

## Non-Covered Fish and Aquatic Species Descriptions

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Non-covered fish and aquatic species have been identified to encompass additional species that are designated as special status by State or Federal agencies or that are of particular ecological, recreational, or commercial importance, as follows:

- Striped Bass
- American Shad
- Largemouth Bass
- Sacramento–San Joaquin Roach
- Hardhead
- Sacramento Perch
- Sacramento Tule Perch
- Threadfin Shad
- Bay Shrimp

### 11B.1 Striped Bass

Striped Bass are nonnative to the San Francisco Bay–Delta Watershed, and are not listed as Threatened or Endangered under Federal or State regulations, nor are they a State Species of Special Concern or a Federal Species of Concern. Because the Delta supports an important recreational fishery for Striped Bass, recreational fishing for Striped Bass is regulated by the California Department of Fish and Wildlife (DFW). Commercial fisheries for Striped Bass do not exist in the Delta.

#### 11B.1.1 Status, Distribution, Life History, and Habitat Requirements

Striped Bass were introduced to the Bay-Delta in July 1879, when about 135 fish, originally collected in New Jersey, were released into the Carquinez Straight with the goal of establishing a commercial fishery (Dill and Cordone 1997). Within 10 years of their introduction into California waters, the fishery had begun, and by 1889 a commercial catch of over 1.2 million pounds was recorded by the U. S. Bureau of Fisheries (Skinner 1962). Striped Bass currently support one of California’s largest recreational fisheries.

Although Striped Bass are one of the most abundant fish in the Bay-Delta, their numbers have declined since the 1930s (Moyle 2002). The Striped Bass commercial fishery was closed in 1935 to relieve fishing pressure on the population, despite information suggesting that the population was actually increasing (Dill and Cordone 1997). The exact period of decline and the rate of decline are not very clear before 1980, but by 1985 the adult population was one quarter of the population 20 years prior (Stevens et al. 1985). Since 1985, the adult Striped Bass population has continued to

1 decline. Between 2002 and 2004, the Interagency Ecological Program observed record low  
2 abundances for Striped Bass (Baxter et al. 2008). The age-0 Striped Bass abundance index has  
3 declined since the 1970s, and record low abundances of young-of-year (YOY) Striped Bass have  
4 occurred since 2000, following trends of other pelagic organisms known to be suffering from Pelagic  
5 Organism Decline (POD) (Baxter et al. 2008). The decline of early life stages exceeds the rate of  
6 decline of the adult population (age 3 and greater), although the adult population is declining  
7 (California Department of Fish and Game 2010:Figure 11B-1). The number of Striped Bass collected  
8 during the 2008 Striped Bass Population Study shows Striped Bass in the Bay-Delta was significantly  
9 lower (approximately 50 percent) than the prior year (California Department of Fish and Game  
10 2008).

11 An anadromous fish, Striped Bass spends the majority of its life in saltwater, returning to freshwater  
12 to spawn. When not migrating for spawning, the population located in the Bay-Delta is concentrated  
13 in San Pablo Bay, San Francisco Bay, and the Pacific Ocean, but only within approximately 40 miles  
14 of the Golden Gate Bridge (Moyle 2002). During the spawning migration, adult Striped Bass are  
15 located in the freshwaters of the Delta (Hassler 1988).

16 Striped Bass can withstand a wide range of environmental conditions including high water  
17 temperatures, low dissolved oxygen (DO), high turbidity, and rapid temperature changes. According  
18 to Moyle (2002), three specific habitats are required for Striped Bass to be successful and the only  
19 system in California to satisfy all three requirements is the Bay-Delta. A large body of water with  
20 sufficient amounts of forage fish is necessary for adult Striped Bass to survive. This type of habitat in  
21 the Bay-Delta can be found in San Pablo and San Francisco bays. For spawning, a large river with  
22 significant velocities is required to keep eggs and larvae suspended in the water column. These  
23 spawning grounds are found in the mid and lower reaches of the Sacramento and San Joaquin rivers.  
24 The last of the three “necessary” habitats, according to Moyle, is an estuary with a large invertebrate  
25 population available as a food source for juveniles.

26 Adults are voracious predators that demonstrate considerable trophic adaptability (Nobriga and  
27 Feyrer 2007). Adults are mainly piscivores consuming primarily forage fish such as the nonnative  
28 Threadfin Shad and juvenile Striped Bass (Stevens 1966), and they are constantly changing their  
29 diet to match what is present and abundant in the estuary. For example, Nobriga and Feyrer (2007)  
30 found that following the establishment of Siberian prawn in the Bay-Delta, this species began to  
31 make up a significant portion of the Striped Bass diet. Striped Bass have also been found to consume  
32 the Threatened Delta Smelt, although they made up only a small portion of the Striped Bass diet  
33 (Stevens 1966). Recently, concern has been raised over Striped Bass consumption of juvenile  
34 Chinook Salmon, including Threatened and Endangered species (Lindley and Mohr 2003; CALFED  
35 Bay-Delta Program 2008).

36 Spawning occurs in spring, between April and June, when mature Striped Bass migrate upstream  
37 from saltwater to freshwater (Turner 1976). Spawning occurs in two major areas within the Bay-  
38 Delta, including the Sacramento River between Sacramento and Colusa and the Western Delta in the  
39 San Joaquin River between Antioch and Venice Island (Farley 1966). However, actual spawning  
40 location within the Bay-Delta depends on water temperature, river flow, and salinity. Spawning  
41 occurs in the lower reaches of the rivers in years of low flow, farther upriver in years of high flow  
42 (Farley 1966).

