 counties: Butte, Colusa, Glenn, Fresno, Merced, Sacramento, San Joaquin, Solano, Stanislaus, Sutter, and Yolo.

The Project Area is in the Delta Basin Recovery Unit identified in the revised draft recovery plan (U.S. Fish and Wildlife Service 2015). The Project Area overlaps with three management units within this recovery unit: Stone Lakes, White Slough, and Stockton Management Units (U.S. Fish and Wildlife Service 2015). The distribution of giant garter snakes in the Project Area is uncertain. The limited dispersal in female giant garter snakes³ and longstanding reclamation of wetlands for intense agricultural applications has eliminated most suitable habitat (Hansen 1986) and prevented the re-establishment of viable giant garter snake breeding populations in the Delta. A recent study found that proximity to historic marsh best explained variation in the probability of occurrence of giant garter snakes at the landscape scale, with greater probability of occurrence near historic marsh (Halstead et al. 2014).

2.6.2 Life History and Habitat Requirements

³ Female snakes are philopatric, remaining near their point of origin; male giant garter snakes actively search for females during the breeding season (Paquin et al. 2006).

The giant garter snake resides in marshes, ponds, sloughs, small lakes, low-gradient streams, and other waterways, and in agricultural wetlands, including irrigation and drainage canals, rice fields, and the adjacent uplands (58 FR 54053). One study found giant garter snakes in upland habitat more than half the time during the summer, and found the use of upland habitat to increase to nearly 100% during winter dormancy (Halstead et al. 2015). It resides in small mammal burrows and soil crevices located above prevailing flood elevations throughout its winter dormancy period (U.S. Fish and Wildlife Service 2006a). Burrows are typically located in sunny exposures along south- and west-facing slopes. Data based on radiotelemetry studies show that home range varies by location, with median home range estimates varying between 23 acres (range 10.3 to 203 acres, n = 8 [9 hectares, range = 4.2 to 82 hectares]) in a semi-native perennial marsh system and 131 acres (range 3.2 to 2,792 acres, n = 29) (53 hectares, range = 1.3 to 1130 hectares) in a managed refuge (U.S. Fish and Wildlife Service 1999a).

Habitat for the species includes the following elements.

- Adequate water during the snake's active season (early spring through mid-fall) to provide food and cover.
- Emergent, herbaceous wetland vegetation, such as cattails (*Typha* spp.) and bulrushes (*Schoenoplectus*, formerly *Scirpus*), accompanied by vegetated banks for escape cover and foraging habitat during the active season.
- Basking habitat of grassy banks and openings in waterside vegetation.
- High-elevation uplands for cover and refuge from floodwaters during the snake's dormant season in the winter (Hansen and Brode 1980; Hansen 2008; U.S. Fish and Wildlife Service 2006a).

Because of lack of habitat and emergent vegetation cover, giant garter snakes generally are not present in larger rivers and wetlands with sand, gravel, or rock substrates. In addition, the major rivers within the species' range have been highly channelized, removing oxbows and backwater areas that probably at one time provided suitable habitat. Riparian woodlands do not generally provide suitable habitat because most have excessive shade, lack of basking sites, and absence of prey populations. Giant garter snakes are also absent from most permanent waters that support established populations of predatory game fishes and from most sites that undergo routine dredging, mechanical or chemical weed control, or compaction of bank soils (Hansen and Brode 1980; Brode 1988; U.S. Fish and Wildlife Service 1999a, 2006a).

Changing agricultural regimes, development, and other shifts in land use create an ever-changing mosaic of available habitat. Giant garter snakes move around in response to these changes in order to find suitable sources of food, cover, and prey. Connectivity between regions is therefore extremely important for providing access to available habitat and for genetic interchange. In an agricultural setting, giant garter snakes rely largely on the network of canals and ditches that provide irrigation and drainage to establish connectivity.

In the Central Valley, rice fields have become habitat for giant garter snakes. Irrigation water typically enters the rice fields during April along canals and ditches. Giant garter snakes use

these canals and their banks as permanent habitat for both spring and summer active behavior and winter hibernation. Where these canals are not regularly maintained, lush aquatic, emergent, and streamside vegetation develops prior to the spring emergence of giant garter snakes. This vegetation, in combination with cracks and holes in the soil, provides much-needed shelter and cover during spring emergence and throughout the remainder of the summer active period.

Rice is planted during spring, after the winter fallow fields have been cultivated and flooded with several inches of standing water. In some cases, giant garter snakes move from the canals and ditches into these rice fields soon after the rice plants emerge above the water's surface, and they continue to use the fields until the water is drained during late summer or fall (Hansen and Brode 1993). It appears that the majority of giant garter snakes move back into the canals and ditches as the rice fields are drained; a few may overwinter in the fallow fields, where they hibernate in burrows in the small berms separating the rice checks (low dikes) (Hansen 2008, 2011).

While in the rice fields, the snakes forage in the shallow, warm water for small fish and the tadpoles of bullfrogs and tree frogs. For shelter and basking sites, giant garter snakes use the rice plants, vegetated berms dividing the rice checks, and vegetated field margins. Gravid (pregnant) females may be observed in the rice fields during summer, and at least some giant garter snakes are born there (Hansen and Brode 1993; Hansen 2008).

Water is drained from the fields during late summer or fall by a network of drainage ditches. These ditches are sometimes routed alongside irrigation canals and are often separated from the irrigation canals by narrow vegetated berms that may provide additional shelter. Remnants of old sloughs also may remain within rice-growing regions, where they serve as drains or irrigation canals. Giant garter snakes may use vegetated portions along any of these waterways as permanent habitat. Studies indicate that despite the presence of ditches or drains, giant garter snakes will generally abandon aquatic habitat that is not accompanied by adjacent shallow-water wetlands (Wylie and Amarello 2008; Hansen 2007; Jones & Stokes Associates 2008), underscoring the important role that this crop plays in this species' life history.

2.6.3 Species Threats

Habitat loss and fragmentation, flood control activities, changes in agricultural and land management practices, predation by introduced species, parasites, and water pollution are the main causes for the decline of this species. Conversion of Central Valley wetlands for agriculture and urban uses has resulted in the loss of as much as 95% of historical habitat for the giant garter snake (Wylie et al. 1997). In areas where the giant garter snake has acclimated to agriculture, maintenance activities such as vegetation and rodent control, bankside grading or dredging, and discharge of contaminants threaten their survival (Hansen and Brode 1980; Hansen and Brode 1993; U.S. Fish and Wildlife Service 1999a; Wylie et al. 2004). In developed areas, threats of vehicular mortality also are increased. Paved roads likely have a higher rate of mortalities than dirt or gravel roads due to increased traffic and traveling speeds. The loss of wetland habitat is compounded by elimination or compaction of adjacent upland and associated bankside vegetation cover, as well as water fouling; these conditions are often associated with cattle grazing (Thelander 1994). While irrigated pastures may provide the summer water that giant garter snakes require, high stocking rates may degrade habitat by removing protective plant cover and underground and aquatic retreats such as rodent and crayfish burrows (Hansen 1986;

U.S. Fish and Wildlife Service 1999a; Szaro et al. 1985). However, cattle grazing may provide an important function in controlling invasive vegetation that can compromise the overall value of wetland habitat. Giant garter snakes are also threatened by the introduction of exotic species such as introduced bullfrogs (*Lithobates catesbeiana*) which prey on juvenile giant garter snakes throughout their range (Dickert 2003; U.S. Geological Survey 2004). Large vertebrates, including raccoons (*Procyon lotor*), striped skunks (*Mephitis mephitis*), red foxes (*Vulpes vulpes*), gray foxes (*Urocyon cinereoargenteus*), river otters (*Lutra canadensis*), opossums (*Didelphis virginiana*), northern harriers (*Circus cyaneus*), hawks (*Buteo* spp.), herons (*Ardea herodias*, *Nycticorax nycticorax*), egrets (*Ardea alba*, *Egretta thula*), and American bitterns (*Botaurus lentiginosus*) also prey on giant garter snakes (U.S. Fish and Wildlife Service 1999a). In areas near urban development, giant garter snakes may also fall prey to domestic or feral house cats (*Felis domesticus*). In permanent waterways, introduced predatory game fishes, such as bass (*Micropterus* spp.), sunfish (*Lepomis* spp.), and channel catfish (*Ictalurus* spp.), prey on giant garter snakes and compete with them for smaller prey (58 FR 54053; Hansen 2008). Selenium contamination and impaired water quality have been identified as a threat to giant garter snakes, particularly in the southern portion of their range (U.S. Fish and Wildlife Service 1999a; Ohlendorf et al. 1988; Saiki and May 1988; Saiki et al. 1991).

2.6.4 Species Habitat Suitability Model

2.6.4.1 GIS Model Data Sources

The giant garter snake GIS-based habitat model uses vegetation types and associations from the following data sets: composite vegetation layer (Hickson and Keeler-Wolf 2007 [Delta]; TAIC 2008 [Yolo Basin]), DWR 2007 land use survey of the Delta area-version 3, land use survey of the Delta and Suisun Marsh area - version 3 (California Department of Water Resources 2007), and the USGS-National Hydrography Dataset, 1:24,000 (U.S. Geological Survey 1999). Using these data sets, the model maps the distribution of suitable giant garter snake habitat in the Delta. Vegetation types and spatial buffers are assigned based on the species' requirements as described above and the assumptions described below.

2.6.4.2 Habitat Model Description

2.6.4.2.1 Aquatic Habitat

Modeled breeding, foraging, and movement habitat for the giant garter snake in the Delta includes aquatic land cover types occurring throughout the Delta. With the exception of Suisun Marsh (which lies outside of the species' acknowledged range), all perennial aquatic and emergent wetland habitat (described below) as well as artificial canals and ditches in the Delta were considered for including as aquatic habitat in the model. For this reason, a GIS layer was developed to exclude habitat west of Sherman Island and the western tip of Sherman Island. The composite vegetation layer (Hickson and Keeler-Wolf 2007 [Delta] and TAIC 2008 [Yolo Basin]) data sets were used to characterize tidal and nontidal emergent wetland types and perennial aquatic vegetation types. The tidal perennial aquatic types were also used to characterize the shorelines of larger hydrologic features such as Liberty Island and Sacramento and San Joaquin Rivers, and the area within 20 feet (6 meters) of bank margins for inclusion in the model. Features are evaluated separately as tidal freshwater or nontidal freshwater types

based on the differences in prey/predator and cover composition and relative stability of habitat associated with the different hydrographic profiles.

The model includes the following aquatic cover categories and associated types.

- Tidal aquatic habitat
 - Tidal freshwater perennial aquatic—all types
 - Tidal freshwater emergent wetland—all types
- Nontidal aquatic habitat
 - Nontidal freshwater emergent wetland—all types
 - Nontidal freshwater perennial aquatic—all types
 - Managed wetland (all except Suisun)
 - Bulrush–cattail freshwater marsh, not formally defined (NFD) super alliance (all except Suisun)
- Agriculture
 - Rice
 - Wild rice

2.6.4.2.2 *Upland Habitat*

Modeled upland overwintering and movement habitat for giant garter snakes includes all the terrestrial land cover types listed below that are immediately adjacent to and within 200 feet (61 meters) of the aquatic habitat types previously listed.

The model includes the following upland and overwintering movement terrestrial land cover types.

- Agriculture
 - Native vegetation⁴
 - Non-irrigated mixed pasture
 - Non-irrigated native pasture

⁴ Native vegetation is a land use designation within the DWR crop type dataset (California Department of Water Resources 2007). For the purposes of incorporating native vegetation classes into the correct species models, the management on these lands most resembles that of non-irrigated pasture or annual grassland.

- Alkali seasonal wetland complex
 - Alkali heath (*Frankenia salina*)
 - *Allenrolfea occidentalis* mapping unit
 - Alkaline vegetation mapping unit
 - Creeping wild ryegrass (*Leymus triticoides*)
 - *Distichlis spicata*–annual grasses
 - *Distichlis spicata*–*Juncus balticus*
 - *Distichlis spicata*–*Salicornia virginica* (formerly *Sarcocornia*)
 - *Frankenia salina*–*Distichlis spicata*
 - *Juncus balticus*-meadow vegetation
 - Pickleweed (*Salicornia virginica*)
 - *Salicornia virginica*–*Cotula coronopifolia*
 - *Salicornia virginica*–*Distichlis spicata*
 - Salt scalds and associated sparse vegetation
 - Saltgrass (*Distichlis spicata*)
 - *Suaeda moquinii*–(*Lasthenia californica*) mapping unit
- Developed
 - Levee rock riprap
 - Unclassified
- Grassland
 - *Bromus diandrus*–*Bromus hordeaceus*
 - California annual grasslands-herbaceous
 - Degraded vernal pool complex–California annual grasslands–herbaceous
 - Degraded vernal pool complex–Italian ryegrass (*Lolium multiflorum*)
 - Italian ryegrass (*Lolium multiflorum*)

- *Lolium multiflorum*–*Convolvulus arvensis*
- Ruderal herbaceous grasses & forbs
- Upland annual grasslands & forbs formation
- Unclassified
- Inland dune scrub
 - *Lotus scoparius*–Antioch Dunes
 - *Lupinus albifrons*–Antioch Dunes
- Managed wetland
 - Barren gravel and sand bars
 - Bulrush–cattail fresh water marsh NFD super alliance
 - *Crypsis* spp.–wetland grasses–wetland forbs NFD super alliance
 - Intermittently flooded perennial forbs
 - Intermittently or temporarily flooded undifferentiated annual grasses and forbs
 - *Lepidium latifolium*–*Salicornia virginica*–*Distichlis spicata*
 - Managed alkali wetland (*Crypsis*)
 - Managed annual wetland vegetation (nonspecific grasses & forbs)
 - Perennial pepperweed (*Lepidium latifolium*)
 - Poison hemlock (*Conium maculatum*)
 - *Polygonum amphibium*
 - Rabbitsfoot grass (*Polypogon maritimus*)
 - *Schoenoplectus* (formerly *Scirpus*) spp. in managed wetlands
 - Seasonally flooded undifferentiated annual grasses and forbs
 - Shallow flooding with minimal vegetation at time of photography
 - Smartweed *Polygonum* spp.–mixed forbs
 - Temporarily flooded grasslands

- Other natural seasonal wetland
 - Degraded vernal pool complex-vernal pools
 - *Juncus bufonius* (salt grasses)
 - Santa Barbara sedge (*Carex barbarae*)
 - Seasonally flooded grasslands
 - Temporarily flooded perennial forbs
 - Vernal pools
- Valley/foothill riparian
 - *Acacia-robinia*
 - *Acer negundo-Salix gooddingii*
 - *Alnus rhombifolia/Cornus sericea*
 - *Alnus rhombifolia/Salix exigua (Rosa californica)*
 - Arroyo willow (*Salix lasiolepis*)
 - *Baccharis pilularis*/annual grasses & herbs
 - Black willow (*Salix gooddingii*)
 - Black willow (*Salix gooddingii*) –valley oak (*Quercus lobata*) restoration
 - Blackberry (*Rubus discolor*)
 - Blackberry NFD super alliance
 - Box elder (*Acer negundo*)
 - Buttonbush (*Cephalanthus occidentalis*)
 - California dogwood (*Cornus sericea*)
 - California wild rose (*Rosa californica*)
 - Coast live oak (*Quercus agrifolia*)
 - *Cornus sericea-Salix exigua*
 - *Cornus sericea-Salix lasiolepis/(Phragmites australis)*

- Coyote bush (*Baccharis pilularis*)
- Fremont cottonwood–valley oak–willow (ash–sycamore) riparian forest NFD association
- Fremont cottonwood (*Populus fremontii*)
- Giant cane (*Arundo donax*)
- Hinds’ walnut (*Juglans hindsii*)
- Horsetail (*Equisetum* spp.)
- Intermittently flooded to saturated deciduous shrubland
- Intermittently or temporarily flooded deciduous shrublands
- Mexican elderberry (*Sambucus mexicana*)
- Mixed Fremont cottonwood–willow spp. NFD alliance
- Mixed willow super alliance
- Narrow-leaf willow (*Salix exigua*)
- Oregon ash (*Fraxinus latifolia*)
- Pampas grass (*Cortaderia selloana*–*C. jubata*)
- *Quercus lobata*–*Acer negundo*
- *Quercus lobata*–*Alnus rhombifolia* (*Salix lasiolepis*–*Populus fremontii*–*Quercus agrifolia*)
- *Quercus lobata*–*Fraxinus latifolia*
- *Quercus lobata*/Rosa californica (*Rubus discolor*–*Salix lasiolepis*/Carex spp.)
- Restoration sites
- *Salix exigua*–(*Salix lasiolepis*–*Rubus discolor*–*Rosa californica*)
- *Salix gooddingii*–*Populus fremontii*–(*Quercus lobata*–*Salix exigua*–*Rubus discolor*)
- *Salix gooddingii*–*Quercus lobata*/wetland herbs
- *Salix gooddingii*/Rosa californica
- *Salix gooddingii*/wetland herbs

- *Salix lasiolepis*–(*Cornus sericea*)/*Schoenoplectus* spp. –(*Phragmites australis*–*Typha* spp.) complex unit
- *Salix lasiolepis*–mixed brambles (*Rosa californica*–*Vitis californica*–*Rubus discolor*)
- Shining willow (*Salix lucida*)
- Temporarily or seasonally flooded–deciduous forests
- Tobacco brush (*Nicotiana glauca*) mapping unit
- Valley oak (*Quercus lobata*)
- Valley oak (*Quercus lobata*) restoration
- Valley oak alliance–riparian
- White alder (*Alnus rhombifolia*)
- White alder (*Alnus rhombifolia*) –arroyo willow (*Salix lasiolepis*) restoration
- Unclassified
- Vernal Pool Complex
 - *Allenrolfea occidentalis* mapping unit
 - California annual grasslands–herbaceous
 - *Distichlis spicata*–annual grasses
 - Italian ryegrass (*Lolium multiflorum*)
 - Mixed *Schoenoplectus* mapping unit
 - Ruderal herbaceous grasses & forbs
 - Salt scalds and associated sparse vegetation
 - Saltgrass (*Distichlis spicata*)
 - Seasonally flooded grasslands
 - *Suaeda moquinii*–(*Lasthenia californica*) mapping unit
 - Vernal pools

In addition to the methodology described above for most the Delta, upland habitat areas mapped for Plan expansion areas include the following land cover types.