43 Spawning occurs en masse, with average female fecundity within the Bay-Delta population being  
44 between 243,000 and 1.4 million eggs, depending on the size of the spawning female (Stevens et

1 al. 1985). Eggs are semi-buoyant and are distributed throughout the water column by currents (Able  
2 and Fahay 1998). A current strong enough to keep the eggs suspended in the water column is an  
3 important requirement for spawning habitat. If the current is not strong enough, eggs may settle on  
4 the bottom and become smothered (Collette and Klein-MacPhee 2002). After fertilization, eggs hatch  
5 within 2 to 3 days, followed by a net movement of the larval fish from upstream locations to  
6 downstream, tidal portions of the river (Moyle 2002).

7 Larvae begin feeding actively 5 days after hatching, mainly consuming copepods (Hassler 1988;  
8 Nobriga and Feyrer 2007). Larvae remain suspended in the water column by swimming, but more  
9 so due to river and tidal currents (Fay et al. 1983). Between swimming efforts, in areas of little water  
10 movement, yolk-sac larvae tend to sink toward the bottom (Collette and Klein-MacPhee 2002).  
11 According to Hassler (1988), larvae can be distributed throughout portions of the estuary depending  
12 on river flow. In low-flow years, all Striped Bass eggs and larvae are found in the Delta. However, in  
13 high-flow years, eggs and larvae are transported downstream into Suisun Bay. In years of the  
14 highest flow, the majority of the eggs and larvae are located within Suisun Bay. The greatest survival  
15 of young bass has been found when high flows resulted in the bass being located in Suisun Bay  
16 (Turner and Chadwick 1972). The larval stage lasts from 23 to 68 days, depending on water  
17 temperature (USFWS 1989).

18 The juvenile stage of the Striped Bass lasts from metamorphosis until sexual maturity. Early  
19 juveniles prey mainly on copepods, while larger juveniles begin consuming larger crustaceans and  
20 fish (Nobriga and Feyrer 2007). Juvenile Striped Bass abundance is highest at the confluence of  
21 marine waters and freshwaters, which changes location within the Bay-Delta based on river flows  
22 (Hassler 1988; Turner and Chadwick 1972). Historically, plankton productivity was highest when  
23 this zone was in the Suisun Bay, leading to large numbers of prey species for juvenile Striped Bass  
24 (Hassler 1998). However, one study found that the lower region of the San Joaquin River was the  
25 most important nursery for Striped Bass in the Delta (Sasaki 1966).

## 26 **11B.1.2 Stressors**

27 Changes in annual indices of Striped Bass juvenile abundance have been directly correlated with  
28 outflow from the Delta (Turner and Chadwick 1972). During low flow, water diversion has been  
29 found to have a greater effect on larvae and eggs than when flows are high (Chadwick et al. 1977).  
30 This is likely due to more eggs and larvae being diverted to the State Water Project (SWP)/Central  
31 Valley Project (CVP) pumps and water being diverted at other pumping stations or for agricultural  
32 reasons. It is unknown how many egg and larval stage Striped Bass are entrained in the pumping  
33 facilities throughout the Delta.

34 SWP/CVP export pumping can reduce Delta outflow, with numerous potential effects on Striped  
35 Bass, such as a reduction in nursery area, reduced food availability, increased exposure to  
36 pollutants, and decreased turbidity, making early life stages more susceptible to predation. The  
37 small agricultural diversions in the Delta pump intermittently and probably do not take many small  
38 bass during most years, especially early in the season when agricultural water demands are low and  
39 flows are high. Larger diversions, such as the North Bay Aqueduct and cooling water intakes at the  
40 power plants, together with multiple agricultural diversions, likely entrain large numbers of small  
41 Striped Bass, especially in low flow years. It is generally assumed that these diversions have a  
42 relatively small impact on bass populations compared to other factors (Moyle 2002).

1 Juvenile Striped Bass are susceptible to entrainment at the SWP/CVP export facilities. Striped Bass  
2 are observed in salvage operations throughout the year, with the majority of juvenile Striped Bass  
3 occurring during the summer months (May through July). Striped Bass have been observed in  
4 salvage operations throughout the year, with the majority occurring during the summer months  
5 (May through July). According to data from Herbold et al. (2005), between 1994 and 2005, the peak  
6 annual salvage of Striped Bass from the SWP/CVP pumping plants was over 3.5 million individuals  
7 in 2000; an annual low of approximately 420,000 individuals was salvaged in 2005. Although these  
8 bass were salvaged from the pumping plants, it is likely that few individuals actually survived the  
9 process of collection, analysis, transport, and reintroduction to the Bay-Delta. Since 2000, Striped  
10 Bass salvage at the SWP and CVP plants has decreased. This decrease follows the apparent reduction  
11 in overall adult Striped Bass abundance within the Bay-Delta. However, the density of salvaged  
12 Striped Bass (total salvaged/total amount of water exported from November through March) in  
13 relation to the estimated abundance of the Striped Bass population is actually increasing despite the  
14 reduction in the number of individuals salvaged. The number of individuals entrained in the  
15 pumping facilities likely makes up a sizeable portion of the Bay-Delta Striped Bass population  
16 (Moyle 2002). However, no quantitative estimate on the impact of entrainment losses on the Striped  
17 Bass population has been made.