- Pasture
- Alkali seasonal wetland complex
- Grassland
- Grassland–pasture
- Upland annual grasslands and forbs formation
- *Crypsis* species–wetland grasses–wetland forbs NFD super alliance
- Vernal pools
- Other natural seasonal wetland
- Vernal pool complex

In 2011, and again in 2012, the species habitat models were updated to include previously unmapped portions of the Delta. For most areas newly mapped, vegetation data were not available at the alliance level as in the rest of the Delta and so most of the new analysis areas were mapped at the natural community level. Additional detail regarding crop types was available for cultivated lands and was incorporated into the mapping. For the giant garter snake, in the new analysis areas, the following natural communities are assumed to provide the listed habitat type.

- Agriculture
 - Rice (aquatic nontidal)
- Managed wetland (all except Suisun)
 - Bulrush–cattail freshwater marsh, NFD super alliance (all except Suisun) (aquatic nontidal)
- Nontidal freshwater perennial emergent wetland
 - Nontidal perennial aquatic–water (aquatic nontidal)

In the areas of additional analysis, the following tidal aquatic natural communities were assumed to provide giant garter snake aquatic habitat.

- Tidal freshwater emergent wetland (aquatic tidal)
- Tidal perennial aquatic
 - Tidal perennial aquatic–water (all except Suisun) (aquatic tidal)

In the areas of additional analysis, the following upland natural communities within 200 feet of aquatic habitat were assumed to provide giant garter snake upland habitat.

- Agriculture
 - Pasture (upland)
- Grasslands
 - Pasture (upland)
 - Upland annual grasslands & forbs formation (upland)
 - Managed wetlands
- *Crypsis* spp.-wetland grasses-wetland forbs NFD super alliance (upland)
- Vernal pools (upland)
- Other seasonal wetlands (upland)
- Vernal pool complex (upland)

Since the last update in 2012, the model has gone through several additional changes which are described below.

- Rice patches were removed from Bouldin Island; rice is no longer grown in this region and this area is now categorized as “grain and hay” per the verified wetland delineation and a conversation between Mike Bradbury and the owner’s group (Bradbury pers. comm.).
- The November 2014 crop type layer replaced the June 2013 layer; the new layer provided more detail regarding the irrigation status of pasturelands (i.e., irrigated versus nonirrigated). This change had no effect on the giant garter snake impacts analysis, it was simply done so that all models are using the most up-to-date information.
- Where there was overlap with the former aquatic model, the verified wetland delineation data replaced the tidal and nontidal aquatic habitat model. The nontidal and tidal aquatic portions of the former model remain in areas outside of the wetland delineation area.
- The process of replacing the former aquatic portion of the model with the new wetland delineation data resulted in small “slivers” of land without coverage by the habitat model. This is because the wetland delineation data was more accurate than the previous tidal and nontidal model (i.e., the spatial extent of the wetland data was smaller and did not overlap 100% with the former model).

- These slivers described above were manually classified as either upland or determined to not be suitable habitat using aerial photography. Most of the slivers were classified as upland. A separate data layer of these slivers has been maintained to allow for review.
- The wetland delineation data included 13 types of wetland, 7 of which were considered giant garter snake habitat. Table 2-1 below presents which wetland types are considered habitat.
- The wetland types were categorized for the giant garter snake by Jean Witzman (technical lead for wetland delineation at the Department of Water Resources) and Laura Patterson (giant garter snake expert with the California Department of Fish and Wildlife).
- The aquatic habitat was buffered by 1,000 feet and the agricultural ditches that were within the buffer were added to the model as aquatic habitat, replacing the “linear” portion of the model.
- The uplands portion of the model was not modified, however, upland habitat was added to the model where there were slivers of land that were reclassified from aquatic to upland based on the new wetland delineation data. The upland habitat may have small changes as it is based on suitable land cover types within 200 feet of aquatic habitat and the above changes to the aquatic habitat could affect changes to the upland habitat.

Table 2-3. Wetland Types and Assumed Habitat Quality Values for the Revised Giant Garter Snake Aquatic Model.

Wetland or Water Group Type	Cowardin Class	Suitable Giant Garter Snake Habitat (Yes/No)	Rationale
Agricultural Ditch	R4	Yes	Giant garter snakes are known to occur in agricultural ditches.
Alkaline Wetland	PEM/PSS	No	Giant garter snakes are not known to occur in vernal pools or alkali seasonal wetlands.
Clifton Court Forebay	R1UB	No	Giant garter snakes are not known from Clifton Court Forebay.
Conveyance Channel	R1UB	No	Giant garter snakes are not known to occur within the conveyance channel on the western edge of Clifton Court Forebay.
Depression	PUB	Yes	Open water infested with predatory, non-native fish; small amount of emergent wetland.
Emergent Wetland	PEM	Yes	Emergent, herbaceous wetland vegetation, such as cattails and bulrushes provide foraging habitat during the active season
Forest	PFO	No	The small number of wetlands in this type are in the Coumnes-Mokelumne area and because they are surrounded by forest/riparian areas are not considered habitat.
Lake	L1UB	Yes	Open water infested with predatory, non-native fish; small amount of emergent wetland.
Natural Channel	R4	Yes	Does not have permanent water, forested up to the edge of the aquatic habitat.
Scrub-Shrub	PSS	No	Scrub shrub is an alkali seasonal wetland type and alkali wetland types are not known to support giant garter snake in the action area, west of Clifton Court Forebay.
Seasonal Wetland	PEM	No	Because of their seasonality and poor vegetation quality, seasonal wetlands are not considered habitat. Surrounding uplands and ag ditches would be the primary habitat in these regions.
Tidal Channel	R1UB/R1UB V	Yes	Open-water, high flows, high density of predatory, invasive fish; emergent wetland habitat is the high value habitat and tidal channels are just providing movement habitat.
Vernal Pool	PEM2	No	Giant garter snakes are not known to occur in vernal pools or alkali seasonal wetlands in the action area.

2.6.4.3 Assumptions

Giant garter snakes inhabit marshes, ponds, sloughs, small lakes, low-gradient streams and other waterways, and agricultural wetlands, including irrigation and drainage canals, rice fields, and the adjacent uplands (U.S. Fish and Wildlife Service 2006b). In the Sacramento Valley, their habitat requirements include adequate water during the snake's active season (early spring through mid-fall) to provide food and cover, and emergent herbaceous wetland vegetation for escape cover and foraging habitat during the active season.

- **Assumption:** Suisun Marsh does not support potentially occupied giant garter snake habitat.

Rationale: Suisun Marsh lies outside of the acknowledged range of the species (U.S. Fish and Wildlife Service 1999).

- **Assumption:** Giant garter snakes could potentially use any watercourse within 1,000 feet of aquatic habitat, perennial marsh, or flooded rice field in the Delta.

Rationale: Watercourses, perennial marsh, and flooded rice fields are most likely consistently inundated during most of the snake's active season and are therefore available for breeding, foraging, or movement.

- **Assumption:** Tidal perennial aquatic habitat suitable for giant garter snake consists of those areas within 20 feet (6 meters) of bank margins.

Rationale: In tidal perennial aquatic features (e.g., the Sacramento and San Joaquin Rivers and tidal zones in the central Delta), giant garter snakes are limited to shallow, near-shore habitats providing vegetative cover, foraging, thermoregulating opportunities, and refuge from predatory fishes. Accordingly, tidal perennial aquatic features are buffered internally by 20 feet (6 meters) to capture the near-shore habitat and exclude the relatively deep water areas that are considered unsuitable.

- **Assumption:** Potentially occupied giant garter snake upland habitat consists of the land cover types listed above that are within 200 feet (61 meters) of modeled aquatic habitat

Rationale: Giant garter snakes use grassy stream banks and upland habitats adjacent to perennial watercourses or wetlands as overwintering and movement habitat.

2.6.4.4 Model Limitations

Suitable upland overwintering habitat is overestimated in areas subject to prolonged inundation by flood events such as that which occurs in the Yolo Bypass. Periodic inundation influences suitability for use as overwintering habitat and, depending on the frequency of inundation, could create a biological sink as snakes reestablish overwintering patterns in the inundation zone during nonflood years and then are displaced from or killed at overwintering sites during an inundation event. Because there is little research on this topic, the Yolo Bypass is included as potential overwintering habitat for giant garter snake; however, it is likely that either the bypass is not used for this purpose because of the current frequency and extent of flooding or that it

represents a site where snakes are periodically displaced during the inactive season when inundation occurs.

Most historical and recent occurrences of the giant garter snake in the Delta have been reported from areas outside of the central Delta, including portions of the Coldani Marsh/White Slough along the eastern edge of the Delta (California Department of Fish and Game 2013; Hansen 2006, 2007, 2009, 2011; Wylie and Amarello 2008). These areas are also consistent with the USFWS' description of extant populations within the Delta (U.S. Fish and Wildlife Service 1999). Additional relatively recent occurrences extend north of Coldani Marsh/White Slough to Stone Lakes and east of the Mokelumne and Sacramento Rivers. The northern and eastern portions of the Delta are known to support extant populations and are where recent and historical records suggest a greater likelihood of undiscovered extant populations to occur as described above.

Scattered records from the central Delta suggest that giant garter snakes may have occupied this region at one time, but longstanding reclamation of wetlands for intense agricultural applications has eliminated most suitable habitat (Hansen 1986). Historical and recent surveys conducted in the Delta have failed to identify any extant population clusters in the region (Hansen 1986; Patterson 2005; California Department of Water Resources 2006), including 2009 surveys conducted by DWR (Hansen 2011). There is also some speculation that recent observations in the central Delta (e.g., Sherman Island) could be of snakes that occasionally move into the central Delta by 'washing-down' from known populations, such as Liberty Island or Coldani Marsh/White Slough, and that these occurrences do not represent local breeding populations (California Department of Fish and Game 2013; Hansen 2011; Vinnedge Environmental 2013). There are also only two known isolated occurrences south of the San Joaquin River and none south of SR 4. This area is within the approximately 50-air-mile gap that separates the northern and southern populations (Hansen and Brode 1980; 58 FR 54053). Areas that support suitable habitat (as defined here) throughout the legal Delta are considered potentially occupied by giant garter snakes. The western end of Sherman Island represents the western extent of potentially occupied habitat, and consistent with the permitted *East Contra Costa Habitat Conservation Plan/Natural Communities Conservation Plan* (East Contra Costa Habitat Conservancy 2006), SR 160 approximately represents the westernmost extent south of the San Joaquin River near Antioch. USFWS and CDFW giant garter snake experts now believe recent sightings in the Central Delta may represent an extant population that lives in emergent vegetation on the various islands (pers. comm., Brian Hansen, USFWS, 2016); based on CNDDDB records, snakes have typically been found in this area along levee roads away from typically used habitat, so the status of snakes found in the Central Delta remains unknown.

2.6.5 Suitable Habitat Definition

Suitable habitat is described by USFWS in the 2015 Draft Recovery Plan (U.S. Fish and Wildlife Service 2015), including:

2.6.5.1 Aquatic Component

The giant garter snake has been recognized as requiring aquatic habitat since it was first described, and has been consistently observed and captured in association with aquatic habitats

since accounts of the snake were first published. The aquatic component of the giant garter snake habitat has been regarded as necessary for the survival of the snake, and researchers acknowledge the following qualitative attributes of ideal aquatic habitat for the giant garter snake (U.S. Fish and Wildlife Service 2015):

1. Water present from March through November.
2. Slow moving or static water flow with mud substrate.
3. Presence of emergent and bankside vegetation that provides cover from predators and may serve in thermoregulation.
4. The absence of a continuous canopy of riparian vegetation.
5. Available prey in the form of small amphibians and small fish.
6. Thermoregulation (basking) sites with supportive vegetation such as folded tule clumps immediately adjacent to escape cover.
7. The absence of large predatory fish.
8. Absence of recurrent flooding, or where flooding is probable the presence of upland refugia.

2.6.5.2 Upland Component

Although the giant garter snake is predominately an aquatic species, incidental observations and radio telemetry studies have shown that the snake can be found in upland areas near the aquatic habitat component during the active spring and summer seasons. Upland habitat (land that is not typically inundated during the active season and is adjacent to the aquatic habitat of the giant garter snake) is used for basking to regulate body temperature, for cover, and as a retreat into mammal burrows and crevices in the soil during ecdysis (shedding of skin) or to avoid predation. Giant garter snakes have been observed using burrows for refuge in the summer as much as 50 meters (164 feet) away from the marsh edge. Important qualities of upland habitat have been found by researchers (U.S. Fish and Wildlife Service 2015) to include:

1. Availability of bankside vegetative cover, typically tule (*Scirpus* sp.) or cattail (*Typha* sp.), for screening from predators.
2. Availability of more permanent shelter, such as bankside cracks or crevices, holes, or small mammal burrows.
3. Free of poor grazing management practices (such as overgrazed areas).

2.6.5.3 Upland Winter Refugia Component

During the colder winter months, giant garter snakes spend their time in a lethargic state. During this period, giant garter snakes over-winter in locations such as mammal burrows along canal

banks and marsh locations, or riprap along a railroad grade near a marsh or roads. Giant garter snakes typically do not over-winter where flooding occurs in channels with rapidly moving water, such as the Sutter Bypass. Over-wintering snakes use burrows as far as 200 to 250 meters (656 to 820 feet) from the edge of summer aquatic habitat (U.S. Fish and Wildlife Service 2015).

2.7 Swainson's Hawk

The Swainson's hawk (*Buteo swainsoni*) is listed as a threatened species under the CESA (California Fish and Game Code, Sections 2050 *et seq.*). The Swainson's hawk has no federal regulatory status. However, the species is included on the USFWS list of Birds of Conservation Concern for Region 1 (U.S. Fish and Wildlife Service 2008).

2.7.1 Geographic Distribution and Status

Swainson's hawks nest in the grassland plains and agricultural regions of western North America from southern Canada (and possibly in the northern provinces and territories, and Alaska) to northern Mexico. Other than a few documented small wintering populations in the United States (Herzog 1996; England et al. 1997), most populations in the species winter primarily in the pampas of Argentina. The Central Valley population, however, winters mainly between Mexico and central South America (City of Elk Grove 2007).

The 2007 statewide population estimate for California was 2,081 breeding pairs (Anderson et al. 2007) and was based on a statistically valid statewide survey conducted in 2005 and 2006. Nearly 94% of nesting Swainson's hawks in California are found in the Central Valley from Tehama County south to Kern County (Anderson et al. 2007). Over 60% of the statewide population occurs within Yolo, Sacramento, Solano, and San Joaquin Counties (Anderson et al. 2007). Although intensively farmed for over 100 years, much of this area retains a relative abundance of nesting habitat—narrow riparian corridors along rivers and streams, remnant oak groves and trees, roadside trees—and agricultural uses conducive to Swainson's hawk foraging (Estep 2007, 2008; Anderson et al. 2007). There are numerous nesting records for Swainson's hawk in the project vicinity.

2.7.2 Life History and Habitat Requirements

In the Central Valley, Swainson's hawks usually nest in large native trees such as valley oak (*Quercus lobata*), Fremont cottonwood (*Populus fremontii*), Hinds' walnut (*Juglans hindsii*), and willows (*Salix* spp.), and in nonnative trees, such as eucalyptus (*Eucalyptus* spp.). Nests occur in riparian woodlands, roadside trees, trees along field borders, isolated trees, small groves, and on the edges of remnant oak woodlands. Stringers of remnant riparian forest contain the majority of known nests in the Central Valley (Estep 1984; Schlorff and Bloom 1984; England et al. 1997). However, this appears to be a function of nest tree availability rather than dependence on riparian forest. Nests are usually constructed as high as possible in the tree, providing protection to the nest as well as better visibility from it.

Nesting pairs are highly traditional in their use of nesting territories and nesting trees. Many nest sites in the Central Valley are known to have been occupied annually since 1979 and banding studies conducted since 1986 confirm a high degree of nest and mate fidelity (Yolo County Habitat Conservation Plan/Natural Community Conservation Plan Joint Powers Agency 2009).

The 2006 and 2007 baseline surveys of nesting habitat in South Sacramento County and Yolo County (Estep 2007, 2008) found that riparian habitat was the most frequently used nesting habitat type. Isolated trees, roadside trees, tree rows, farmyard trees, and rural residential trees were also frequently used. Valley oak and Fremont cottonwood were the most frequently used nest trees, followed by walnut, willow, and eucalyptus trees.

Swainson's hawks require large areas of open landscape for foraging. Historically, the species foraged the grasslands of the Central Valley and other inland valleys. With substantial conversion of these grasslands to farming operations, Swainson's hawks have shifted their nesting and foraging into those agricultural lands that provide large rodent prey populations amid low, open vegetation. Foraging habitat value is a function of the following elements:

- Patch size: sensitivity to fragmented landscapes; use will decline as suitable patch size decreases.
- Prey accessibility: the ability of hawks to access prey depends on vegetation structure and management activities.
- Prey availability: the abundance of prey populations in a field.

Data on minimum foraging patch size are largely anecdotal, but are in the range of between 5 and 25 acres (2 and 10 hectares) (Estep and Teresa 1992; California Department of Fish and Game 1994). Although Swainson's hawks have been observed foraging in habitat patches smaller than 40 acres (16 hectares), 40-acre (16 hectare) fields are more likely to be seen by Swainson's hawks and more likely to provide higher density prey (Stillwater Sciences 2014). In the Central Valley, land use or specific crop type and management practices determine the foraging value of a field at any given time. Important land cover or agricultural crops for foraging are alfalfa and other hay, grain and row crops, fallow fields, dryland pasture, and annual grasslands (Estep 1989; Babcock 1995; Woodbridge 1998). The matrix of these cover types across a large area creates a dynamic foraging landscape as temporal changes in vegetation results in changing foraging patterns and foraging ranges.

Home ranges are highly variable depending on cover type, and fluctuate seasonally and annually with changes in vegetation structure (e.g., growth and harvest) (Estep 1989; Woodbridge 1991; Babcock 1995). Smaller home ranges consist of high percentages of alfalfa, fallow fields, and pastures (Estep 1989; Woodbridge 1991; Babcock 1995). Larger home ranges are associated with higher proportions of cover types with reduced prey accessibility, such as orchards and vineyards, or reduced prey abundance, such as flooded rice fields. Though Swainson's hawks can forage across a very large landscape compared with most other raptor species and still successfully reproduce (Estep 1989, England et al 1995), travelling more than 5 miles from a nest site to high-quality foraging sites statistically reduces reproductive success (England et al. 1995).

Swainson's hawks are highly responsive to farming and management activities that expose and concentrate prey, such as cultivating, harvesting, and disking. During these activities, particularly late in the season, Swainson's hawks will hunt behind tractors searching for exposed prey. Other

activities, such as flood irrigation and burning, also expose prey and attract foraging Swainson's hawks.