18 Contaminants and toxins in the Bay-Delta have been shown to accumulate and to possibly have  
19 detrimental effects on adult Striped Bass. Moribund snail individuals, collected in 1987 by Cashman  
20 et al. (1992), were examined for chemical pollutants and shown to be heavily contaminated with  
21 industrial, agricultural, and urban pollutants. Cashman et al. (1992) also found that these  
22 contaminants may contribute to an annual die-off of adult Striped Bass. Striped Bass are known to  
23 have high selenium content due to the introduction of selenium pollutants into their habitat.  
24 Concentrations in Striped Bass from the estuary have been found to be one quarter to one half the  
25 concentrations found in fish collected from the San Joaquin River (Saiki et al. 1992).

26 It is likely that Striped Bass eggs and larvae suffer chronic effects from concentrations of toxic  
27 substances that are below lethal levels (Stevens et al. 1985). These toxins are a result of widespread  
28 runoff and, therefore, it is difficult to understand how the Striped Bass population may be  
29 influenced. Recently, through field sampling, xenobiotics (i.e., foreign chemicals in cells) have been  
30 found to pass from maternal Striped Bass to their eggs. Further, the xenobiotics within the  
31 developing eggs and larvae have been found to be detrimental, causing abnormalities in  
32 development such as retarded growth in body size, brain, and liver, and abnormal utilization of the  
33 yolk sac (Ostrach et al. 2008). Striped Bass, as a long-lived apex predator, are particularly prone to  
34 the bioaccumulation of toxic substances. For example, consumption advisories due to high levels of  
35 methylmercury in sportfish have been issued for San Francisco Bay and the Delta.

36 Nonnative species have the ability to alter many important ecological interactions in the Bay-Delta.  
37 It is likely that nonnative species will continue to gain access into the system with unknown  
38 consequences. Species that have recently established a viable population also will continue to affect  
39 the Bay-Delta, and specifically the Striped Bass population. Two hydromedusae, *Maeotias marginata*  
40 and *Moerisia* sp., were recently found in the estuary. These hydromedusae may threaten the Striped  
41 Bass population through both competition for prey species and predation of juvenile Striped Bass  
42 (Rees and Gershwin 2000). However, the effect of these species is not yet fully understood.

43 A nonnative species that has indirectly altered the feeding habits of Striped Bass is the overbite  
44 clam. This bivalve has caused a significant reduction in phytoplankton productivity within the Bay-  
45 Delta (Kimmerer et al. 1994). This invasive clam has also caused a decrease in mysid shrimp, a

1 primary food for juvenile Striped Bass (Feyrer et al. 2003). The recent establishment of the overbite  
2 clam has caused a major reduction in phytoplankton in the Bay-Delta (Kimmerer et al. 1994).  
3 Zooplankton, which feed on phytoplankton, are the main food source of larval bass. Greatest success  
4 of year class individuals has been attributed to areas of large phytoplankton blooms (Turner and  
5 Chadwick 1972), likely due to the benefits of the blooms on the zooplankton community. The result  
6 of a reduction of phytoplankton by the overbite clam is reported to be likely to remain a threat to  
7 larval Striped Bass because they do not demonstrate trophic adaptability like adults (Nobriga and  
8 Feyrer 2007). This relationship may change as overbite clam populations increase or decrease in  
9 abundance in the estuary, or if new nonnative species establish a viable population within the Bay-  
10 Delta. Further, the reduction in phytoplankton productivity likely leads to a reduction in turbidity  
11 within the Bay-Delta, making larvae and juvenile Striped Bass more susceptible to predation.

12 Although recreational fishing exerts some pressure on the adult Striped Bass population, Striped  
13 Bass are regulated by DFW so that recreational catch can support a sustainable Striped Bass  
14 population. Currently, legal action is being taken against CDFW to eliminate fishing regulations on  
15 Striped Bass. This lawsuit is an attempt to protect Delta Smelt and other Threatened or Endangered  
16 species within the Bay-Delta from predation by Striped Bass (Coalition for a Sustainable Delta  
17 2008). The removal of fishing regulations may lead to overfishing of Striped Bass, the consequences  
18 of which are not clear, but could lead to a population decline from current levels.

19 The Delta supports an important recreational fishery for Striped Bass. Although commercial  
20 fisheries for Striped Bass do not exist in the Delta, commercial enterprises such as professional  
21 guide and party-boat services, bait and tackle shops, sponsored sportfishing tournaments, and  
22 associated service industries depend on the Striped Bass recreational fishery in the Delta.

## 23 **11B.2 American Shad**

### 24 **11B.2.1 Status, Distribution, Life History, and Habitat** 25 **Requirements**

26 American Shad occur in the Sacramento River, its major tributaries, the San Joaquin River, and the  
27 Delta. Because of its importance as a sport fish, the American Shad has been the subject of  
28 investigations by DFW. American Shad are native to the Atlantic coast and were planted in the  
29 Sacramento River in 1871 and 1881 (Moyle 2002).

30 Adult American Shad typically enter Central Valley rivers from April through early July (California  
31 Department of Fish and Game 1986), with the majority of immigration and spawning occurring from  
32 mid-May through June (Urquhart 1987). Water temperature is an important factor influencing the  
33 timing of spawning. American Shad are reported to spawn at water temperatures ranging from  
34 approximately 46°F to 79°F (U.S. Fish and Wildlife Service 1967), although optimal spawning  
35 temperatures are reported to range from about 60°F to 70°F (Bell 1986; California Department of  
36 Fish and Game 1980; Leggett and Whitney 1972; Painter et al. 1979; Leidy et al. 1987). Spawning  
37 takes place mostly in the main channels of rivers, and generally about 70 percent of the spawning  
38 run is made up of first-time spawners (Moyle 2002).

39 Shad have remarkable abilities to navigate and to detect minor changes in their environment  
40 (Leggett 1973). Although homing is generally assumed in the Sacramento River and its tributaries,

1 there is some evidence that numbers of first-time spawning (i.e., “virgin”) fish are proportional to  
2 flows of each river at the time the Shad arrive. When suitable spawning conditions are found,  
3 American Shad school and broadcast their eggs throughout the water column. The optimal  
4 temperature for egg development is reported to occur at 62°F. At this temperature, eggs hatch in 6  
5 to 8 days; at temperatures near 75°F, eggs would hatch in 3 days (MacKenzie et al. 1985). Egg  
6 incubation and hatching, therefore, are coincident with the spawning period.

## 7 **11B.2.2 Stressors**

8 American Shad population abundance in the Central Valley has declined from historical levels  
9 (Moyle 2002). The major cause of their decline in recent years is most likely the increased diversion  
10 of water from the rivers and the Delta, combined with changing ocean conditions, although pesticide  
11 effects on larvae and other factors also may be contributing (Moyle 2002). From 1993 through 2003,  
12 approximately 520,000 American Shad were reportedly salvaged at the SWP and CVP fish salvage  
13 facilities, or an annual average salvage of approximately 47,000 (Bay Delta and Tributaries  
14 Project 2010). Salvage of American Shad occurs year-round, but peak reported salvage appears to  
15 have occurred from about June through December in many years (Bay Delta and Tributaries  
16 Project 2010). However, these salvage numbers represent only the actual number of American Shad  
17 counted, not the actual number of American Shad salvaged. Therefore, the number of American Shad  
18 actually salvaged may be much higher.

## 19 **11B.3 Largemouth Bass**

### 20 **11B.3.1 Status, Distribution, Life History, and Habitat** 21 **Requirements**

22 Largemouth Bass, a nonnative species to the Bay-Delta Watershed, is not listed as Threatened or  
23 Endangered under Federal or State regulations, nor is it a State Species of Special Concern or a  
24 Federal Species of Concern. Because the Delta supports an important recreational fishery for  
25 Largemouth Bass, recreational fishing for Largemouth Bass is regulated by DFW. In addition, the  
26 Delta supports world-renowned fishery tournaments for Largemouth Bass. Commercial fisheries for  
27 Largemouth Bass do not exist in the Delta.

28 Largemouth Bass are not native to the Delta. They were first introduced in California in 1891 (Dill  
29 and Cordone 1997; Moyle 2002). Since then, Largemouth Bass have been introduced to suitable  
30 waters throughout the State. Among the reasons for introduction were mosquito and algal control,  
31 and recreational sportfishing. Their numbers in the Delta have increased only recently (Brown and  
32 Michniuk 2007). This increase was associated with increasing water clarity and submerged  
33 macrophyte abundance in the Delta. The recent increase in abundance has been apparent based on  
34 fishing patterns; the population has increased sufficiently to support a significant sportfishery (Lee  
35 2000). In addition to the Delta, almost all large reservoirs and permanent ponds of the estuary  
36 support populations of Largemouth Bass.

37 The majority of Largemouth Bass in California are the northern subspecies *Micropterus salmoides*  
38 *salmoides*, with a minority of the population being the larger *Micropterus salmoides floridanus*, which  
39 was experimentally introduced in the mid-1970s (Moyle 1976). The two subspecies are now known  
40 to hybridize (Dill and Cordone 1997).

1 Spawning occurs for the first time during the second or third spring at about 18 to 21 centimeters  
2 (cm) total length. The first noticeable sign is nest building by males, which starts when the water  
3 temperature reaches 14°C to 16°C (57°F to 61°F). Spawning takes place from April through June, up  
4 to temperatures of 24°C (75°F). Nests are shallow pits in depths of 3.3 to 6.6 feet (1 to 2 meters),  
5 made by the male fanning sand, gravel, or debris from the substrate. The nests are often built next to  
6 submerged objects, located large distances from other Largemouth Bass nests. The male will defend  
7 the nest by staying over it, but does not defend the nest as vigorously as other species. Each female  
8 lays 2,000 to 94,000 eggs depending on her size, in one or more nests. The eggs adhere to the  
9 substrate and hatch in 2 to 5 days. The sac fry usually spend 5 to 8 days in or near the nest (Moyle  
10 1976). Largemouth Bass spawning is limited to freshwater (Moyle 2002).