2.7.3 Species Threats

Swainson's hawks face different threats in different portions of their range. In California, causes of population decline are thought to be loss of nesting habitat (Schlorff and Bloom 1984) and loss and fragmentation of foraging habitat to urban development and to conversion to unsuitable agriculture, such as orchards and vineyards (England et al. 1995, 1997). Conversion from compatible to incompatible crop patterns also reduces available foraging habitat and influences the distribution of nesting Swainson's hawks. Large regions of the Central Valley have been converted to rice, vineyards, orchards, cotton, and other incompatible crop types that support few Swainson's hawks. The conversion of suitable agricultural landscapes (e.g., annually rotated irrigated cropland, hayfields, and pasturelands) to vineyards and other unsuitable cover types continues to reduce available foraging habitat on a local and regional basis. Spring and summer inundation of agricultural lands or other habitats also reduces available foraging habitat.

Nestlings are vulnerable to starvation, fratricide (the larger nestling killing the smaller nestling in times of food stress), and predation from crows, ravens, and other raptors. Natural population cycles of voles in central California may be a factor in reproductive success when vole population crashes suppress Swainson's hawk reproduction or lead to increased nestlings starvation rates. Insecticides and rodenticides may contribute to food scarcity by reducing prey abundance.

Loss of riparian and other nesting habitat continues throughout the Central Valley from levee projects, agricultural practices, and local development along watercourses. A related issue is the loss and lack of regeneration of valley oak and other native trees, an ongoing problem in areas that have continued to support remnant valley oaks and oak groves.

Adult Swainson's hawks are rarely killed by natural predators or competitors, but collisions with moving vehicles and illegal shooting and trapping have been identified as significant sources of mortality (England et al. 1997). Well-documented mass poisonings of hundreds or thousands of Swainson's hawks wintering in Argentina (Woodbridge et al. 1995; Goldstein et al. 1996) have led to that country's ban of an insecticide (monocrotophos) used on alfalfa and sunflower fields to control grasshopper populations. Levels of dichlorodiphenyldichloroethylene (DDE) (a toxic degradation product of dichlorodiphenyltrichloroethane [DDT], a pesticide used extensively until 1972 when it was banned in the U.S.) in Swainson's hawks from the Central Valley may have been high enough to negatively affect reproductive success during the decades when DDT was used extensively in the United States. However, levels of DDE measured in eggs collected in 1982 and 1983 were not considered high enough to indicate a health threat (Risebrough et al. 1989).

2.7.4 Species Habitat Suitability Model

2.7.4.1 GIS Model Data Sources

The Swainson's hawk habitat suitability model uses vegetation types and associations from the following data sets: composite vegetation layer (Hickson and Keeler-Wolf 2007 [Delta], Boul

and Keeler-Wolf 2008 [Suisun Marsh], TAIC 2008 [Yolo Basin]), aerial photography (U.S. Department of Agriculture 2005, 2010), Farmland Mapping and Monitoring Program (California Department of Conservation 2004), and land use survey of the Delta and Suisun Marsh area-version 3 (California Department of Water Resources 2007). Using these data sets, the model maps the distribution of suitable Swainson's hawk habitat in the Delta according to the species' two primary life requisite parameters, nesting habitat and foraging habitat. Vegetation types are assigned based on the species requirements as described above and the assumptions described below.

2.7.4.2 *Habitat Model Description*

Modeled nesting habitat in the Delta includes the following types from the composite vegetation layer:

- White alder (*Alnus rhombifolia*)
- *Alnus rhombifolia*/*Salix exigua*
- *Alnus rhombifolia*/*Cornus sericea*
- Oregon ash (*Fraxinus latifolia*)
- Box elder (*Acer negundo*)
- *Acer negundo*–*Salix gooddingii*
- Hinds' walnut (*Juglans hindsii*)
- Fremont cottonwood (*Populus fremontii*)
- Black willow (*Salix gooddingii*)
- *Salix gooddingii*/wetland herbs
- *Salix gooddingii*–*Populus fremontii* (*Quercus lobata*–*Salix exigua*–*Rubus discolor*)
- *Salix gooddingii*–*Quercus lobata*/wetland herbs
- *Salix gooddingii*/*Rubus discolor*
- Coast live oak (*Quercus agrifolia*)
- Valley oak (*Quercus lobata*)
- *Quercus lobata*/*Rosa californica* (*Rubus discolor*–*Salix lasiolepis*/*Carex* spp.)
- *Quercus lobata*–*Acer negundo*
- *Quercus lobata*–*Alnus rhombifolia* (*Salix lasiolepis*–*Populus fremontii*–*Quercus agrifolia*)
- *Quercus lobata*–*Fraxinus latifolia*
- Black willow (*Salix gooddingii*) –valley oak (*Quercus lobata*) restoration

- Valley oak (*Quercus lobata*) restoration
- White alder (*Alnus rhombifolia*) arroyo willow (*Salix lasiolepis*) restoration
- *Eucalyptus*
- *Eucalyptus globulus*
- *Fraxinus latifolia*
- Fremont cottonwood–valley oak–willow riparian forest
- Landscape trees
- Mixed Fremont cottonwood–willow spp. not formally defined (NFD) alliance
- Mixed willow super alliance
- Oaks
- *Salix lasiolepis/Quercus agrifolia*
- Valley oak alliance–riparian
- Willow trees

While valley oak and/or cottonwood-dominated riparian forests are considered optimal nesting habitat for this species, the model does not distinguish habitat value according to overstory composition, tree density, structure, or patch size. For purposes of this model, all overstory riparian and other mature trees are considered potential Swainson’s hawk nesting habitat. Natural vegetation types designated as species habitat in this model correspond to the mapped vegetation associations in the composite vegetation data layer.

Foraging habitat includes the following types from the composite vegetation layer using a 5-acre minimum patch size:

- Grasslands
 - Ruderal herbaceous grasses and forbs
 - California annual grasslands–herbaceous
 - *Bromus diandrus–Bromus hordeaceus*
 - Italian ryegrass (*Lolium multiflorum*)
 - *Lolium multiflorum–Convolvulus arvensis*
 - *Suaeda moquinii (Lasthenia californica)*
 - Degraded vernal pool complex–California annual grasslands
 - Degraded vernal pool complex–ruderal herbaceous grasses and forbs
 - Degraded vernal pool complex–Italian ryegrass (*Lolium multiflorum*)

- Managed Wetlands
 - Rabbitsfoot grass (*Polypogon monspeliensis*)
 - Intermittently flooded perennial forbs
 - Managed annual wetland vegetation (nonspecific grasses and forbs)
 - Shallow flooding with minimal vegetation
 - Seasonally flooded undifferentiated annual grasses and forbs
 - Managed alkali wetland (*Crypsis*)
 - Intermittently or temporarily flooded undifferentiated annual grasses and forbs
- Alkali seasonal wetland complex and other natural seasonal wetlands
 - *Distichlis spicata*–annual grasses
 - Seasonally flooded grasslands
 - Vernal pools
 - Degraded vernal pool complex–vernal pools
 - Degraded vernal pool complex–rabbitsfoot grass
 - Temporarily flooded perennial forbs
 - Alkaline vegetation mapping unit
 - *Allenrolfea occidentalis* mapping unit
 - *Suaeda moquinii* mapping unit
 - Salt scalds and associated sparse vegetation
- Vernal pool complex
 - Annual grasses generic
 - Annual grasses/weeds
 - California annual grasslands–herbaceous
 - *Distichlis*/annual grasses
 - *Distichlis spicata*–annual grasses
 - Italian ryegrass (*Lolium multiflorum*)
 - Ruderal herbaceous grasses and forbs
 - Salt scalds and associated sparse vegetation
 - Vernal pools
- Annual grasses generic

- Annual grasses/weeds
- *Baccharis*/annual grasses
- *Bromus* spp./*Hordeum*
- *Crypsis schoenoides*
- *Crypsis* spp.–wetland grasses–wetland forbs NFD super alliance
- Cultivated annual graminoid
- *Cynodon dactylon*
- *Distichlis*/annual grasses
- Fallow disced field
- Field crops
- *Hordeum/Lolium*
- *Lolium* (generic)
- *Lolium/Rumex*
- *Lotus corniculatus*
- Medium upland herbs
- Medium wetland graminoids
- Medium wetland herbs
- Pasture
- Perennial grass
- Short upland graminoids
- Short wetland graminoids
- Tall wetland graminoids
- Truck/nursery/berry crops
- Upland annual grasslands and forbs formation
- Upland herbs

- Agriculture

The following DWR 2007 Land Use survey types are included as suitable agricultural foraging habitats for Swainson's hawk. These types represent the typical agricultural cover types in the Delta that are included in the DWR 2007 land use survey. Rotational crop types that are not common to the Delta are not included here. Pasture types are mostly perennial; alfalfa is semi-perennial (3 to 7 years); and all other types are annually or seasonally rotated irrigated crops, only some of which provide suitable foraging habitat for Swainson's hawks.

- Grain and hay crops
 - Wheat
 - Oats
 - Miscellaneous grain and hay
 - Nonirrigated miscellaneous grain and hay
 - Mixed grain and hay
 - Nonirrigated mixed grain and hay
- Field crops
 - Safflower
 - Sugar beets
 - Corn
 - Grain sorghum
 - Sudan
 - Beans
 - Miscellaneous field
 - Sunflowers
- Pasture
 - Alfalfa and alfalfa mixtures
 - Clover
 - Mixed pasture
 - Nonirrigated mixed pasture
 - Native pasture
 - Nonirrigated native pasture
 - Miscellaneous grasses

- Truck, nursery and berry crops
 - Asparagus
 - Green beans
 - Carrots
 - Lettuce (all types)
 - Melons, squash and cucumbers (all types)
 - Onions and garlic
 - Mixed berry crops
 - Tomatoes
 - Peppers
 - Broccoli
- Idle
 - Land not cropped the current or previous crop season, but cropped within the past three years
 - New lands being prepped for crop production

The model includes all grassland types, many managed and natural seasonal wetland types, all irrigated pastures and hays, and all seasonally rotated croplands. The model excludes suitable habitat fragments less than 40 acres in size if they are completely within urbanized areas. Suitable habitat fragmented by unsuitable agricultural crop types is not excluded. Agricultural crop types designated as species habitat correspond to DWR 2007 land use database categories.

2.7.4.3 Assumptions

- **Assumption:** Swainson's hawk use nesting sites as shown on Figure 4.7-1.

Rationale: In the Central Valley, Swainson's hawks typically nest in large native trees such as cottonwood, valley oak, walnut, and black willow. These trees (and thus most nest sites) are most often found along stringers of valley riparian forest (Estep 1984; Schlorff and Bloom 1984; England et al. 1997). Because the age or structure of the overstory trees is not considered in the model, it may overestimate the extent of suitable riparian nesting habitat. However, Swainson's hawks also nest in a variety of other native and nonnative trees (e.g., Oregon ash, box elder, white alder; eucalyptus) and habitats such as roadside trees, windbreaks, oak groves, isolated trees, and trees around rural residences. These nesting habitat types are not sufficiently captured by this model primarily due to the small mapping units that would be required, and thus potential nonriparian nesting habitat is underestimated by the model. Although the model focuses on riparian habitats, to address this issue, impact assessments include all potential nesting habitat types that occur in association with modeled foraging habitat.

- **Assumption:** Swainson's hawk foraging habitat is restricted to the vegetation types described in Section 2.7.4.2 *Habitat Model Description*.

Rationale: In the Central Valley, foraging habitat consists primarily of irrigated croplands and pasturelands. Swainson's hawks also forage in annual grasslands and during the summer will use noninundated seasonal wetlands. Because foraging Swainson's hawks must have access to the ground, vegetation structure influences foraging use, which varies according to the crop type and seasonal planting and harvesting regime (Estep 2009). Swainson's hawks feed primarily on small rodents, usually in large fields that support low vegetation cover (to provide access to the ground) and high densities of prey (Bechard 1982; Estep 1989). These habitats include hay fields, grain crops, certain row crops, and lightly grazed pasturelands. Because the grain and hay, field, and truck, nursery and berry crop types listed above are seasonally rotated, the value of individual fields changes each year. Therefore, these crop types are not differentiated based on their seasonal value and are instead combined into a category of seasonally rotated croplands. As a result, this model overestimates the extent of available agricultural foraging habitat in any given year. Foraging use is also a function of patch size. Foraging use generally decreases as suitable foraging patch size decreases below approximately 40 acres. However, this usually occurs due to fragmentation of foraging habitat due to urbanization, and not due to unsuitable crop types. To maintain consistency with CDFW guidance, a minimum foraging patch size of 5 acres is used.

2.7.4.4 Habitat Value Categories

Most of the Delta consists of agricultural land and most is considered to have some value as foraging habitat for Swainson's hawks. However, the value of crop types differ widely due to their growth and structure, which influences accessibility by foraging hawks, and in prey abundance, which influences the availability of prey. Because of the dynamic nature of the agricultural landscape and the variability of crop patterns and conditions seasonally and

annually, only a proportion of the agricultural landscape is suitable or available for foraging in any given season or year.

Sufficient information is available on the growth and structure of different agricultural crops (Estep 1989, 2009) and the prey abundance and use of different crop types to generally categorize crops based on their value as foraging habitat. **Error! Reference source not found.** categorizes modeled cover types according to five relative value classes, high, moderate, low, very low and none. These value classes correspond to the mitigation requirement for the Swainson's hawk with regard to sustaining maintaining moderate to high-value types on protected mitigation lands.

Table 2-4. Swainson's Hawk Agricultural Foraging Habitat Value Classes

Foraging Habitat Value Class	Assigned Agricultural Crops/Habitats	Rationale for Assignment of Agricultural Crop Class	Information Sources
Very High Value	Alfalfa	Alfalfa has the highest value because it is semi-perennial (up to 5 years before rotation), which increases prey abundance; has a relatively low profile such that prey are accessible season-long; and has a management regime (mowing and irrigation) which further increases prey accessibility.	Estep 1989, 2009; Swolgaard et al. 2008
High Value	Native pasture, mixed pasture, clover, miscellaneous grasses, non-irrigated native pasture and pasture, native vegetation ^a	These pasture types provide a relatively consistent vegetation structure and rodent prey populations. There is less seasonal variability with respect to prey abundance and accessibility compared with grain and vegetable crops, but they lack the management practices that enhance prey accessibility found in alfalfa.	Estep 1989, 2009; Swolgaard et al. 2008
Medium Value	Grasslands, managed wetlands, alkali seasonal wetlands, Vernal pool complex, tomatoes, beets, wheat, oats, miscellaneous grain and hay, nonirrigated miscellaneous grain and hay, mixed grain and hay, non-irrigated mixed grain and hay	Certain row crops, such as beets and tomatoes have a relatively high value because they support large rodent prey populations, are accessible season-long because of their relatively low vegetation profile, and they are harvested prior to migration, when an abundance of prey becomes available. Most grain crops (primarily wheat in Yolo County) provide value during and following harvesting, when prey become accessible. Grasslands are generally available season-long but provide lower prey abundance compared with higher value agricultural habitats, don't provide a peak period of high-value abundance and accessibility like some agricultural crops (e.g., tomatoes), and in some cases grass height reduces prey accessibility during a portion of the breeding season.	Estep 1989, 2009; Swolgaard et al. 2008
Low Value	Broccoli, sudan, dry beans, field crops, asparagus, green beans, carrots, melons/squash/cucumbers, onions/garlic, peppers, lettuce truck/nursery/berry crops, miscellaneous field, Safflower, corn, grain sorghum, sunflower	The truck and berry/field crop agriculture types are suitable for a portion of the breeding season depending on their structure and planting/harvesting regime. In general, they produce less prey abundance and less prey availability than the other agriculture types listed above.	Estep 1989, 2008; Swolgaard et al. 2008
No Value	Rice, orchards, vineyards (i.e., permanent crops)	Permanent crops have little use because they are very difficult for Swainson's Hawks to access prey in them.	Estep 1989, 2009; Swolgaard et al. 2008

^a Native vegetation is a land use designation within the California Department of Water Resources crop type dataset (2007). For the purposes of incorporating native vegetation classes into the correct species models, and, when applicable, assigning habitat foraging values, the management on these lands most resembles that of native pasture, an irrigated pasture type.

2.7.5 Suitable Habitat Definition

Swainson's hawk suitable foraging habitat consists of the land cover types indicated in Table 2-4, *Swainson's Hawk Agricultural Foraging Habitat Value Classes*.

Swainson's hawk suitable nesting habitat includes mature trees (20 feet or greater) in riparian systems as well as in single, isolated and roadside trees (CDFW 1994). Nest sites are generally adjacent to or within easy flying distance to alfalfa or hay fields or other habitats or agricultural crops which provide abundant prey source. The following tree types are known to be preferred by Swainson's hawk (CDFW 1994).

- Valley oaks (*Quercus lobata*)
- Fremont's cottonwood (*Populus fremontii*)
- Willows (*Salix* spp.)
- Sycamores (*Platanus* spp.)
- Walnuts (*Juglans* spp.)

2.8 Tricolored Blackbird

The tricolored blackbird (*Agelaius tricolor*) is a candidate for listing as threatened or endangered by the CDFW. Nests are protected in California under Fish and Game Code, Section 3503.

The tricolored blackbird has no federal regulatory status; however, the species is protected under the federal Migratory Bird Treaty Act and is designated as a Bird of Conservation Concern by the USFWS (U.S. Fish and Wildlife Service 2002). A petition submitted to USFWS in 2004 was denied in 2006, based on insufficient scientific evidence to warrant listing the species under the federal Endangered Species Act.

2.8.1 Geographic Distribution and Status

The tricolored blackbird is a colonial nesting passerine bird that is largely restricted to California. The species forms some of the largest colonies of any North American passerine bird, which may contain tens of thousands of breeding pairs (Beedy and Hamilton 1999). More than 95 percent of the California breeding population of tricolored blackbirds occurs in the Central Valley (Kyle and Kelsey 2011). Approximately 2 percent of adult tricolored blackbirds occur south of the Tehachapi Mountains (Meese pers. comm.), and breeding also occurs in the foothills of the Sierra Nevada south to Kern County, the coastal slopes from Sonoma County to the Mexican border, and sporadically in the Modoc Plateau. However, very few locations in the range of the tricolored blackbird provide the landscape characteristics required for successful breeding by colonies of tens of thousands of breeding pairs. Wintering tricolored blackbirds often form huge, mixed species flocks that forage across the landscape. The Sacramento–San Joaquin River Delta (Delta) and central coast are recognized as major wintering areas for tricolored blackbirds (Hamilton 2004; Beedy 2008). Tricolored blackbirds may make extensive movements during the breeding season and during winter (Beedy 2008). While the geographic

extent of the tricolored blackbird's range has been largely unchanged since the 1930s (Neff 1937; DeHaven et al. 1975; Beedy et al. 1991; Hamilton 1998), large gaps have since developed in the species' former range.

Historical population sizes of tricolored blackbirds are unknown, but by the mid-1930s, following the removal of most major wetland areas in the state, populations still likely exceeded 1.1 million adult birds (Hamilton 1998). In the first systematically conducted range-wide surveys, Neff (1937) documented 252 colonies of tricolored blackbirds in 26 California counties, including over 700,000 adults in eight Central Valley counties. Surveys conducted in the 1960s and 1970s indicated that range-wide populations declined by more than 50 percent during the 30- to 35-year period following Neff's surveys in the 1930s (Orians 1961; Payne 1969; DeHaven et al. 1975).

In the 1990s and 2000s, USFWS, CDFW, and California Audubon have cosponsored systematic tricolored blackbird surveys throughout California. Surveys during the 1990s (Hamilton et al. 1995; Beedy and Hamilton 1997; Hamilton 2000) confirmed the significant declining trend in California populations since the 1930s, with a particularly rapid decline noted after 1994. A population low of 94,269 adult birds was documented during the 1999 survey. Statewide surveys conducted during the 2000s indicate some recovery from the 1999 low; however, the population increases have primarily been limited to the San Joaquin Valley and the Tulare Basin (Kyle and Kelsey 2011). A total of 145,135 adults were counted during the most recent (Meese 2014) statewide survey. The 2014 count represents a population decline of about 44 percent from the previous statewide count of 258,000 birds in 2011. These recent results suggest the rate of population decline is increasing; between 2008 and 2011, the population declined 34 percent (from 395,000 birds in 2008 to 258,000 birds in 2011). The 2014 survey was the most comprehensive to date and represents the least productive breeding season ever recorded during the statewide surveys (Meese 2014).

Survey data also indicate that populations continue to decline in several areas of the state where the species was formerly common, particularly in the San Joaquin Valley counties of Kern and Merced where the breeding bird population has dropped 78 percent in the last six years. Breeding bird populations in counties along the Central Coast were less than 10 percent of those seen in 2008 (Meese 2014). The total proportion of breeding birds from the 10 largest colonies has decreased from 77.5 percent and 81 percent in years in 2008 and 2011, respectively, to 64 percent in 2014. This reflects a downward trend in the sizes of the largest colonies.

Based upon recent survey results, the tricolored blackbird appears to be an uncommon breeder in the Delta. Historical nesting activity was generally restricted to the northern and southern ends of the Delta. There are 25 sites where breeding occurred between 1972 and 2015 that are within 6 km of activities associated with the proposed action. Only 8 known breeding sites are within 6 km of activities that include a permanent habitat loss: construction of conveyance facilities near Clifton Court Forebay (5 sites) and Intake 1 (1 site), and construction of the Head of Old River Gate (2 sites). Most of these breeding records are single year occurrences. These nesting sites range from having as few as 3 to as many as 2,000 breeding adults per site (<http://tricolor.ice.ucdavis.edu/>). Fourteen detections of tricolored blackbird were recorded in 2009 in the legal Delta (California Department of Water Resources et al. 2012). These surveys were thought to be completed before the optimal nesting period for tricolored blackbirds in the

Delta, so additional surveys were conducted in potential breeding habitat during the optimal breeding period in 2010 and 2011. Five tricolored blackbirds were detected during those surveys, but all observations were foraging birds; no nesting was detected.

The Delta is also recognized as an important wintering area for tricolored blackbirds (Hamilton 2004; Beedy 2008). Large, mixed wintering flocks of tricolored blackbirds and other species numbering in the hundreds of thousands have been reported to roost on Sherman Island, though the actual roost location has not been precisely identified (Meese pers. comm.).

2.8.2 Life History and Habitat Requirements

Many tricolored blackbirds reside throughout the year in the Central Valley of California. Local populations can move considerable distances, and some are migratory and move from inland breeding locations to wintering habitat in the Delta and coastal areas. During the first breeding effort of the season, most birds nest in the San Joaquin Valley. Most later move northward throughout the Sacramento Valley, northeast California, and southern Oregon to nest again (Hamilton 1998). Thus, individual tricolored blackbirds may occupy and breed at several sites, or re-nest at the same site, during a given breeding season, depending on environmental conditions and their previous nesting success (Hamilton 1998; Beedy and Hamilton 1999; Meese 2006). In the fall, after the nesting season, large roosts form at managed wildlife refuges and other marshes near abundant food supplies such as cultivated rice (*Oryza sativa*) and water grass (*Echinochloa crus-galli*) (Beedy and Hamilton 1997). During winter, many tricolored blackbirds move from the Sacramento Valley to the Delta. Large flocks also winter in the central and southern San Joaquin Valley and at the dairy farms in coastal areas such as Point Reyes and Monterey County (Beedy and Hamilton 1997). Roosting by tricolored blackbirds during the fall and winter generally occurs in emergent wetlands and shrub stands (Kyle pers. comm.). Winter foraging habitat primarily consists of dairy farms and recently cultivated fields, supplemented by grassland (Beedy and Hamilton 1997). From early March to early April, tricolored blackbird flocks move from wintering areas to their breeding colonies in the San Joaquin Valley (Beedy and Hamilton 1997).

Tricolored blackbirds nest colonially, enabling them to synchronize their timing of nest building and egg laying (Beedy and Hamilton 1999). A few breeding colonies documented during fall months (September to November) had more protracted nest-building periods that led to asynchronous egg laying and fledging of young (Orians 1960). In the Central Valley, adults typically arrive on the breeding grounds from early March to early April (Hamilton 2004). Females usually breed in their first year, but most males apparently defer breeding until they are at least 2 years old (Payne 1969). Females typically lay three to four eggs and incubate them for 11 to 14 days (Emlen 1941; Orians 1961); then both parents feed young until they fledge 10 to 14 days after hatching (Meese pers. comm.).

Tricolored blackbird young transition from hatchlings to fledglings in approximately 4 to 6 days. Thus, a successful nesting effort requires approximately 32 days from nest initiation to independence of young (Meese pers. comm.). However, because birds may continue to be recruited into the nesting colony following the initial nest establishment, the colony itself remains active and in various stages of the breeding cycle for an extended period. This period

may sometimes last more than 90 days, but generally requires a minimum of 50 days for a complete breeding cycle of a less asynchronous colony (Beedy and Hamilton 1997).

Like other blackbirds, tricolored blackbirds often forage in flocks. They usually forage on the ground by walking, hopping, or taking short flights. Most forage within 3 miles of their colony sites (Orians 1961) but may forage up to 5 miles away (Meese pers. comm.).

Diets of adult tricolored blackbirds are dependent on geographic location and the availability of local insect foods. Among the most important prey for adults provisioning nestlings include coleopterans (beetles), orthopterans (grasshoppers, locusts), hemipterans (true bugs), other larval insects, and arachnids (spiders and allies) (Crane and DeHaven 1977; Beedy and Hamilton 1999). The primary diet of a colony depends on the local food availability (large hatches of dragonflies, caterpillars, and grasshoppers are especially favorable to this species [Meese 2013]). Individuals are also attracted to large outbreaks of grasshoppers (Orians 1961). Adult females require insects to form eggs, and nestlings are fed almost exclusively insects until they are at least 9 days old, after which a mixture of both plant and animal foods are provided (Crane and DeHaven 1977; Skorupa et al. 1980; Meese 2013). During the nonbreeding season, tricolored blackbirds often congregate at dairy feedlots to consume grains and other livestock feed, while others forage on insects, grains, and other plant material in grasslands and agricultural fields (Skorupa et al. 1980; Beedy and Hamilton 1999).

2.8.3 Species Threats

The most significant historical and ongoing threat to the tricolored blackbird is habitat loss and alteration. The initial conversion from native landscapes to agriculture removed vast wetland areas in the state and caused initial declines in populations. The more recent conversion of suitable agricultural lands to urban areas has permanently removed historical breeding and foraging habitat for this species.

In urbanizing areas, habitat fragmentation and proximity to human disturbances has also led to abandonment of large historical colonies (Beedy and Hamilton 1999).

In Sacramento County, a historical breeding center of this species, the conversion of grassland and pastures to vineyards expanded from 7,537 acres in 1996, to 13,171 acres in 1998 (DeHaven 2000), to 16,709 acres in 2003 (U.S. Department of Agriculture 2012). Conversions of pastures and grasslands to vineyards in Sacramento County and elsewhere in the species' range in the Central Valley have resulted in the recent loss of several large colonies and the elimination of extensive areas of suitable foraging habitat for this species (DeHaven 2000; Hamilton 2004; Yolo County 2008).

Entire colonies (up to tens of thousands of nests) in cereal crops and silage are often destroyed by harvesting and plowing of agricultural lands (Beedy and Hamilton 1999; Hamilton 2004; Cook and Toft 2005). While adult birds can fly away, eggs and fledglings cannot. The concentration of a high proportion of the known population in a few breeding colonies increases the risk of major reproductive failures, especially in vulnerable habitats such as active agricultural fields (Yolo County 2008).

Historical accounts documented the destruction of nesting colonies by a diversity of avian, mammalian, and reptilian predators (Beedy and Hamilton 1999). Recently, especially in perennial freshwater marshes of the Central Valley, entire colonies have been lost to black-crowned night-herons (*Nycticorax nycticorax*) and common ravens (*Corvus corax*). Since 2006, cattle egrets (*Bubulcus ibis*) have been observed preying on tricolored blackbird nests in Tulare County. Predation by cattle egrets has become so severe that complete reproductive failure has occurred in at least one large colony for 5 consecutive years (Meese 2011). Some large colonies (up to 100,000 adults) may lose greater than 50 percent of nests to coyotes (*Canis latrans*), especially in silage fields, but also in freshwater marshes when water is withdrawn (Hamilton et al. 1995). Thus, water management by humans often has the effect of increasing predator access to active colonies (Yolo County 2008).

Tricolored blackbird colonies are highly sensitive to human disturbances. Proximity to urbanizing areas can cause colonies to be permanently abandoned. Increases in noise, loose pets, and human presence can cause nest abandonment. Even entry into colonies for management or scientific purposes can cause disturbance and should be avoided (Beedy and Hamilton 1999).

Various poisons and contaminants have caused mass mortality of tricolored blackbirds. McCabe (1932) described the strychnine poisoning of 30,000 breeding adults as part of an agricultural experiment. Neff (1942) considered poisoning to regulate numbers of blackbirds preying upon crops (especially rice) to be a major source of mortality. This practice continued until the 1960s, and thousands of tricolored blackbirds and other blackbirds were exterminated to control damage to rice crops in the Central Valley. Beedy and Hayworth (1992) observed a complete nesting failure of a large colony (about 47,000 breeding adults) at Kesterson Reservoir in Merced County; selenium toxicosis was diagnosed as the primary cause of death. At a colony in Kern County, all eggs sprayed by mosquito abatement oil failed to hatch (Beedy and Hamilton 1999). Other factors that may affect the nesting success of colonies in agricultural areas include herbicide and pesticide applications (Beedy and Hamilton 1999; Yolo County 2008).

2.8.4 Species Habitat Suitability Model

The tricolored blackbird model uses vegetation types and associations from the following data sets: composite vegetation layer (Hickson and Keeler-Wolf 2007 [Delta]; Boul and Keeler-Wolf 2008 [Suisun Marsh]; TAIC 2008 [Yolo Basin]); aerial photography (U.S. Department of Agriculture 2005), and land use survey of the Delta area-version 3, land use survey of the Delta and Suisun Marsh area - version 3 (California Department of Water Resources 2007). Using these data sets, the model maps the distribution of suitable tricolored blackbird habitat in the Plan Area according to the species' two primary life requisites, breeding habitat and nonbreeding habitat. Vegetation types were assigned to a suitability category based on the species requirements, as described above, and the assumptions described below.

2.8.4.1 *Breeding Season Habitat Model*

2.8.4.1.1 *Nesting Habitat*

The nesting component of breeding season habitat in the Delta consists of the following types from the composite vegetation layer that occur within 6 kilometers of breeding colonies documented during the period of 2007-2015.

- Nontidal freshwater perennial emergent
 - American bulrush (*Schoenoplectus americanus*)
 - Hard-stem bulrush (*Schoenoplectus acutus*)
 - Mixed *Schoenoplectus*/floating aquatics (*Hydrocotyle–Eichhornia*) complex
 - Mixed *Schoenoplectus*/submerged aquatics (*Egeria–Cabomba–Myriophyllum* spp.) complex
 - Mixed *Schoenoplectus* mapping unit
 - Broad-leaf cattail (*Typha latifolia*)
 - Narrow-leaf cattail (*Typha angustifolia*)
 - *Schoenoplectus acutus–(Typha latifolia)–Phragmites australis*
 - *Schoenoplectus acutus–Typha angustifolia*
 - *Schoenoplectus acutus* pure
 - *Schoenoplectus acutus–Typha latifolia*
- Valley/foothill riparian
 - Blackberry (*Rubus discolor*)
 - Mexican elderberry (*Sambucus mexicana*)
 - *Salix lasiolepis–Mixed brambles (Rosa californica–Vitis californica–Rubus discolor)*
 - *Salix exigua–(Salix lasiolepis)–Rubus discolor–Rosa californica*
 - *Salix gooddingii/Rubus discolor*
 - Black willow (*Salix gooddingii*)
 - Narrow-leaf willow (*Salix exigua*)
 - *Rubus discolor*

2.8.4.1.2 *Breeding Season Foraging Habitat*

The foraging component of breeding season habitat includes both uncultivated (i.e., natural) and cultivated lands within 6 kilometers of nesting colonies documented during the period of 2007-

2015. The following noncultivated types from the composite vegetation layer provide foraging habitat for tricolored blackbirds in the Delta:

- Grassland
 - All types
- Alkali seasonal wetlands complex
 - All types
- Other natural seasonal wetlands
 - All types
- Vernal pool complex
 - Annual grasses generic
 - Annual grasses/weeds
 - California annual grasslands
 - *Distichlis* (generic)
 - *Distichlis spicata*
 - *Distichlis spicata*–annual grasses
 - *Distichlis*/annual grasses
 - *Distichlis/S. maritimus*
 - Ruderal herbaceous grasses and forbs
 - Italian ryegrass (*Lolium multiflorum*)
 - *Salicornia virginica*
 - *Salicornia*/annual grasses

The following crop types from the DWR 2007 land use survey types represent potentially suitable foraging habitats for tricolored blackbirds (Hickson and Keeler-Wolf 2007). All foraging habitat was considered to be winter foraging habitat. Foraging habitat within 6 km. of recent nest colonies (2007-2015) was considered to be breeding season foraging habitat.

- Grain and hay crops
 - Wheat
 - Miscellaneous grain and hay
 - Mixed grain and hay
- Field crops
 - Sunflower

- Pasture
 - Alfalfa and alfalfa mixtures
 - Mixed pasture
 - Native pasture
 - Induced high-water-table native pasture
 - Miscellaneous grasses
- Nonirrigated mixed pasture
- Nonirrigated native pasture
- Rice
- Idle
 - Land not cropped the current or previous crop season, but cropped within the past three years
 - New lands being prepped for crop production
- Semiagricultural and incidental to agricultural
 - Farmsteads
 - Livestock feedlots
 - Dairies

2.8.4.1.3 *Assumptions*

- **Assumption:** Tricolored blackbird breeding season nesting habitat is restricted to the vegetation types described above.

Rationale: Tricolored blackbirds typically nests in areas with open accessible water, a nesting substrate that is protected from ground predators (e.g., vegetation that is flooded, thorny, or spiny), and suitable foraging habitat (e.g., pastures, dry seasonal pools, agricultural fields such as alfalfa and sunflower) that provides abundant insect prey within 5 miles of the nesting colony (Hamilton et al. 1995; Beedy and Hamilton 1999). Hamilton (2004) reported that open water within 500 meters of nesting substrate is a requirement for colony settlement.

- **Assumption:** Tricolored blackbird breeding season foraging habitat is restricted to the vegetation types described above.

Rationale: Proximity of nesting colonies to high-value foraging habitat appears to be a key factor for high reproductive success by tricolored blackbirds. Most breeding tricolored blackbirds usually forage within 5 miles of their colony sites (Meese pers. comm.). Foraging is typically concentrated in areas that support abundant insect populations, a vital food resource required for egg laying and for successful rearing and fledging of young (Meese 2014). Breeding season foraging habitat encompasses grassland, natural seasonal wetlands

(e.g., vernal pool complex, alkali seasonal wetland complex), pasturelands (including alfalfa), and sunflower croplands, all habitats known to support abundant insect prey. Foraging value of cultivated lands is substantially reduced whenever widespread use of insecticide occurs.

2.8.4.2 Nonbreeding Season Habitat Model

Although tricolored blackbirds occasionally nest in the Delta, greatest use is by wintering birds that often form huge, mixed-species flocks that forage across the landscape. Nonbreeding habitat comprises two key components: the presence of suitable lands for foraging and suitable vegetative structure for roosting. Outside of the breeding season, tricolored blackbirds are primarily granivores that forage opportunistically within grasslands, pasturelands, and croplands (Meese 2014). Cultivated lands constitute major foraging sites for nonbreeding tricolored blackbirds, with substantial use associated with a variety of croplands, pasturelands, dairies, and livestock feed lots. Grains associated with livestock feedlots and dairies are particularly attractive to tricolored blackbirds. Roosting by nonbreeding tricolored blackbirds generally occurs in emergent wetlands and shrub stands (Kyle pers. comm.).

The nonbreeding season habitat model for tricolored blackbirds does not overlap with the breeding season habitat model. Although breeding and nonbreeding season habitats overlap for this species, where they overlap in the model they are considered breeding season habitat.

2.8.4.2.1 Nonbreeding Season Foraging Habitat

The following noncultivated types from the composite vegetation layer provide nonbreeding season foraging habitat for tricolored blackbirds in the Delta:

- Grassland
 1. All types
- Alkali seasonal wetland complex
 1. All types
- Vernal pool complex
 1. Annual grasses generic
 2. Annual grasses/weeds
 3. California annual grasslands
 4. *Distichlis* (generic)
 5. *Distichlis spicata*
 6. *Distichlis spicata*–annual grasses
 7. *Distichlis*/annual grasses
 8. *Distichlis/S. maritimus*

9. Ruderal herbaceous grasses and forbs
10. Italian ryegrass (*Lolium multiflorum*)
11. *Salicornia virginica*
12. *Salicornia*/annual grasses

The following crop types from the DWR 2007 land use survey types represent potentially suitable foraging habitats for tricolored blackbirds during the nonbreeding season (Meese pers. comm.; Kyle pers. comm.).