11 For the first month or two after hatching, fry feed mainly on rotifers and small crustaceans. YOY bass  
12 stay close to shore in schools that swim in the open water. By the time they are about 50 to 60  
13 millimeters (mm) (2 inches) standard length they feed largely on aquatic insects and fish fry,  
14 including other Largemouth Bass. After they reach about 100 to 125 mm (4 to 5 inches) standard  
15 length, they prey primarily on fish and crayfish. However, bass may be selective, preferring crayfish,  
16 tadpoles, or frogs to fish. Sometimes specific fish species are the selected prey for a local bass  
17 community, and can vary year to year. Selective feeding has been shown to not be proportional to  
18 the relative abundance of the prey species (Moyle 1976). Largemouth Bass are thought to be a major  
19 predator of juvenile Chinook Salmon in the Delta, contributing to the latter species' Threatened and  
20 Endangered status (CALFED Bay-Delta Program 2008).

21 In the Bay-Delta, Largemouth Bass are known to prey on a greater diversity of fish species than  
22 other shallow water piscivores, such as Striped Bass and Sacramento Pikeminnow. Largemouth Bass  
23 prey on native fish in higher percentages than the other two species, despite having much lower  
24 percentages of habitat overlap with native species. For example, native prey species such as smelts  
25 use freshwater only for spawning, reducing the time span during which they would interact with  
26 Largemouth Bass, which are primarily restricted to freshwater. The highest level of native fish  
27 species predation was during spring months. Largemouth Bass begin a piscivorous diet at a younger  
28 age and size than other predators in the Bay-Delta, and are especially adept at predation in and  
29 around structures, such as vegetation (Nobriga and Feyrer 2007).

30 Juvenile Largemouth Bass feed on zooplankton, as do Threadfin Shad, which were introduced to  
31 California to be a forage species for predatory game fish such as adult Largemouth Bass. When mild  
32 winters result in increased winter survival of adult Threadfin Shad there tends to be poor spring  
33 survival of juvenile Largemouth Bass due to competition with adult Threadfin Shad for zooplankton  
34 (Von Geldern 1974; Von Geldern and Mitchell 1975; Dill and Cordone 1997). Growth rates are highly  
35 variable, depending on genetic background, food availability, inter- and intra-specific competition,  
36 temperature regimes, and other limnological factors. They can reach about 5 to 20 cm (2 to 8 inches)  
37 total length in their first year, about 7 to 32 cm (3 to 12 inches) in their second year, about 15 to 37  
38 cm (6 to 14 inches) in their third year, and about 20 to 41 cm (8 to 16 inches) in their fourth year.  
39 Maximum size for the species is approximately 76 cm (30 inches) total length. Maximum age is 16  
40 years (Moyle 1976). Largemouth Bass may have substantially faster growth rates and higher  
41 survival rates on floodplains than elsewhere (Moyle et al. 2007).

42 Largemouth Bass prefer warm, quiet waters with aquatic vegetation and low turbidity (Lee et al.  
43 1980; Moyle 2002). The current Bay-Delta invasion of Brazilian waterweed has enhanced the  
44 habitat of Largemouth Bass and other centrarchids, to the disadvantage of native species (CALFED  
45 Bay-Delta Program 2008). Brown and Michniuk (2007) noted that Brazilian waterweed presence

1 increased catch per unit effort for alien fish species, particularly centrarchids, but did not alter the  
2 overall fish species composition. Brazilian waterweed forms thick wall-like stands along the margins  
3 of channels and shallow water habitat in the Delta. Water hyacinth creates dense floating mats that  
4 can impede river flows and alter the aquatic environment beneath the mats. By reducing water  
5 velocities near plants, these species reduce turbidity in the water column. DO levels beneath the  
6 mats often drop below suitable levels for other fish species due to the increased amount of decaying  
7 vegetative matter produced from the overlaying mat and diel respiration required by aquatic plants.  
8 Largemouth Bass are known to tolerate DO levels as low as 1 mg/L and prefer warm, clear water  
9 (Moyle 2002). Like Brazilian waterweed, water hyacinth is often associated with the margins of the  
10 Delta waterways in its initial colonization, but can eventually cover the entire channel if conditions  
11 permit. High levels of infestation by these nonnative aquatic plants appear to be enhancing  
12 Largemouth Bass habitat.

### 13 **11B.3.2 Stressors**

14 As with Striped Bass, Largemouth Bass are affected by similar stressors, such as entrainment into  
15 water diversions in the Delta. Salvage of Largemouth Bass occurs year-round, but reported salvage  
16 appears to peak from about May through July during many years (Bay Delta and Tributaries  
17 Project 2010). From 1993 through 2003 salvage of Largemouth Bass at the SWP and CVP fish  
18 salvage facilities was reportedly about 24,000, or an annual average salvage of approximately 2,000  
19 (Bay Delta and Tributaries Project 2010). However, these salvage numbers represent only the actual  
20 number of Largemouth Bass counted, not the actual number of Largemouth Bass salvaged.  
21 Therefore, the number of Largemouth Bass actually salvaged is likely much higher.

22 Similar to that described above for Striped Bass, contaminants and toxins in the Bay-Delta have been  
23 shown to accumulate and to possibly have detrimental effects on adult Largemouth Bass. Selenium  
24 is a generally known threat in the Delta, and has been found to bioaccumulate in upper trophic level  
25 predators such as Largemouth Bass. Baumann and Gillespie (1986) found the eggs in female  
26 Largemouth Bass to contain over 1,000 times the concentration of selenium in the surrounding  
27 waters. Selenium is known to cause reproductive difficulties in fish, including lowered fecundity and  
28 slow growth rates (Baumann and Gillespie 1986). Given the observed recent increase in abundance  
29 of Largemouth Bass, the presence of selenium in the aquatic environment is not inhibiting  
30 population growth.