Pasture types are mostly perennial; alfalfa is semi-perennial (3 to 7 years); and all other crop types are annually or seasonally rotated irrigated crops.

- Grain and hay crops
 1. Wheat
 2. Oats
 3. Miscellaneous grain and hay
 4. Mixed grain and hay
- Field crops
 1. Corn
 2. Millet
 3. Sunflowers
- Pasture
 1. Alfalfa and alfalfa mixtures
 2. Mixed pasture
 3. Native pasture
 4. Induced high-water-table native pasture
 5. Miscellaneous grasses
- Nonirrigated mixed pasture
- Nonirrigated native pasture
- Rice
- Idle

1. Land not cropped the current or previous crop season, but cropped within the past three years
 2. New lands being prepped for crop production
- Semi-agricultural and incidental to agricultural
 1. Farmsteads
 2. Livestock feed lots
 3. Dairies

Additional areas mapped include the following natural community and land cover types as nonbreeding season foraging habitat:

- Agricultural
- Cultivated annual graminoid
- Field crops
- Grain/hay crops
- Pasture
- Rice
- Alkali seasonal wetland complex
- Grassland
- Upland annual grasslands and forbs formation
- *Crypsis* spp.–wetland grasses–wetland forbs NFD super alliance
- Vernal pools

2.8.4.2.2 *Roosting Habitat*

The roosting component of nonbreeding habitat in the Delta consists of the following types from the composite vegetation layer:

- Managed wetland
 1. *Schoenoplectus* spp. in managed wetlands
- Tidal freshwater emergent wetland and tidal brackish emergent wetland
 1. Mixed *Schoenoplectus* mapping unit

2. Mixed *Schoenoplectus*/floating aquatics complex
 3. Mixed *Schoenoplectus*/submerged aquatics complex
 4. Hardstem bulrush (*Schoenoplectus acutus*)
 5. *Schoenoplectus acutus* pure
 6. *Schoenoplectus acutus*–*Typha angustifolia*
 7. *Schoenoplectus acutus*–*Typha latifolia*
 8. *Schoenoplectus acutus*–(*Typha latifolia*)–*Phragmites australis*
 9. California bulrush (*Schoenoplectus californicus*)
 10. *Schoenoplectus californicus*–*Eichhornia crassipes*
 11. *Schoenoplectus californicus*–*Schoenoplectus acutus*
 12. American bulrush (*Schoenoplectus americanus*)
 - 13.** Narrow-leaf cattail (*Typha angustifolia*)
 14. *Typha angustifolia*–*Distichlis spicata*
- Nontidal freshwater perennial emergent
 1. American bulrush (*Schoenoplectus americanus*)
 2. Hardstem bulrush (*Schoenoplectus acutus*)
 3. Mixed *Schoenoplectus*/floating aquatics (*Hydrocotyle*–*Eichhornia*) complex
 4. Mixed *Schoenoplectus*/submerged aquatics (*Egeria*–*Cabomba*–*Myriophyllum* spp.) complex
 5. Mixed *Schoenoplectus* mapping unit
 6. Broad-leaf cattail (*Typha latifolia*)
 7. Narrow-leaf cattail (*Typha angustifolia*)
 8. *Schoenoplectus acutus*–(*Typha latifolia*)–*Phragmites australis*
 9. *Schoenoplectus acutus*–*Typha angustifolia*
 10. *Schoenoplectus acutus* pure
 11. *Schoenoplectus acutus*–*Typha latifolia*
 - Valley/foothill riparian
 1. Blackberry (*Rubus discolor*)
 2. Mexican elderberry (*Sambucus mexicana*)

3. *Salix lasiolepis*–Mixed brambles (*Rosa californica*–*Vitis californica*–*Rubus discolor*)
4. *Salix exigua*–(*Salix lasiolepis*)–*Rubus discolor*–*Rosa californica*
5. *Salix gooddingii*/*Rubus discolor*
6. Black willow (*Salix gooddingii*)
7. Narrow-leaf willow (*Salix exigua*)
8. *Rubus discolor*

Additional areas mapped include the following natural community and land cover types as nonbreeding season roosting habitat:

- Tidal brackish emergent wetland
- Tidal freshwater emergent wetland
- Bulrush–cattail freshwater marsh NFD super alliance in managed wetland

2.8.4.2.3 *Assumptions*

During the nonbreeding season, tricolored blackbirds forage widely throughout the Delta without regard to proximity of colony sites or breeding habitats. Suitable cultivated lands generally include pasturelands, grasslands, and a variety of croplands. Tricolored blackbirds also forage in livestock feedlots and dairies. Because the grain and hay, and field crop types listed above are seasonally rotated, the availability and relative value of individual fields as foraging habitat may change each year. As a result, this model may overestimate or underestimate the extent of available cultivated lands that provide nonbreeding season foraging habitat in any given year.

2.8.5 **Suitable Habitat Definition**

Although habitat for tricolored blackbird was modeled for the entire Delta, minimization and mitigation will be based on suitable habitat identified by a Qualified Biologist within the Project Area. Suitable habitat for tricolored blackbirds during the breeding season consists of the land cover types listed above in Section 2.8.4.1.1, *Breeding Season Habitat Model*, within 6 kilometers of nesting colonies observed since 2007. Suitable habitat for tricolored blackbirds during the nonbreeding season consists of the land cover types listed above in Section 2.8.4.2, *Nonbreeding Season Habitat Model*.

2.9 **Mason’s Lilaeopsis**

Mason’s lilaeopsis (*Lilaeopsis masonii*) is state-listed as rare under the California Native Plant Protection Act (November 1979). It is not listed under the CESA or ESA. Its Heritage Ranking in the California Natural Diversity Database (CNDDDB) is G2/S2, which means that globally (G) and within the state (S), the species is considered imperiled (California Department of Fish and Game 2012).

The California Rare Plant Rank of 1B.1 for Mason's lilaepsis indicates that it is rare, threatened, or endangered in California and elsewhere, and is seriously endangered in California (California Native Plant Society 2012; California Department of Fish and Game 2012). Plants with a rank of 1B meet the definitions of rare, threatened, and endangered as defined in Section 1901, Chapter 10 (Native Plant Protection Act) or Sections 2062 and 2067 (CESA) of the California Fish and Game Code (California Department of Fish and Game 2012).

2.9.1 Geographic Distribution and Status

Mason's lilaepsis is endemic to California and is known from 197 occurrences, all but one of which are presumed extant (Delta Habitat Conservation and Conveyance Program 2011; California Department of Fish and Wildlife 2013). The range of Mason's lilaepsis extends from Napa and Solano Counties in the north, to Contra Costa and Alameda Counties in the south, to Marin County in the west, and to Sacramento and San Joaquin Counties in the east (California Department of Fish and Wildlife 2013).

Mason's lilaepsis is found throughout the Delta along rivers and sloughs; the majority of known occurrences, 160, are within the Delta (California Department of Water Resources 2013) (Delta Habitat Conservation and Conveyance Program 2011; California Department of Fish and Wildlife 2013). Most occurrences are from the central and west Delta, and the species is locally common in Suisun Bay (California Native Plant Society 2012). In the south Delta, occurrences are predominately along Victoria Canal, Old River, Middle River, and surrounding Clifton Court Forebay. In the north Delta, it occurs in the Cache Slough complex, in the Sacramento Deep Water Channel, and near Delta Meadows.

2.9.2 Life History and Habitat Requirements

Mason's lilaepsis primarily reproduces vegetatively by creeping rhizomes or by being dislodged and floating to new sites. Because it is a rhizomatous plant, the number of individuals in a population is difficult to determine. Thus, population size is often expressed as "several colonies" or "in square feet." Reported colony sizes range from 16 to 3,000 square feet (5 to 700 square meters) (California Department of Fish and Wildlife 2013).

Mason's lilaepsis is found in otherwise unvegetated areas in brackish or fresh water habitats that are inundated by waves or tides, such as estuarine wetlands and immediately below the banks of tidal sloughs, rivers, and creeks (Golden and Fiedler 1991; Fiedler and Zebell 1993; California Department of Fish and Game 2000; California Native Plant Society 2012). It is a colonizing species that establishes on newly deposited or exposed sediments (California Native Plant Society 2012). Although some reports suggest that Mason's lilaepsis is not substrate-specific, because it is found in organic mucks, silty clays, and even pure sand throughout its range (Golden and Fiedler 1991), other reports find that it has a preference for low tidal flats on clay or silty soils (Witham and Kareofelas 1994). It is occasionally found distributed in soil pockets along riprap-lined levees (Golden and Fiedler 1991) and along the edges of tule marshes (Witham and Kareofelas 1994; May & Associates 2005). It has been found in areas with high soil salinity, but those sites are not optimum habitat (Fiedler and Zebell 1993). Within the Delta, Mason's lilaepsis is not found upstream from where tides affect water levels (Suisun Ecological Workgroup 1997).

Plant species commonly associated with Mason's lilaepsis in the Delta include California bulrush (*Schoenoplectus californicus*), whorled marsh pennywort (*Hydrocotyle verticillata*), and low bulrush (*Isolepis cernua*) (Golden and Fiedler 1991). In the sloughs west of Liberty Island at the south end of the Sacramento River Deep Water Ship Channel, it grows in a narrow band between the mudflats and mesic terrestrial vegetation (Meisler 2002). In Suisun Marsh and other places, Mason's lilaepsis is predominantly associated with California tule, low bulrush, and three-ribbed arrowgrass (*Triglochin striata*) (Suisun Ecological Workgroup 1997; May & Associates 2005; California Department of Fish and Game 2012). During the Delta Habitat Conservation and Conveyance Program 2009 to 2011 surveys, some of the species associated with Mason's lilaepsis included hardstem bulrush (*Schoenoplectus acutus*), water iris (*Iris pseudacorus*), marshpepper (*Persicaria hydropiper*), giant reed (*Arundo donax*), whorled marshpennywort, nutsedge (*Cyperus* sp.), iris-leaved rush (*Juncus xiphioides*), common buttonbush (*Cephalanthus occidentalis*), red willow (*Salix laevigata*), smooth beggartick (*Bidens laevis*), alkali weed (*Cressa truxillensis*), water pygmyweed (*Crassula aquatica*), Himalayan blackberry (*Rubus armeniacus*), common reed (*Phragmites australis*), sneezeweed (*Helenium puberulum*), Pacific aster (*Symphyotrichum chilense*), Santa Barbara sedge (*Carex barbarae*), common rush (*Juncus effusus*), seep monkeyflower (*Mimulus guttatus*), dallis grass (*Paspalum dilatatum*), and hedge false bindweed (*Calystegia sepium*) (Delta Habitat Conservation and Conveyance Program 2011).

2.9.3 Species Threats

The primary threat to Mason's lilaepsis is the loss of marsh and shoreline habitat. In addition to human activity associated with fishing and hunting access posing a threat from trampling (Witham and Kareofelas 1994), the major threats to this species are considered to be habitat loss, invasions of nonnative species, and exposure to toxics. Some of the processes and activities that threaten this habitat include erosion, flood-control improvements (e.g., channel stabilization, levee maintenance and construction, dredging), dumping spoils, agriculture, recreation, and water quality changes (California Native Plant Society 2012; California Department of Fish and Wildlife 2013). A long-term threat is the stabilization of banks and mudflats due to highly regulated water flow regimes, which can cause floodplain habitat to be less dynamic (Fiedler and Zebell 1993). Successional changes in marsh vegetation, brought on by invasions of nonnative species such as water hyacinth (*Eichhornia crassipes*) to denser vegetation types or to types that can grow in the intertidal area pose an additional threat (California Native Plant Society 2012; Zebell and Fiedler 1996; California Department of Fish and Wildlife 2013; California Native Plant Society 2012). Additionally, diked salt marshes generally lack rare tidal marsh species. Petroleum product spills could have a significant impact on tidal flat biota, and nonbiodegradable litter such as plastics could collect near the tidal drift line, inhibiting plant establishment and growth (Witham and Kareofelas 1994).

2.9.4 Species Habitat Suitability Model

A habitat suitability model was not used to analyze effects on Mason's lilaepsis. As described in Appendix 4.B *Terrestrial Impact Analysis Methods*, effects on this species were analyzed based on site specific habitat assessments and identification of suitable habitat as defined in Section 2.9.5, *Suitable Habitat Definition*.

2.9.5 Suitable Habitat Definition

Mason's lilaeopsis grows only on substrates that are frequently tidally inundated. Most known occurrences are within two meters of sea level, with the greatest known elevation at ten meters above sea level. Mason's lilaeopsis is found on many different substrates: bare soil of mudflats and river banks, old wooden pilings, riprapped banks, and other exposed substrates. Fiedler et al. (2011) state that the broad range of soil textures on which the species has been observed indicates that substrate texture is probably not a limiting factor.

2.10 References Cited

- Anderson, D. A., J. Dinsdale, and R. Schlorff. 2007. *California Swainson's Hawk Inventory: 2005–2006; Final Report* Sacramento, CA: California Department of Fish and Game, Resource Assessment Program.
- Anderson, J. D. 1968. Comparison of the Food Habits of *Ambystoma macrodactylum sigillatum*, *Ambystoma macrodactylum croceum*, and *Ambystoma tigrinum californiense*. *Herpetologica* 24:273–284.
- Austin, C. C. and H. B. Shaffer. 1992. Short, Medium, and Long-Term Repeatability of Locomotor Performance in the Tiger Salamander, *Ambystoma californiense*. *Functional Ecology* 6:145–153.
- Babcock, K. W. 1995. Home Range and Habitat Use of Breeding Swainson's Hawks in the Sacramento Valley of California. *Journal of Raptor Research* 29:193–197.
- Baerwald, M. R., B. M. Schreier, G. Schumer, and B. May. 2012. Detection of Threatened Delta Smelt in the Gut Contents of the Invasive Mississippi Silverside in the San Francisco Estuary Using TaqMan Assays. *Transactions of the American Fisheries Society* 141(6):1600-1607.
- Barry, S. J. and H. B. Shaffer. 1994. The Status of the California Tiger Salamander (*Ambystoma californiense*) at Lagunita: a 50-Year Update. *Journal of Herpetology* 28:159–164.
- Baskerville-Bridges, B., J. C. Lindberg, and S. I. Doroshov. 2004. The Effect of Light Intensity, Alga Concentration, and Prey Density on the Feeding Behavior of Delta Smelt Larvae. In: F. Feyrer, L. Brown, R. Brown, and J. Orsi (eds.). *Early Life History of Fishes in the San Francisco Estuary and Watershed*. American Fisheries Society. Symposium 39, Bethesda, MD. Pages 219-228.
- Baxter, R. D. 1999. Osmeridae. Pages 179-216 in J. Orsi, editor. Report on the 1980-1995 fish, shrimp and crab sampling in the San Francisco Estuary. Interagency Ecological Program for the Sacramento-San Joaquin Estuary Technical Report 63.
- Baxter, R. D., R. Breuer, L. Brown, L. Conrad, F. Feyrer, S. Fong, K. Gehrts, L. Grimaldo, B. Herbold, P. Hrodey, A. Mueller-Solgar, T. Sommer, and K. Souza. 2010. *Interagency Ecological Program 2010 Pelagic Organism Decline Work Plan and Synthesis of Results*. Available: <www.water.ca.gov/iep/docs/FinalPOD2010Workplan12610.pdf>.

- Bechard, M. J. 1982. Effect of Vegetative Cover on Foraging Site Selection by Swainson's Hawk. *Condor* 84:153–159.
- Beedy, E. C., and W. J. Hamilton III. 1997. *Tricolored Blackbird Status Update and Management Guidelines*. (Jones & Stokes Associates, Inc. 97-099.) Sacramento, CA: Prepared for U.S. Fish and Wildlife Service, Portland, OR and California Department of Fish and Game, Sacramento, CA.
- Beedy, E. C., S. D. Sanders, and D. Bloom. 1991. *Breeding Status, Distribution, and Habitat Associations of the Tricolored Blackbird (Agelaius tricolor) 1850–1989*. Jones & Stokes Associates, Inc., 88-197. Sacramento, CA: Prepared for the U.S. Fish and Wildlife Service.
- Beedy, E.C. 2008. Tricolored Blackbird. In: Shuford, W. D., and T. Gardali. 2008. *California Bird*
- Bennett, W. A. 1998. Silversides, Smelt, and the Slough of Dreams: Who Will Come if We Restore It? Proceedings of San Francisco Estuary Institute workshop. Biological Invasions in Aquatic Ecosystems: Impacts on Restoration and Potential for Control. April 25.
- Bennett, W. A. 2005. Critical Assessment of the Delta Smelt Population in the San Francisco Estuary, California. *San Francisco Estuary and Watershed Science* 3(2): Article 1. Available: <<http://escholarship.org/uc/item/0725n5vk>>. Accessed: December 14, 2011.
- Bennett, W. A., W. J. Kimmerer, and J. R. Burau. 2002. Plasticity in Vertical Migration by Native and Exotic Estuarine Fishes in a Dynamic Low-Salinity Zone. *Limnology and Oceanography* 47(5):1496–1507.
- Bobzien, S. and J. E. DiDonato. 2007. *The Status of the California Tiger Salamander (Ambystoma californiense), California Red-Legged Frog (Rana draytonii), and Foothill Yellow-Legged Frog (Rana boylei), and Other Herpetofauna in the East Bay Regional Park District, California*. East Bay Regional Park District.
- Boul, P. and T. Keeler-Wolf. 2008. *2006 Vegetation Map Update for Suisun Marsh, Solano County, California*. Sacramento, CA: California Department of Water Resources.
- Boul, P. and T. Keeler-Wolf. 2008. *2006 Vegetation Map Update for Suisun Marsh, Solano County, California*. Sacramento, CA: California Department of Water Resources.
- Bradbury, Mike. pers. Comm. Statement made at a TTT meeting on July 2, 2015. Mr. Bradbury is the California WaterFix permitting lead for 404/2081/Section 7 compliance, and a Program Manager II.
- Brode, J. 1988. Natural History of the Giant Garter Snake (*Thamnophis couchii gigas*). In: H.F. DeListe, P. R. Brown, B. Kaufman, and B. M. McGurty (eds). *Proceedings of the Conference on California Herpetology, Southwestern Herpetologist's Society, Special Publication No. 4:25–28*.

- Brooks, M., E. Fleishman, L. Brown, P. Lehman, I. Werner, N. Scholz, C. Mitchelmore, J. Lovvorn, M. Johnson, D. Schlenk, S. van Drunick, J. Drever, D. Stoms, A. Parker, and R. Dugdale. 2012. Life Histories, Salinity Zones, and Sublethal Contributions of Contaminants to Pelagic Fish Declines Illustrated with a Case Study of San Francisco Estuary, California, USA. *Estuaries and Coasts* 35(2):603-621.
- Brown, L. R., and D. Michniuk. 2007. Littoral Fish Assemblages of the Alien-Dominated Sacramento-San Joaquin Delta, California, 1980-1983 and 2001-2003. *Estuaries and Coasts* 30(1):186-200.
- Brown, L. R., L. M. Komoroske, R. W. Wagner, T. Morgan-King, J. T. May, R. E. Connon, and N. A. Fangue. 2016. Coupled Downscaled Climate Models and Ecophysiological Metrics Forecast Habitat Compression for an Endangered Estuarine Fish. *PLoS One* 11(1):e0146724.
- Brown, L. R., W. A. Bennett, R. W. Wagner, T. Morgan-King, N. Knowles, F. Feyrer, D. H. Schoellhamer, M. T. Stacey, and M. Dettinger. 2013. Implications for Future Survival of Delta Smelt from Four Climate Change Scenarios for the Sacramento-San Joaquin Delta, California. *Estuaries and Coasts* 36(4):754-774.
- California Department of Conservation. 2004. Farmland Mapping and Monitoring Program. Available: <<http://www.conservation.ca.gov/dlrp/fmmp/Pages/Index.aspx>>. Accessed: July 15, 2013.
- California Department of Fish and Game. 1994. Staff report regarding mitigation for impacts to Swainson's hawks (*Buteo swainsoni*) in the Central Valley of California. Sacramento, CA.
- California Department of Fish and Game. 2000. *The Status of Rare, Threatened, and Endangered Animals and Plants of California*, Mason's Lilaepsis. Available: <http://www.dfg.ca.gov/hcpb/cgi-bin/read_one.asp?specy=plants&idNum=142>. Accessed: August 8, 2007.
- California Department of Fish and Game. 2009. *Report to the Fish and Game Commission: A Status Review of the Longfin Smelt (Spirinchus thaleichthys) in California*. January 23. Available: <<http://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=10263>>.
- California Department of Fish and Game. 2010. *Report to the Fish and Game Commission: A status review of the California Tiger Salamander (Ambystoma californiense)*. Wildlife Branch Nongame Wildlife Program Report 2010-4.
- California Department of Fish and Game. 2012. *Lilaepsis masonii* Mason's Lilaepsis. In: *Special Vascular Plants, Bryophytes, and Lichens List*. California Natural Diversity Database (CNDDDB). Quarterly publication. May. Sacramento, CA. Page 45. Available: <<http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/SPPlants.pdf>>. Accessed: May 25, 2012.
- California Department of Fish and Wildlife. 2013. California Natural Diversity Database, RareFind 3, Version 3.1.0. June.

- California Department of Fish and Wildlife. 2013. California Natural Diversity Database, RareFind 3, Version 3.1.0. June.
- California Department of Fish and Wildlife. 2013. California Natural Diversity Database, RareFind 3, Version 3.1.0. June.
- California Department of Fish and Wildlife. 2014. *GrandTab 2014.04.22. California Central Valley Chinook Population Report*. Compiled April 22, 2014. Fisheries Branch.
- California Department of Fish and Wildlife. 2015. California Natural Diversity Database.
- California Department of Fish and Wildlife. 2015. California Natural Diversity Database.
- California Department of Fish and Wildlife. 2015. California Natural Diversity Database.
- California Department of Fish and Wildlife. 2015. California Natural Diversity Database.
- California Department of Fish and Wildlife. 2016a. Summer Towntnet Survey. Available: <https://www.wildlife.ca.gov/Conservation/Delta/Towntnet-Survey> Accessed: September 8, 2016.
- California Department of Fish and Wildlife. 2016b. *GrandTab 2016.04.11. California Central Valley Chinook Population Report*. Compiled April 11, 2016. Fisheries Branch.
- California Department of Water Resources. 2006. *Draft Supplemental Report to 2004 Draft State Feasibility Study, In-Delta Storage Project*. California Department of Water Resources, Division of Planning and Local Assistance.
- California Department of Water Resources. 2007. *Land Use Survey of Delta and Suisun Marsh Area*. Version 3 GIS dataset. Sacramento, CA: California Department of Water Resources.
- California Department of Water Resources. 2007. *Land Use Survey of Delta and Suisun Marsh Area*. Version 3 GIS dataset. Sacramento, CA.
- California Department of Water Resources. 2007. *Land Use Survey of Delta and Suisun Marsh Area*. Version 3 GIS dataset. Sacramento, CA.
- California Department of Water Resources. 2013. *Public Draft of the Bay Delta Conservation Plan*. Prepared by ICF International. Sacramento, CA.
- California Native Plant Society. 2012. *Lilaeopsis masonii* Mason's Lilaeopsis Inventory of Rare and Endangered Plants (online edition, v8-01a). Sacramento, CA. Available: <http://www.rareplants.cnps.org/detail/974.html> Accessed: February 3, 2012.
- California Hatchery Scientific Review Group (California HSRG). 2012. *California Hatchery Review Report*. Prepared for the U.S. Fish and Wildlife Service and Pacific States Marine Fisheries Commission. June 2012. 100 pgs.

- City of Elk Grove. 2007. *The Distribution, Abundance, and Habitat Associations of Swainson's Hawk (Buteo swainsoni) in South Sacramento County*. Prepared by Estep Environmental Consulting, Sacramento, CA.
- Cloern, J. E., and A. D. Jassby. 2012. Drivers of change in estuarine-coastal ecosystems: Discoveries from four decades of study in San Francisco Bay. *Reviews of Geophysics* 50(4).
- Conrad, J. L., A. J. Bibian, K. L. Weinersmith, D. De Carion, M. J. Young, P. Crain, E. L. Hestir, M. J. Santos, and A. Sih. 2016. Novel Species Interactions in a Highly Modified Estuary: Association of Largemouth Bass with Brazilian Waterweed *Egeria densa*. *Transactions of the American Fisheries Society* 145(2):249-263.
- Cook, D. G., Trenham, P. C., and Northern, P. T. 2006. Demography and Breeding Phenology of the California Tiger Salamander (*Ambystoma Californiense*) in an Urban Landscape. *Northwestern Naturalist* 87: 215-224. Davidson, C., H. B. Shaffer, and M. R. Jennings. 2002. Spatial Tests of the Pesticide Drift, Habitat Destruction, UV-B and Climate Change Hypotheses for California Amphibian Declines. *Conservation Biology* 16:1588–1601.
- Cook, L. F. and C. A. Toft. 2005. Dynamics of Extinction: Population Decline in the Colonially Nesting Tricolored Blackbird (*Agelaius tricolor*). *Bird Conservation International* 15: 73–88.
- Crase, F. T. and R. W. DeHaven. 1977. Food of Nestling Tricolored Blackbirds. *Condor* 79: 265–269.
- Davidson, C., H. B. Shaffer, and M. R. Jennings. 2002. Spatial Tests of the Pesticide Drift, Habitat Destruction, UV-B and Climate Change Hypotheses for California Amphibian Declines. *Conservation Biology* 16:1588–1601.
- Dege, M. and L. R. Brown. 2004. Effect of Outflow on Spring and Summertime Distribution and Abundance of Larval and Juvenile Fishes in the Upper San Francisco Estuary. In: F. Feyrer, L. R. Brown, R. L. Brown, and J. J. Orsi (eds.). *Early Life History of Fishes in the San Francisco Estuary and Watershed. American Fisheries Society Symposium* 39:49–66.
- DeHaven, R. W. 2000. *Breeding Tricolored Blackbirds in the Central Valley, California: A Quarter Century Perspective*. U.S. Fish and Wildlife Service white paper.
- DeHaven, R. W., F. T. Crase, and P. D. Woronecki. 1975. Breeding Status of the Tricolored Blackbird, 1969–1972. *California Fish and Game* 61: 166–180.
- Delta Habitat Conservation and Conveyance Program. 2011. *2009 to 2011 Bay Delta Conservation Plan EIR/EIS Environmental Data Report*. Review Draft 1. December.
- Dickert, C. 2003. *Progress Report for the San Joaquin Valley Giant Garter Snake Conservation Project*. Los Banos Wildlife Complex, California Department of Fish and Game, CA.

- Dugdale, R. C., F. P. Wilkerson, V. E. Hogue, and A. Marchi. 2007. The role of ammonium and nitrate in spring bloom development in San Francisco Bay. *Estuarine, Coastal and Shelf Science* 73(1):17-29.
- Dugdale, R., F. Wilkerson, A. E. Parker, A. Marchi, and K. Taberski. 2012. River flow and ammonium discharge determine spring phytoplankton blooms in an urbanized estuary. *Estuarine, Coastal and Shelf Science* 115:187-199.
- East Contra Costa County Habitat Conservancy. 2006. *East Contra Costa County Habitat Conservation Plan and Natural Community Conservation Plan*. Available: <http://www.co.contra-costa.ca.us/depart/cd/water/HCP/archive/final-hcp-rev/pdfs/hcptitleverso_9-27-06.pdf>. Accessed: December 22, 2011.
- East Contra Costa County Habitat Conservancy. 2006. *East Contra Costa County Habitat Conservation Plan and Natural Community Conservation Plan*. Available: <http://www.co.contra-costa.ca.us/depart/cd/water/HCP/archive/final-hcp-rev/pdfs/hcptitleverso_9-27-06.pdf>. Accessed: December 22, 2011.
- Emlen, J. T. 1941. An Experimental Analysis of the Breeding Cycle of the Tricolored Red-Wing. *Condor* 43:209–219.
- England, A. S., J. A. Estep, and W. R. Holt. 1995. Nest-Site Selection and Reproductive Performance of Urban-Nesting Swainson's Hawks in the Central Valley of California. *Journal of Raptor Research* 29:179–186.
- England, A. S., M. J. Bechard, and C. S. Houston. 1997. Swainson's Hawk (*Buteo swainsoni*). In: A. Poole and F. Gill (eds.). *Birds of North America* 265. Philadelphia, PA: The Academy of Natural Sciences; Washington, DC: The American Ornithologists' Union,
- Estep, J. A. 1984. *Diurnal Raptor Eyrie Monitoring Program*. Nongame Wildlife Investigations. Project Report W-65-R-1, Job No. II-2.0. Sacramento, CA: California Department of Fish and Game.
- Estep, J. A. 1989. *Biology, Movements, and Habitat Relationships of the Swainson's Hawk in the Central Valley of California, 1986–87*. Unnumbered report. California Department of Fish and Game.
- Estep, J. A. 2007. *The Distribution, Abundance, and Habitat Associations of the Swainson's Hawk (Buteo swainsoni) in South Sacramento County*. Prepared by Estep Environmental Consulting for the City of Elk Grove.
- Estep, J. A. 2008. *The Distribution, Abundance, and Habitat Associations of the Swainson's Hawk (Buteo swainsoni) in Yolo County*. Prepared by Estep Environmental Consulting for Technology Associates International Corporation and the Yolo County Habitat/Natural Community Conservation Plan JPA.

- Estep, J. A. 2009. *The Influence of Vegetation Structure on Swainson's Hawk Foraging Habitat Suitability in Yolo County*. Prepared for Technology Associates International Corporation and Yolo Natural Heritage Program. Woodland, CA.
- Estep, J. A. and S. Teresa. 1992. Regional Conservation Planning for the Swainson's Hawk (*Buteo swainsoni*) in the Central Valley of California. In: D. R. McCullough and R. H. Barrett (eds.). *Wildlife 2001: Populations*. New York, NY: Elsevier. Pages 775–789.
- Ferrari, M. C. O., L. Ranåker, K. L. Weinersmith, M. J. Young, A. Sih, and J. L. Conrad. 2014. Effects of turbidity and an invasive waterweed on predation by introduced largemouth bass. *Environmental Biology of Fishes* 97(1):79-90.
- Feyrer, F., K. Newman, M. Nobriga, and T. Sommer. 2011. Modeling the Effects of Future Outflow on the Abiotic Habitat of an Imperiled Estuarine Fish. *Estuaries and Coasts* 34:120-128.
- Feyrer, F., M. L. Nobriga, and T. R. Sommer. 2007. Multidecadal Trends for Three Declining Fish Species: Habitat Patterns and Mechanisms in the San Francisco Estuary, California, USA. *Canadian Journal of Fisheries and Aquatic Science* 64:723–734.
- Fiedler, P. and R. Zebell. 1993. *Restoration and Recovery of Mason's lilaepsis: Phase I*. Final report. Submitted to the California Department of Fish and Game.
- Fiedler, P.L., Crumb, E.K., and Knox, A.K. 2011. *Reconsideration of the taxonomic status of Mason's lilaepsis – a state-protected rare species in California*. Madrono, 58: 131-144. doi:10.3120/0024-9637-58.3.131.
- Fisch, K. M., J. A. Ivy, R. S. Burton, and B. May. 2013. Evaluating the Performance of Captive Breeding techniques for Conservation Hatcheries: A Case Study of the Delta Smelt Captive Breeding Program. *Journal of Heredity* 104:92–104.
- Fisher, F. W. 1994. Past and Present Status of Central Valley Chinook Salmon. *Conservation Biology* 8:870–873.
- Fisher, R. N. and H. B. Shaffer. 1996. The decline of amphibians in California's Great Central Valley. *Conservation Biology* 10:1387–1397.
- Fitzpatrick, B. M. and H. B. Shaffer. 2004. Environment-Dependent Admixture Dynamics in a Tiger Salamander Hybrid Zone. *Evolution* 58:1282–1293.
- Fitzpatrick, B. M., J. R. Johnson, D. K. Kump, H. B. Shaffer, J. J. Smith and S. R. Voss. 2009. Rapid Fixation of Non-Native Alleles Revealed by Genome-Wide SNP Analysis of Hybrid Tiger Salamanders. *BMC Evolutionary Biology* 9:176.
- Fitzpatrick, B., Johnson, J., Kump, D., Smith, J., Voss, S., & Shaffer, H. 2010. Rapid spread of invasive genes into a threatened native species Proceedings of the National Academy of Sciences, 107 (8), 3606-3610 DOI: 10.1073/pnas.0911802107

- Glibert, P. M., D. Fullerton, J. M. Burkholder, J. C. Cornwell, and T. M. Kana. 2011. Ecological Stoichiometry, Biogeochemical Cycling, Invasive Species, and Aquatic Food Webs: San Francisco Estuary and Comparative Systems. *Reviews in Fisheries Science* 19(4):358-417.
- Golden, M., and P. Fiedler. 1991. *Characterization of the Habitat for Lilaeopsis Masonii (Umbelliferae): A California State Listed Rare Plant Species*. Final report to the California Department of Fish and Game, Endangered Plant Program.
- Goldstein, M. I., B. Woodbridge, M. E. Zaccagnini, and S. B. Canavelli. 1996. An Assessment of Mortality of Swainson's Hawks on Wintering Grounds in Argentina. *Journal of Raptor Research* 30:106–107.
- Good, T. P., R. S. Waples, and P. Adams (eds.). 2005. *Updated Status of Federally Listed ESU Of West Coast Salmon And Steelhead*. U.S. Department of Commerce, NOAA Technical Memo. NMFS-NWFSC-66.
- Grimaldo, L. F., and Z. Hymanson. 1999. What is the Impact of the Introduced Brazilian Waterweed *Egeria Densa* to the Delta Ecosystem? *Interagency Ecological Program Newsletter* 12(1):43–45.
- Grimaldo, L. F., T. Sommer, N. Van Ark, G. Jones, E. Holland, P. B. Moyle, P. Smith and B. Herbold. 2009. Factors Affecting Fish Entrainment into Massive Water Diversion in a Tidal Freshwater Estuary: Can Fish Losses Be Managed? *North America Journal of Fisheries Management* 29:1253–1270.
- Grimaldo, L., F. Feyrer, J. Burns, and D. Maniscalco. 2015. Sampling uncharted waters: examining longfin smelt (*Spirinchus thaleichthys*) rearing habitat in fringe marshes of the low salinity zone. Delta Science Conference presentation.
- Hallock, R. J. and F. Fisher. 1985. Status of Winter-Run Chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento River. Unpublished Anadromous Fisheries Branch Office Report, January 25, 1985.
- Halstead, B. J., G. D. Wylie, M. L. Casazza. 2014. *Ghost of Habitat: Historic Habitat Affects the Contemporary Distribution of Giant Garter Snakes in a Modified Landscape*. Animal Conservation. April. 144–15.
- Halstead, BJ, SM Skalos, GD Wylie, ML Casazza. 2015. Terrestrial Ecology of Semi-Aquatic Giant Gartersnakes (*Thamnophis gigas*). *Herpetological Conservation and Biology* 10(2):633-644.
- Hamilton, W. J., III, L. Cook, and R. Grey. 1995. *Tricolored Blackbird Project, 1994*. Unpublished report. Portland, OR: U.S. Fish and Wildlife Service.
- Hamilton, W. J., III. 1998. Tricolored Blackbird Itinerant Breeding in California. *Condor* 100:218–226.