31 Largemouth Bass, as a predator, is prone to the bioaccumulation of toxic substances. For example,  
32 consumption advisories due to high levels of methylmercury in sportfish have been issued for San  
33 Francisco Bay and the Delta. Largemouth Bass are known in their native locations to tolerate  
34 salinities up to 16 parts per thousand (ppt). In California, they rarely tolerate salinity levels as high  
35 as 3 ppt, and almost never as high as 5 ppt (Moyle 2002).

36 Nonnative species at various trophic levels exist in the Bay-Delta. Several of these species enhance  
37 Largemouth Bass habitat. Asian clams are abundant throughout the lower salinity areas of the Delta,  
38 and reportedly filter turbidity from the water. Another Asian clam species, *Corbicula fluminea*, is also  
39 reducing turbidity levels, but is probably being masked by the effects of Brazilian waterweed. As  
40 previously discussed, Brazilian waterweed is currently providing a vast amount of suitable  
41 Largemouth Bass habitat.

42 Within the Delta there has been a growing popularity for Largemouth Bass recreational angling  
43 tournaments (Bureau of Reclamation et al. 2009). Tournaments are held year-round with prizes



1 awarded based on weight of individual bass and total weight of up to five bass. Tournament anglers  
2 are required to maintain the bass alive, which are then released back into the Delta after completing  
3 the weigh-in. The number of bass anglers, the number of tournaments, and the size of individual  
4 bass have all been increasing in recent years. Several of the recreational tournaments held recently  
5 in the Delta have been televised nationally (e.g., Bass Masters Invitational).

## 6 **11B.4 Sacramento–San Joaquin Roach**

### 7 **11B.4.1 Status, Distribution, Life History, and Habitat** 8 **Requirements**

9 The Sacramento–San Joaquin Roach, a California Species of Special Concern, is part of the California  
10 Roach complex, which consists of various subspecies (Moyle 2002). The Sacramento–San Joaquin  
11 Roach is found in the Sacramento and San Joaquin river drainages, except the Pit River, as well as  
12 tributaries to San Francisco Bay (Moyle 2002). Sacramento–San Joaquin Roach are generally found  
13 in small, warm, intermittent streams, and are most abundant in mid-elevation streams in the Sierra  
14 foothills and in the lower reaches of some coastal streams (Moyle 2002; Moyle et al. 1982).

15 Assuming that the Sacramento–San Joaquin Roach is indeed a single taxon (which is unlikely), it is  
16 abundant in a large number of streams although it is now absent from a number of streams and  
17 stream reaches where it once occurred (Moyle 2002). When by themselves, Roach tend to be most  
18 abundant and occupy the open waters of large pools; in the presence of predatory Pikeminnows,  
19 Roach are mostly confined to the edges of pools and to riffles and other shallow-water habitats  
20 (Moyle 2002).

21 Roach spawn from March through early July, usually when water temperatures exceed about 16°C  
22 (61°F) (Moyle 2002). Roach are tolerant of relatively high temperatures (about 86°F to 95°F) and  
23 low oxygen levels (1 to 2 ppm) (Moyle 2002). However, they are habitat generalists, also being  
24 found in cold, well-aerated clear “trout” streams (Moyle 2002), in human-modified habitats (Moyle  
25 2002), and in the main channels of some rivers, such as the Tuolumne (Moyle 2002).

### 26 **11B.4.2 Stressors**

27 Most Sacramento–San Joaquin Roach populations are isolated by downstream barriers such as  
28 dams, diversions, or polluted water containing nonnative predatory fishes (e.g., green sunfish)  
29 (Moyle 2002). Much of their current habitat is on private land, and many streams they inhabit dry  
30 up more frequently or more completely than historically due to diversions and pumping from  
31 aquifers that feed them (Moyle 2002). Predatory fishes such as Largemouth Bass and green sunfish  
32 are often introduced into remaining deep pools for recreational fishing, which typically eliminates  
33 Roach from these areas (Moyle 2002).

34 Only two Roach have been salvaged at the SWP and CVP fish salvage facilities between 1959 and  
35 2005 (Bay Delta and Tributaries Project 2010). However, these salvage numbers represent only the  
36 actual number of Roach counted, not the actual number of Roach salvaged. Therefore, the number of  
37 Roach actually salvaged may be much higher.

## 11B.5 Hardhead

### 11B.5.1 Status, Distribution, Life History, and Habitat Requirements

Hardhead, a California Species of Special Concern, is a large, native cyprinid (minnow) species that is widely distributed throughout the Sacramento–San Joaquin River system, although it is absent from the valley reaches of the San Joaquin River (Moyle 2002). Hardhead generally occur in large, undisturbed low- to mid-elevation rivers and streams of the region (Moyle 2002). While Hardhead are no longer common in the San Joaquin river drainage, they are still fairly common in the mainstem Sacramento River, in the lower reaches of the American and Feather rivers, and in some smaller tributary streams (e.g., Deer, Pine, and Clear Creeks) (Moyle 2002). The precise historical distribution and abundance patterns of Hardhead are unknown, but the presence of their remains in Indian middens (i.e., a mound or deposit containing shells, animal bones, and other refuse) suggests that they were common in the general Delta region when the Delta was still a largely undisturbed intertidal swamp (The Bay Institute 1998). Most spawning is restricted to foothill streams (Wang and Reyes 2007) and, therefore, outside of the Delta. Historically, Hardhead were very abundant in reservoirs; however, most reservoir populations were temporary due to the introduction of nonnative predatory species (Moyle 2002). Populations in Shasta Reservoir declined dramatically within a period of 2 years, although Hardhead may still be present there in small numbers (Moyle 2002).

Most streams in which Hardhead occur have summer water temperatures above 20°C (68°F), while their optimal temperatures appear to be about 24°C to 28°C (75°F to 82°F) (Moyle 2002).

### 11B.5.2 Stressors

Hardhead distribution and abundance in the Central Valley have declined in central California (Moyle 2002). The causes of Hardhead declines appear to be habitat loss and predation by introduced fishes, particularly Smallmouth Bass and other centrarchids (Moyle 2002). Many large to medium, cool to warm water streams have been dammed and diverted, eliminating Hardhead habitat, isolating upstream areas, and creating temperature and flow regimes that are not suitable for Hardhead (Moyle 2002).

Very few Hardhead appear to be salvaged at the SWP and CVP fish salvage facilities. For example, from April 1, 2000, through March 31, 2003, the average annual salvage of Hardhead at the Tracy Fish Facility was four individuals (Bureau of Reclamation 2009). Between 1993 and 2000, only 38 Hardhead were counted at the SWP and CVP fish salvage facilities, occurring during the months of January, May, July, November, and December (Bay Delta and Tributaries Project 2010). However, these salvage numbers represent only the actual number of Hardhead counted, not the actual number of Hardhead salvaged. Therefore, the number of Hardhead actually salvaged may be much higher. However, very few Hardhead appear to be collected during fisheries surveys in the Delta (e.g., Fall Midwater Trawl, Towntnet Survey) (Bay Delta and Tributaries Project 2010).

## 11B.6 Sacramento Perch

### 11B.6.1 Status, Distribution, Life History, and Habitat Requirements

Sacramento Perch is the only species of the family Centrarchidae (i.e., sunfishes) that naturally occurs west of the Rocky Mountains (Moyle 2002). Sacramento Perch are deep-bodied, laterally compressed centrarchids (sunfishes). Historically, Sacramento Perch were found throughout the Central Valley, the Pajaro and Salinas rivers, and Clear Lake (Moyle 2002). The only populations today that represent continuous habitation within their native range are those in Clear Lake and Alameda Creek (Moyle 2002). Within their native range, Sacramento Perch exist primarily in farm ponds, reservoirs, and lakes into which they have been introduced (Moyle 2002). Sacramento Perch are often associated with beds of rooted, submerged, and emergent vegetation and other submerged objects. Sacramento Perch are able to tolerate a wide range of physicochemical water conditions. This tolerance is thought to be an adaptation to fluctuating environmental conditions resulting from floods and droughts. Thus, Sacramento Perch do well in highly alkaline water (McCarragher and Gregory 1970; Moyle 1976). Most populations today are established in warm, turbid, moderately alkaline reservoirs or farm ponds. Spawning occurs during spring and early summer when water temperatures are about 18°C to 29°C (64°F to 82°F), and usually begins by the end of March, continuing through early August (McCarragher and Gregory 1970).

### 11B.6.2 Stressors

Sacramento Perch were apparently largely gone from the Delta by the time of the major fish surveys of the 1950s and 1960s (Moyle 2002). Because Sacramento Perch are tolerant of a wide range of conditions, they would still likely be abundant throughout their native range in the absence of introduced centrarchids, especially crappie and sunfishes, which successfully compete with Sacramento Perch (Moyle 2002) and may prey on their embryos and larvae (Moyle 2002). Interspecific competition for food and space may be the single most important cause of the Sacramento Perch decline (Moyle 2002).

Only two Sacramento Perch have been reportedly salvaged at the SWP and CVP fish salvage facilities between 1959 and 2005, while only two have been reportedly caught during Delta fisheries surveys during the same time period (Bay Delta and Tributaries Project 2010). However, these salvage numbers represent only the actual number of Sacramento Perch counted, not the actual number of Sacramento Perch salvaged.

## 11B.7 Sacramento Tule Perch

### 11B.7.1 Status, Distribution, Life History, and Habitat Requirements

Tule Perch is the only freshwater species of the family Embiotocidae (i.e., surfperches) (Moyle 2002). Tule Perch consists of three subspecies: Sacramento Tule Perch, Clear Lake Tule Perch, and Russian River Tule Perch (Moyle 2002). Sacramento Tule Perch are native to most lowland rivers and creeks in the Central Valley, larger tributaries to the San Francisco estuary, Petaluma River,

1 Coyote Creek, the San Joaquin River drainage, the Delta, and Suisun Marsh (Moyle 2002). Tule Perch  
 2 in the San Joaquin drainage are found mainly in the Stanislaus River, but they are occasionally found  
 3 in the San Joaquin River near the Delta (Moyle 2002). Tule Perch are often one of the most common  
 4 fish species found in areas with heavy cover or beds of aquatic plants in the mainstem American and  
 5 Sacramento rivers (Moyle 2002). Tule Perch have been caught during Suisun Marsh Fisheries  
 6 Monitoring surveys almost every month of every year from 1979 to 2005 (Bay Delta and Tributaries  
 7 Project 2010). Salvage of Tule Perch occasionally has been documented at the SWP and/or CVP fish  
 8 salvage facilities in the Delta. For example, annual salvage of Tule Perch at the Tracy Fish Collection  
 9 Facility has reportedly ranged from 24 to 228 individuals from 2003 through 2008 (Gartz 2006;  
 10 Gartz 2007; Aasen 2009). However, these salvage numbers represent only the actual number of Tule  
 11 Perch counted, not the actual number of Tule Perch salvaged.