- Hamilton, W. J., III. 2000. *Tricolored Blackbird 2000 Breeding Season Census and Survey -- Observations and Recommendations*. Prepared for the U.S. Fish and Wildlife Service, Portland, OR.
- Hansen, Brian. pers. Comm. Statement made in email on October 3, 2016. Mr. Hansen is a giant garter snake expert with the U.S. Fish and Wildlife Service in Sacramento, CA.
- Hansen, E. C. 2006. *Results of Year 2005 Giant Garter Snake (Thamnophis gigas) Surveys, Yolo County, CA*. Letter to Eric Tattersal, U.S. Fish and Wildlife Service. April 5.
- Hansen, E. C. 2007. *Implementation of Priority 1 Recovery Tasks for the Giant Garter Snake (Thamnophis gigas) in Merced County, California*. Report prepared for the U.S. Fish and Wildlife Service pursuant to FWS Agreement No. 802706G120. April 15.
- Hansen, E. C. 2009. *Giant Garter Snake (Thamnophis gigas) Presence/Absence and Distribution Surveys at the Conaway Ranch, Yolo County, California*. Report completed for the Conaway Preservation Group. December 31.
- Hansen, E. C. 2011. *2011 Implementation of Priority 1, Priority 2, and Priority 3 Recovery Tasks for Giant Garter Snake (Thamnophis gigas) – Status and Distribution Of Giant Garter Snakes at the Eastern Delta’s White Slough Wildlife Area, San Joaquin County, CA*. Draft report prepared for the U.S. Fish and Wildlife Service pursuant to FWS Agreement No. 802709G514. January 28.
- Hansen, G. E. 1986. *Status of the Giant Garter Snake Thamnophis couchii gigas (Fitch) in the Southern Sacramento Valley During 1986*. Final report for the California Department of Fish and Game, Standard Agreement No. C-1433.
- Hansen, G. E. and J. M. Brode. 1980. Status of the Giant Garter Snake *Thamnophis couchii gigas* (Fitch). *Inland Fisheries Endangered Species Special Publication* 80(5):1–14. Sacramento, CA: California Department of Fish and Game.
- Hansen, G. E. and J. M. Brode. 1993. Results of Relocating Canal Habitat of the Giant Garter Snake (*Thamnophis Gigas*) during Widening of SR 99/70 in Sacramento and Sutter Counties, California. Final report for Caltrans Interagency Agreement 03E325 (FG7550) (FY 87/88-91-92). 36 pp.
- Herzog, S. K. 1996. Wintering Swainson’s Hawks in California’s Sacramento-San Joaquin River Delta. *Condor* 98:876–879.
- Hestir, E. L., D. H. Schoellhamer, J. Greenberg, T. Morgan-King, and S. L. Ustin. 2016. The Effect of Submerged Aquatic Vegetation Expansion on a Declining Turbidity Trend in the Sacramento-San Joaquin River Delta. *Estuaries and Coasts* 39(4):1100-1112.
- Hestir, E. L., D. H. Schoellhamer, T. Morgan-King, and S. L. Ustin. 2013. A step decrease in sediment concentration in a highly modified tidal river delta following the 1983 El Niño floods. *Marine Geology* 345:304-313.

- Hickson, D. and T. Keeler-Wolf. 2007. *Vegetation and Land Use Classification and Map of the Sacramento-San Joaquin River Delta*. Sacramento, CA: California Department of Fish and Game, Bay Delta Region. Available: <http://dfg.ca.gov/biogeodata/vegcamp/veg_classification_reports_maps.asp>.
- Hickson, D. and T. Keeler-Wolf. 2007. *Vegetation and Land-Use Classification and Map of the Sacramento-San Joaquin River Delta*. Report to the Bay Delta Region of the California Dept. of Fish and Game. Sacramento, CA. Available: <http://dfg.ca.gov/biogeodata/vegcamp/veg_classification_reports_maps.asp>.
- Hickson, D. and T. Keeler-Wolf. 2007. *Vegetation and Land-Use Classification and Map of the Sacramento-San Joaquin River Delta*. Report to the Bay Delta Region of the California Dept. of Fish and Game. Sacramento, CA. Available: <http://dfg.ca.gov/biogeodata/vegcamp/veg_classification_reports_maps.asp>.
- Hieb, K., and R. Baxter. 1993. Delta Outflow/San Francisco Bay. In: P. L. Herrgesell (ed.). *1991 Annual Report - Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary*. Pages 101–116.
- Hobbs, J. A., W. A. Bennett, and J. E. Burton. 2006. Assessing nursery habitat quality for native smelts (Osmeridae) in the low-salinity zone of the San Francisco estuary. *Journal of Fish Biology* 69(3):907-922.
- Holomuzki, J. R. 1986. Predator Avoidance and Diel Patterns of Microhabitat Use by Larval Tiger Salamanders. *Ecology* 67:737–748.
- ICF International. 2015. Biological Assessment Of Effects On Listed Fishes From The West False River Emergency Drought Barrier Project. Draft. July 10. (ICF 00208.14.) Sacramento, CA. Prepared for AECOM, Sacramento, CA.
- Interagency Ecological Program, Management, Analysis, and Synthesis Team 2015. *An updated conceptual model of Delta Smelt biology: our evolving understanding of an estuarine fish*. Technical Report 90. January. Interagency Ecological Program for the San Francisco Bay/Delta Estuary, Sacramento, CA.
- Jameson, E. W., Jr. and H. J. Peeters. 1988. *California Mammals*. University of California Press.
- Jassby, A. D., J. E. Cloern, and B. E. Cole. 2002. Annual primary production: patterns and mechanisms of change in a nutrient-rich tidal ecosystem. *Limnology and Oceanography* 47(3):698-712.
- Jennings, M. R. and M. P. Hayes. 1994. *Amphibian and Reptile Species of Special Concern in California*. Rancho Cordova, CA: California Department of Fish and Game, Inland Fisheries Division.
- Jones & Stokes Associates, Inc. 2008. *Biological Effectiveness Monitoring for the Natomas Basin Habitat Conservation Project area 2007 Annual Survey Results* (Agency Version). Prepared for the Natomas Basin Conservancy.

- Kimmerer, W. J. 2002. Effects of freshwater flow on abundance of estuarine organisms: Physical effects or trophic linkages? *Marine Ecology Progress Series* 243: 39-55.
- Kimmerer, W. J. 2004. Open Water Processes of the San Francisco Estuary: From Physical Forcing to Biological Responses. *San Francisco Estuary and Watershed Science* [online serial] 2(1), Article 1.
- Kimmerer, W. J. 2008. Losses of Sacramento River Chinook Salmon and Delta Smelt to Entrainment in Water Diversions in the Sacramento-San Joaquin Delta. *San Francisco Estuary and Watershed Science* 6(2).
- Kimmerer, W. J. 2011. Modeling Delta Smelt Losses at the South Delta Export Facilities. *San Francisco Estuary and Watershed Science* 9(1).
- Kimmerer, W. J., and J. K. Thompson. 2014. Phytoplankton Growth Balanced by Clam and Zooplankton Grazing and Net Transport into the Low-Salinity Zone of the San Francisco Estuary. *Estuaries and Coasts* 37(5):1202-1218.
- Kimmerer, W. J., E. S. Gross, and M. L. MacWilliams. 2009. Is the Response of Estuarine Nekton to Freshwater Flow in the San Francisco Estuary Explained by Variation in Habitat Volume? *Estuaries and Coasts* 32:375–389.
- Kyle, K. and R. Kelsey. 2011. *Results of the 2011 Tricolored Blackbird Statewide Survey*. Audubon California, Sacramento, CA. Available: <<http://tricolor.ice.ucdavis.edu/downloads>>.
- Laabs, D. M., M. L. Allaback, and S. G. Orloff. 2001. Pond and Stream Breeding Amphibians. Chapter 5. In: J. E. Vollmar (ed.). *Wildlife and Rare Plant Ecology of Eastern Merced County's Vernal Pool Grasslands, Merced County*. Merced, CA: University of California Development Office. Pages 193–229.
- Lawler, S. P., D. Dritz, T. Strange, and M. Holyoak. 1999. Effects of Introduced Mosquitofish and Bullfrogs on the Threatened California Red-Legged Frog. *Conservation Biology* 13:613–622.
- Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer, Jr. 1980. *Atlas of North American Freshwater Fishes*. North Carolina Biological Survey No. 1980–12. North Carolina State Museum of Natural History, Raleigh, NC.
- Lehman, P. W., S. J. Teh, G. L. Boyer, M. L. Nobriga, E. Bass, and C. Hogle. 2010. Initial impacts of *Microcystis aeruginosa* blooms on the aquatic food web in the San Francisco Estuary. *Hydrobiologia* 637:229-248.
- Leyse, K. 2005. *Intentional Introductions and Biodiversity in Fishless Waters: The Effects of Introduced Fish on Native Aquatic Species*. PhD dissertation, University of California, Davis.

- Lindley, S. T., C. B. Grimes, M. S. Mohr, W. Peterson, J. Stein, J. T. Anderson, L.W. Botsford, D. L. Bottom, C. A. Busack, T. K. Collier, J. Ferguson, J. C. Garza, A. M. Grover, D. G. Hankin, R. G. Kope P. W. Lawson, A. Low, R. B. MacFarlane, K. Moore, M. Palmer-Zwahlen, F. B. Schwing, J. Smith, C. Tracy, R. Webb, B. K. Wells, T. H. Williams. 2009. *What Caused the Sacramento River Fall Chinook Collapse?* NOAA Technical Memorandum. U.S. Department of Commerce.
- Lindley, S. T., R. S. Schick, E. Mora, P. B. Adams, J. J. Anderson, S. Greene, C. Hanson, B. P. May, D. McEwan, R. B. MacFarlane, C. Swanson, J. G. Williams. 2007. Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin. *San Francisco Estuary and Watershed Science* 5(1): Article 4. Available: <http://repositories.cdlib.org/jmie/sfews/vol5/iss1/art4>.
- Lopez, C. B., J. E. Cloern, T. S. Schraga, A. J. Little, L. V. Lucas, J. K. Thompson, and J. R. Burau. 2006. Ecological values of shallow-water habitats: implications for the restoration of disturbed ecosystems. *Ecosystems* 9:422-440.
- Loredo, I. and D. van Vuren. 1996. Reproductive Ecology of a Population of the California Tiger Salamander. *Copeia* 1996:895–901.
- Loredo, I., D. van Vuren, and M. L. Morrison. 1996. Habitat Use and Migration Behavior of the California Tiger Salamander. *Journal of Herpetology* 30:282–285.
- Loredo-Prendeville, I., D. van Vuren, A. J. Kuenzi, and M. L. Morrison. 1994. California Ground Squirrels at Concord Naval Weapons Station: Alternatives for Control and Ecological Consequences. In: W. S. Halverson and A. C. Crabb (eds.). *Proceedings of the 16th Vertebrate Pest Conference*. University of California Publications. Pages 72–77.
- Lott, J. 1998. Feeding habits of juvenile and adult delta smelt from the Sacramento-San Joaquin river estuary. *IEP Newsletter* 11(1):14-19.
- Lucas, L. V., J. E. Cloern, J. K. Thompson, and N. E. Mosen. 2002. Functional variability of habitats within the Sacramento–San Joaquin Delta: restoration implications. *Ecological Applications* 12(5):1528-1547.
- Mac Nally, R., J.R. Thomson, W.J. Kimmerer, F. Feyrer, K.B. Newman, A. Sih, W. A. Bennett, L. Brown, E. Fleishman, S. D. Culberson, and G. Castillo. 2010. Analysis of pelagic species decline in the upper San Francisco Estuary using multivariate autoregressive modeling (MAR). *Ecological Applications* 20:1417-1430.
- Mager R. 1996. Gametogenesis, reproduction, and artificial propagation of delta smelt, *Hypomesus transpacificus* [PhD dissertation]. University of California, Davis.
- Mager, R. C., S. I. Doroshov, J. P. Van Eenennaam, and R. L. Brown. 2004. Early Life Stages of Delta Smelt. Pages 169–180 in F. Feyrer, L. R. Brown, R. L. Brown, and J. J. Orsi (eds), *Early Life History of Fishes in the San Francisco Estuary and Watershed*. American Fisheries Society Symposium 39.

- Maunder, M. N., and R. B. Deriso. 2011. A state-space multistage life cycle model to evaluate population impacts in the presence of density dependence: illustrated with application to delta smelt (*Hypomesus transpacificus*). *Canadian Journal of Fisheries and Aquatic Sciences* 68:1285-1306.
- May & Associates, Inc. 2005. *Rare Plant Survey: Delta Transmission Line Corridor, Solano, Sacramento and Contra Costa Counties, California*. Half Moon Bay, CA: Essex Environmental.
- McCabe, T. T. 1932. Wholesale Poison for the Red Wings. *Condor* 34: 49–50.
- Meese, R. J. 2006. *Settlement and Breeding Colony Characteristics of Tricolored Blackbirds in 2006 in the Central Valley Of California*. Report submitted to U.S. Fish and Wildlife Service and Audubon California.
- Meese, R. J. 2011. *Reproductive Success of Tricolored Blackbird Colonies in 2011 in the Central Valley of California*. California Department of Fish and Game, Wildlife Branch, Nongame Wildlife Program Report 2011-08. Sacramento, CA.
- Meese, R. J. 2013. Low Reproductive Success of the Colonial Tricolored Blackbird. *Western Birds* 44:98–113, 2013.
- Meese, R. J. Staff Research Associate, Department of Environmental Science and Policy (SEP) and Information Center for the Environment (ICE), University of California, Davis. December 7, 2011—Written comments submitted on Chapter 3 of BDCP Administrative Draft.
- Meese, R.J. 2014. Results of the 2014 Tricolored Blackbird Statewide Survey. University of California, Davis. July 31.
- Meisler, J. A. 2002. *Site Conservation Plan for the Jepson Prairie-Prospect Island Corridor*. Prepared for the Solano County Land Trust.
- Merz, J. E., Bergman, P.S., Melgo, J.F., & Hamilton, S. 2013. Longfin smelt: Spatial dynamics and ontogeny in the San Francisco estuary, California. *California Fish and Game* 99(3):122-148.
- Merz, J. E., S. Hamilton, P. S. Bergman, and B. Cavallo. 2011. Spatial perspective for delta smelt: a summary of contemporary survey data. *California Fish and Game* 97(4):164-189.
- Miller, W. J. 2011. Revisiting Assumptions that Underlie Estimates of Proportional Entrainment of Delta Smelt by State and Federal Water Diversions from the Sacramento-San Joaquin Delta. *San Francisco Estuary and Watershed Science* 9(1).
- Miller, W. J., B. F. J. Manly, D. D. Murphy, D. Fullerton, and R. R. Ramey. 2012. An Investigation of Factors Affecting the Decline of Delta Smelt (*Hypomesus transpacificus*) in the Sacramento-San Joaquin Estuary. *Reviews in Fisheries Science* 20(1):1-19.

- Moyle, P. B. 2002. *Inland Fishes of California*. Revised and Expanded. University of California Press, Berkeley, CA.
- Moyle, P. B., B. Herbold, D. E. Stevens, and L. W. Miller. 1992. Life history and status of delta smelt in the Sacramento-San Joaquin estuary, California. *Transactions of the American Fisheries Society* 121(1):67-77.
- Moyle, P. B., L. R. Brown, J. R. Durand, and J. A. Hobbs. 2016. Delta Smelt: Life History and Decline of a Once-Abundant Species in the San Francisco Estuary. *San Francisco Estuary and Watershed Science* 14(2).
- National Marine Fisheries Service. 2011a. *Endangered and Threatened Species. 5-Year Reviews for 5 Evolutionarily Significant Units (ESUs) of Pacific Salmon and 1 Distinct Population Segment (DPS) of Steelhead in California*. Federal Register 76(157): 50447-50448.
- National Marine Fisheries Service. 2011b. *Central Valley Recovery Domain, 5-Year Review: Summary and Evaluation of Central Valley Spring-Run Chinook Salmon ESU*. Southwest Region, Long Beach CA.
- National Marine Fisheries Service. 2012. Memorandum dated April 20, 2012, entitled Final implementation of the 2010 Reasonable and Prudent Alternative Sacramento River winter-run Chinook management framework for the Pacific Coast Salmon Fishery Management Plan.
- National Marine Fisheries Service. 2014. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead. California Central Valley Area Office. July 2014.
- National Marine Fisheries Service. 2016. *California Central Valley Recovery Domain. 5-Year Review: Summary and Evaluation of Central Valley Spring-run Chinook Salmon Evolutionarily Significant Unit*. April. National Marine Fisheries Service, West Coast Region, Sacramento, CA.
- Neff, J. A. 1937. Nesting Distribution of the Tricolored Red-Wing. *Condor* 39: 61–81.
- Neff, J. A. 1942. Migration of the Tricolored Red-Wing In Central California. *Condor* 44: 45–53.
- Nobriga, M. L. 2002. Larval delta smelt diet composition and feeding incidence: environmental and ontogenetic influences. *California Fish and Game* 88(4):149-164.
- Nobriga, M. L., T. R. Sommer, F. Feyrer, and D. Fleming. 2008. Long-Term Trends in Summertime Habitat Suitability for Delta Smelt (*Hypomesus transpacificus*). *San Francisco Estuary and Watershed Science* 6(1):1–13.

- Ohlendorf, H. M., Hoffman, D. J. Saiki, M. K. and T. W. Aldrich. 1988. Bioaccumulation of Selenium by Snakes and Frogs in the San Joaquin Valley, California. *Copeia* 1988(3):704–710.
- Orians, G. H. 1960. Autumnal Breeding in the Tricolored Blackbird. *Auk*. 77: 379–398.
- Orians, G. H. 1961. The Ecology of Clackbird (*Agelaius*) Social Systems. *Ecological Monographs* 31: 285–312.
- Paquin, G. D., G. D. Wylie., E.J. 2006. Population Structure of the Giant Garter Snake. *Conservation Genetics*. Vol. 7: 25-36.
- Parker, A. E., R. C. Dugdale, and F. P. Wilkerson. 2012. Elevated ammonium concentrations from wastewater discharge depress primary productivity in the Sacramento River and the Northern San Francisco Estuary. *Marine Pollution Bulletin* 64(3):574-586.
- Patterson, L. 2005. *Giant Garter Snake Surveys for the In-Delta Storage Program*. Year End and Summary Report. March. Sacramento, CA: California Department of Water Resources.
- Payne, R. 1969. Breeding Seasons and Reproductive Physiology of Tricolored Blackbirds and Redwinged Blackbirds. *University of California Publications in Zoology* 90: 8-28.
- Perry, R. W., J. R. Skalski, P. L. Brandes, P. T. Sandstrom, A. P. Klimley, A. Ammann, and B. MacFarlane. 2010. Estimating Survival and Migration Route Probabilities of Juvenile Chinook Salmon in the Sacramento-San Joaquin River Delta. *North American Journal of Fisheries Management* 30(1):142-156.
- Petranka, J. W. 1998. *Salamanders of the United States and Canada*. Washington, DC: Smithsonian Institution Press.
- Rea, Maria. Assistant Regional Administrator, West Coast Region, National Marine Fisheries Service. January 16, 2015—letter to Mr. Ron Milligan, Operations Manager, Central Valley Project, U.S. Bureau of Reclamation, regarding estimated number of juvenile Sacramento River winter-run Chinook salmon expected to enter the Sacramento-San Joaquin Delta during water year 2015.
- Resources Agency. 2007. *Pelagic Fish Action Plan*. Available: <<http://www.water.ca.gov/deltainit/030507pod.pdf>>.
- Riley, S. P. D., H. B. Shaffer, S. R. Voss, and B. M. Fitzpatrick. 2003. Hybridization Between a Rare, Native Tiger Salamander (*Ambystoma californiense*) and Its Introduced Congener. *Ecological Applications* 13:1263–1275.
- Risebrough, R. W., R. W. Schlorff, P. H. Bloom, and E. E. Littrell. 1989. Investigations of the Decline of Swainson's Hawk Populations in California. *Journal of Raptor Research* 23:63–71.

- Rose, K. A., W. J. Kimmerer, K. P. Edwards, and W. A. Bennett. 2013a. Individual-Based Modeling of Delta Smelt Population Dynamics in the Upper San Francisco Estuary: I. Model Description and Baseline Results. *Transactions of the American Fisheries Society* 142(5):1238-1259.
- Rose, K. A., W. J. Kimmerer, K. P. Edwards, and W. A. Bennett. 2013. Individual-Based Modeling of Delta Smelt Population Dynamics in the Upper San Francisco Estuary: II. Alternative Baselines and Good versus Bad Years. *Transactions of the American Fisheries Society* 142(5):1260-1272.
- Rosenfield, J. A. 2010. *Life History Conceptual Model and Sub-Models for Longfin Smelt, San Francisco Estuary Population for the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP)*. September 21.
- Rosenfield, J. A., and R. D. Baxter. 2007. Population Dynamics and Distribution Patterns of Longfin Smelt in the San Francisco Estuary. *Transactions of the American Fisheries Society* 136:1577–1592.
- Saiki, M. K. and T. W. May. 1988. Trace Element Residues in Bluegills and Common Carp from the Lower San Joaquin River, California, and Its Tributaries. *Science of the Total Environment* 74:199–217.
- Saiki, M. K., M. R. Jennings, and S. J. Hamilton. 1991. Preliminary Assessment of Selenium in Agricultural Drainage on Fish in the San Joaquin Valley. In: A. Dinar and D. Zilberman (eds.). *The Economics and Management of Water and Drainage in Agriculture*. Boston, MA: Kluwer Academic Publishers. Pages 369–385.
- Salmon, T. P. and R. H. Schmidt. 1984. An Introductory Overview to California Ground Squirrel Control. In: D.O. Clark (ed.). *Proceedings of the Eleventh Vertebrate Pest Conference*. March 6–8, 1984. Sacramento, CA. Pages 32–37.
- Schlorff, R. and P. H. Bloom. 1984. Importance of Riparian Systems to Nesting Swainson’s Hawks in the Central Valley of California. In: R.E. Warner and K.M. Hendrix (eds.). *California Riparian Systems: Ecology, Conservation, and Productive Management*. University of California Press, Berkeley, CA. Pages 612–618.
- Schoellhamer, D. H., S. A. Wright, and J. Drexler. 2012. A Conceptual Model of Sedimentation in the Sacramento–San Joaquin Delta. *San Francisco Estuary and Watershed Science* 10(3).
- Schreier, B. M., M. R. Baerwald, J. L. Conrad, G. Schumer, and B. May. 2016. Examination of Predation on Early Life Stage Delta Smelt in the San Francisco Estuary Using DNA Diet Analysis. *Transactions of the American Fisheries Society* 145(4):723-733.
- Semlitsch, R. D., D. E. Scott, J. H. K. Pechmann, and J. W. Gibbons. 1996. *Structure and Dynamics of an Amphibian Community: Evidence From A 16-Year Study of a Natural Pond*.

- Shaffer, H. B. and P. C. Trenham. 2005. *Ambystoma californiense*. In: M. J. Lannoo (ed.). *Status and Conservation of U.S. Amphibians*. Volume 2: Species Accounts. Berkeley, CA: University of California Press. Pages 1093–1102.
- Shaffer, H. B., R. N. Fisher, and S. E. Stanley. 1993. *Status Report: the California Tiger Salamander* (*Ambystoma californiense*). Final report for the California Department of Fish and Game.
- Singer, G. P., Hearn, A. R., Chapman, E. D., Peterson, M. L., LaCivita, P. E., Brostoff, W. N., Klimley, A. 2013. Interannual variation of reach specific migratory success for Sacramento River hatchery yearling late-fall run Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*Oncorhynchus mykiss*). *Environmental Biology of Fishes* 96:363-379.
- Skorupa, J. P., R. L. Hothem, and R. W. DeHaven. 1980. Foods of Breeding Tricolored Blackbirds in Agricultural Areas of Merced County, California. *Condor* 82:465–467.
- Slater, S. B., and R. D. Baxter. 2014. Diet, Prey Selection, and Body Condition of Age-0 Delta Smelt, *Hypomesus transpacificus*, in the Upper San Francisco Estuary. *San Francisco Estuary and Watershed Science* 12(3).
- Sommer, T. 2007. *The Decline of Pelagic Fishes in the San Francisco Estuary: An Update*. Presented to the California State Water Resources Control Board, Sacramento, CA, March 22, 2007. Available: www.waterrights.ca.gov/baydelta/docs/pelagicorganism/dwr_032207sommer.pdf.
- Sommer, T., and Mejia, F. 2013. A place to call home: a synthesis of Delta Smelt habitat in the upper San Francisco Estuary. *San Francisco Estuary and Watershed Science* 11(2). Available: <http://www.escholarship.org/uc/item/32c8t244>.
- Sommer, T., F. Mejia, M. Nobriga, F. Feyrer, and L. Grimaldo. 2011. The Spawning Migration of Delta Smelt in the Upper San Francisco Estuary. *San Francisco Estuary and Watershed Science* 9(2):1–16.
- State Water Resources Control Board. 2015. Order Conditionally Approving a Petition for Temporary Urgency Changes in License and Permit Terms and Conditions Requiring Compliance with Delta Water Quality Objectives in Response to Drought Conditions. Available: http://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/docs/tucp/2015/tucp_order070315.pdf
- Stillwater Sciences. 2014. *Swainson's hawk habitat quantification tool, scientific rationale document*, Version 2. Prepared by Stillwater Sciences, Berkeley, California for Environmental Defense Fund, Sacramento, California.
- Storer, T. I. 1925. A Synopsis of the Amphibia of California. *University of California Publications in Zoology* 27:60–71.

- Suisun Ecological Workgroup. 1997. *Suisun Ecological Workgroup Brackish Marsh Vegetation Subcommittee Report*. Sacramento, CA: California Department of Water Resources Control Board.
- Swanson, C., T. Reid, P. S. Young, and J. J. Cech Jr. 2000. Comparative environmental tolerances of threatened delta smelt (*Hypomesus transpacificus*) and introduced wakasagi (*H. nipponensis*) in an altered California estuary. *Oecologia* 123(3):384-390.
- Swolgaard, C. A., K. A. Reeves, and D. A. Bell. 2008. Foraging by Swainson's Hawks in a Vineyard-Dominated Landscape. *Journal of Raptor Research* 42(3):188–196.
- Szaro, R. C., S. C. Belfit, J. K. Aitkin, and J. N. Rinne. 1985. Impact of Grazing on a Riparian Garter Snake. In: R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Folliott, and R. H. Hamre (technical coordinators). *Riparian Ecosystems and Their Management: Reconciling Conflicting Uses*. U.S. Department of Agriculture, Forest Service, General Technical Report RM-120. Pages 359–363.
- TAIC. 2008. Yolo County Regional Vegetation. July. Available: <http://www.yoloconservationplan.org/yolo_data/YoloCounty_RegionalVegetation_July_08.shp>.
- TAIC. 2008. Yolo County Regional Vegetation. July. Available: <http://www.yoloconservationplan.org/yolo_data/YoloCounty_RegionalVegetation_July_08.shp>.
- TAIC. 2008. Yolo County Regional Vegetation. July. Available: <http://www.yoloconservationplan.org/yolo_data/YoloCounty_RegionalVegetation_July_08.shp>.
- Thelander, C. G. (ed). 1994. *Life on the Edge: A Guide to California's Endangered Natural Resources and Wildlife*. Santa Cruz, CA: Biosystems Analysis, Inc.
- Thomson, J. R., W.J. Kimmerer, L.R. Brown, K.B. Newman, R. MacNally, W. A. Bennett, F. Feyrer, and E. Fleishman. 2010. Bayesian change point analysis of abundance trends for pelagic fishes in the upper San Francisco Estuary. *Ecological Applications* 20(5):1431-1448.
- Trenham, P. C. 1998. *Radio Tracking Information*. Unpublished manuscript.
- Trenham, P. C. 2001. Terrestrial Habitat Use by Adult California Tiger Salamanders. *Journal of Herpetology* 35:343–346.
- Trenham, P. C. 2009. *California Tiger Salamander Biology and Conservation*. PowerPoint presentation at the California tiger salamander workshop, April 10, 2009. Coastal Training Program, Elkhorn Slough National Estuarine Research Reserve.

- Trenham, P. C., W. D. Koenig, and H. B. Shaffer. 2001. Spatially Autocorrelated Demography and Interpond Dispersal in the Salamander *Ambystoma californiense*. *Ecology* 82:3519–3530.
- Trenham, P.C., Shaffer, H.B., and P.B. Moyle 1998. Biochemical Identification and Assessment of Population Subdivision in Morphologically Similar Native and Invading Smelt Species (*Hypomesus*) in the Sacramento-San Joaquin Estuary, California. *Transactions of the American Fisheries Society* 127:417-424.
- Twitty, V. C. 1941. Data on the Life History of *Ambystoma tigrinum californiense* Gray. *Copeia* 1941:1–4.
- U.S. Bureau of Reclamation and California Department of Water Resources. 2013. Bay Delta Conservation Plan Public Draft. Sacramento, CA. Available: <<http://baydeltaconservationplan.com/EnvironmentalReview/EnvironmentalReview/2013-2014PublicReview/2013PublicReviewDraftBDPC.aspx>>. Accessed: July 20, 2015.
- U.S. Department of Agriculture. 2005. *National Agricultural Imaging Program*. USDA Farm Service Agency Aerial Photography Field Office, Salt Lake City, UT. Available at: <http://www.fsa.usda.gov/FSA/apfoapp?area=apfohome&subject=landing&topic=landing>
- U.S. Department of Agriculture. 2005. *National Agricultural Imaging Program*. USDA Farm Service Agency Aerial Photography Field Office, Salt Lake City, UT. Available at: <http://www.fsa.usda.gov/FSA/apfoapp?area=apfohome&subject=landing&topic=landing>.
- U.S. Department of Agriculture. 2005. *National Agricultural Imaging Program*. USDA Farm Service Agency Aerial Photography Field Office, Salt Lake City, UT. Available at: <http://www.apfo.usda.gov/FSA/apfoapp?area=home&subject=prod&topic=cat>
- U.S. Department of Agriculture. 2005. *National Agricultural Imaging Program*. USDA Farm Service Agency Aerial Photography Field Office, Salt Lake City, UT. Available at: <http://www.fsa.usda.gov/FSA/apfoapp?area=home&subject=prog&topic=nai>
- U.S. Department of Agriculture. 2010. *National Agricultural Imaging Program*. USDA Farm Service Agency Aerial Photography Field Office, Salt Lake City, UT. Available at: <http://www.fsa.usda.gov/FSA/apfoapp?area=apfohome&subject=landing&topic=landing>
- U.S. Department of Agriculture. 2012. *National Agricultural Statistics Service: California*. Available: <http://www.nass.usda.gov/Statistics_by_State/California/index.asp>. Accessed: July 13, 2012
- U.S. Fish and Wildlife Service. 1999. *Draft Recovery Plan for the Giant Garter Snake* (*Thamnophis gigas*). Portland, OR.
- U.S. Fish and Wildlife Service. 1999a. *Draft Recovery Plan for the Giant Garter Snake* (*Thamnophis gigas*). Portland, OR.

- U.S. Fish and Wildlife Service. 2002. *Birds of Conservation Concern 2002*. Division of Migratory Bird Management, Arlington, VA. Available: <<http://migratorybirds.fws.gov/reports/bcc2002.pdf>>.
- U.S. Fish and Wildlife Service. 2003. *California Tiger Salamander*. Sacramento: Endangered Species Division. Available: <http://sacramento.fws.gov/es/animal_spp_acct/california_tiger_salamander.htm>.
- U.S. Fish and Wildlife Service. 2006a. *Species Account Giant Garter Snake* (*Thamnophis gigas*). Sacramento, CA. Available: <http://www.fws.gov/sacramento/es/animal_spp_acct/giant_garter_snake.htm>.
- U.S. Fish and Wildlife Service. 2006b. *Giant Garter Snake* (*Thamnophis gigas*) *5-Year Review: Summary and Evaluation*. Sacramento, CA.
- U.S. Fish and Wildlife Service. 2008. *Birds of Conservation Concern*. 2008. Division of Migratory Bird Management. Arlington, Virginia. Available: <<http://www.fws.gov/migratorybirds/>>.
- U.S. Fish and Wildlife Service. 2008. *Birds of Conservation Concern*. 2008. Division of Migratory Bird Management. Arlington, Virginia. Available: <<http://www.fws.gov/migratorybirds/>>.
- U.S. Fish and Wildlife Service. 2008. Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP), Service File No. 81420-2008-F-1481-5. Available: <http://www.fws.gov/sfbaydelta/ocap/>.
- U.S. Fish and Wildlife Service. 2012. *Giant Garter Snake* (*Thamnophis gigas*) *5-Year Review: Summary and Evaluation*. Sacramento Fish and Wildlife Office, CA.
- U.S. Fish and Wildlife Service. 2013. *Species Account: California Tiger Salamander*. Sacramento, CA.
- U.S. Fish and Wildlife Service. 2015. *Revised Draft Recovery Plan for Giant Garter Snake* (*Thamnophis gigas*). Available at <http://www.fws.gov/sacramento/outreach/2015/12-22/docs/GGSrevisedDraftRecoveryPlan2015.pdf>, accessed 2016.03.29.
- U.S. Geological Survey. 2004. *Bullfrogs are significant predators of giant garter snake young of the year*. Publication Brief for Resource Managers. U.S. Geological Service, Western Ecological Research Center, Dixon, CA. Available at: <http://www.werc.usgs.gov/OLDSitedata/pubbriefs/wyliepbf2004.pdf>.
- Vinnedge Environmental Consulting. 2013. *Ironhouse Sanitary District Solar Photovoltaic Project—Draft Initial Study and Mitigated Negative Declaration*. Prepared for Ironhouse Sanitary District by Vinnedge Environmental Consulting, Berkley, CA

- Vogel, D. A. 1985. Information on status of the Sacramento River winter-run Chinook salmon. Letter to E. M. Lorentzen, American Fisheries Society, past president of Sacramento Chapter. U.S. Fish and Wildlife Service, Red Bluff, CA. July 5, 1985. 18 pp.
- Wagner, R. W., M. Stacey, L. R. Brown, and M. Dettinger. 2011. Statistical models of temperature in the Sacramento–San Joaquin Delta under climate-change scenarios and ecological implications. *Estuaries and Coasts* 34:544–556.
- Wilcox, J. T., G. E. Padgett-Flohr, J. A. Alvarez, and J. R. Johnson. 2015. Possible phenotypic influence of superinvasive alleles on larval California tiger salamanders (*Ambystoma californiense*). *The American Midland Naturalist* 173(1): 168-175.
- Wilkerson, F. P., R. C. Dugdale, V. E. Hogue, and A. Marchi. 2006. Phytoplankton blooms and nitrogen productivity in San Francisco Bay. *Estuaries and Coasts* 29(3):401-416.
- Williams, T. H., S. T. Lindley, B. C. Spence, and D. A. Boughton. 2011. *Status Review Update for Pacific Salmon and Steelhead Listed under the Endangered Species Act: Update to January 5, 2011 Report*, National Marine Fisheries Service, Southwest Fisheries Science Center. Santa Cruz, CA.
- Witham, C. W., and G. A. Kareofelas. 1994. *Botanical Resources Inventory at Calhoun Cut Ecological Reserve Following California's Recent Drought*. Sacramento, CA: California Department of Fish and Game.
- Woodbridge, B. 1991. *Habitat Selection by Nesting Swainson's Hawks: A Hierarchical Approach*. Master's thesis. Oregon State University, Corvallis.
- Woodbridge, B. 1998. Swainson's Hawk (*Buteo swainsoni*). In *The Riparian Bird Conservation Plan: a Strategy for Reversing the Decline of Riparian-associated Birds in California*. California Partners in Flight. Available at: http://www.prbo.org/calpif/htmldocs/species/riparian/swainsons_hawk.htm.
- Woodbridge, B., K. K. Finley, and S. T. Seager. 1995. An Investigation of the Swainson's Hawk in Argentina. *Journal of Raptor Research* 29:202–204.
- WRA Environmental. 2005. *California Tiger Salamander Site Assessment. Staples Ranch Pleasanton, Alameda County California*. October. Prepared for Davis Environmental Consulting, LLC. Davis, CA.
- Wylie, G. D. and M. Amarello. 2008. *Results of 2006 Monitoring for Giant Garter Snakes (Thamnophis Gigas) for the Bank Protection Project on the Left Bank of the Colusa Basin Drainage Canal in Reclamation District 108, Sacramento Riverbank Protection Project, Phase II*. December. Dixon, CA: U.S. Geological Survey Western Ecological Research Center, Dixon Field Station.
- Wylie, G. D., M. L. Casazza, and L. L. Martin. 2004. *Monitoring giant garter snakes in the Natomas Basin: 2003 results*. USGS-BRD, Western Ecological Research Center, Dixon Field Station.

Wylie, G. D., M. L. Casazza, E. Burns, M. Paquin, J. Daugherty. 1997. Surveys for giant garter snakes (*Thamnophis gigas*) at Stone Lakes National Wildlife Refuge. Final report. USGS-BRD, Western Ecological Research Center, Dixon Field Station.

Yolo County Habitat Conservation Plan/Natural Community Conservation Plan Joint Powers Agency. 2009. *Species Account: Swainson's Hawk*. Yolo Natural Heritage Program Habitat Conservation Plan/Natural Community Conservation Plan. Prepared by Technology Associates International Corporation (TAIC). Yolo County, CA.

Yolo County. 2008. Species Account: Tricolored Blackbird. *Yolo Natural Heritage Program Plan*. Prepared by Technology Associates International Corporation.

Zebell, R. and P. Fiedler. 1996. *Restoration and Recovery of Mason's Lilaepsis: Phase II*. Final report to the California Department of Fish and Game Plant Conservation Program.