12 Tule Perch are most often found in low-elevation lakes, streams, and estuarine environments  
 13 (University of California, Davis 2010). Tule Perch prefer beds of emergent aquatic plants, deep pools,  
 14 and banks with complex cover, such as overhanging bushes, fallen trees, undercut banks, riprap, and  
 15 forage close to the bottom (Moyle 2002). Tule Perch spawn among tule marshes and other types of  
 16 vegetation during July through September (Wang 1986; Moyle 2002). Females give birth to their  
 17 young during May or June (Moyle 2002). Within a river or stream Tule Perch tend to occupy deep  
 18 pools that have complex cover in the form of aquatic and overhanging vegetation (University of  
 19 California, Davis 2010). Tule Perch eat small invertebrates associated with aquatic plants, small  
 20 amphipods, and benthic prey, such as midge larvae, small clams, brachyuran crabs, mysid shrimp,  
 21 chironomid midges, baetid and ephemereid mayflies, and other aquatic insects (Moyle 2002).  
 22 While Tule Perch focus their feeding on the bottom of a lake, they may also forage in the water  
 23 column (University of California, Davis 2010).

24 Tule Perch typically require cool, well oxygenated water. They are rarely found in water that is  
 25 warmer than 25°C (77°F) for extended periods of time, and generally prefer water temperatures  
 26 below about 22°C (72°F) (Moyle 2002). Tule Perch have a high salinity tolerance and have been  
 27 found in water with a salinity as high as 30 ppt (University of California, Davis 2010).

## 28 **11B.7.2 Stressors**

29 Populations of Tule Perch that have been extirpated in most of the San Joaquin River basin may have  
 30 been caused by poor water quality and toxic chemicals (Moyle 2002). The Stanislaus River  
 31 population is small and is in continual danger of extinction (Moyle 2002). However, they seem to be  
 32 able to persist in small numbers as long as there is suitable cover and suitable water quality (Moyle  
 33 2002). In the San Francisco Estuary, Tule Perch appear to be in long-term decline, potentially due to  
 34 increased populations of centrarchids (Moyle 2002).

## 35 **11B.8 Threadfin Shad**

### 36 **11B.8.1 Status, Distribution, Life History, and Habitat** 37 **Requirements**

38 Threadfin Shad were intentionally introduced to provide forage for game fish. Threadfin Shad were  
 39 planted by DFW in reservoirs throughout California, with the Sacramento–San Joaquin River  
 40 drainage planted in 1959. From these transplants, they have become established in the Sacramento–

1 San Joaquin River system and its estuary. Threadfin Shad live mainly in freshwater and become  
2 progressively less abundant as salinity increases. Juveniles form dense schools and, in estuaries, are  
3 found in water of all salinities, although they are most abundant in freshwater. Threadfin Shad are  
4 fast-growing but short-lived. Few live longer than 2 years. Spawning takes place in California in  
5 April through August, peaking in June and July when water temperatures exceed 68°F, although  
6 spawning has been observed at 14°C to 18°C (57°F to 64°F). The embryos hatch in 3 to 6 days and  
7 larvae immediately assume a planktonic existence.

## 8 **11B.8.2 Stressors**

9 Threadfin Shad larvae are weak swimmers and thus are susceptible to entrainment in water  
10 diversions and power plant intakes. Threadfin Shad is salvaged at the SWP and CVP fish salvage  
11 facilities in higher abundances than any other fish species. Herbold et al. (2005) estimated actual  
12 annual salvage of Threadfin Shad from 1994 through 2005, with annual salvage numbers ranging  
13 from approximately 1.5 million to about 10 million.

## 14 **11B.9 Bay Shrimp**

### 15 **11B.9.1 Status, Distribution, Life History, and Habitat** 16 **Requirements**

17 The Bay Shrimp (*Crangon franciscorum*) is abundant in bays with mud and sandy bottoms and  
18 offshore in deeper waters. It is sensitive to temperature and salinity changes during its life cycle  
19 (Pacific States Marine Fisheries Commission 1996). During reproductive periods that vary greatly  
20 with geographical location, Bay Shrimp move toward more saline areas of the estuaries to spawn. In  
21 their early life stages, juveniles utilize the upper parts of estuaries as nurseries, preferring the lower  
22 salinity there. As it grows and matures, the Bay Shrimp moves to more saline areas of the estuary  
23 and offshore. Water temperature is especially critical to the Bay Shrimp as a regulator of its life  
24 functions. Bay Shrimp commonly feeds on bottom dwelling animals (epibenthic fauna), amphipods,  
25 and plant material. In search of food, Bay Shrimp agitate the bottom and cycle nutrients into coastal  
26 systems.

### 27 **11B.9.2 Stressors**

28 Because of the Bay Shrimp's preference for different levels of salinity during its lifecycle, freshwater  
29 inflow into estuaries strongly influences distribution, survival, and abundance. Maintaining the flow  
30 of freshwater into estuaries is critical because of its impact on water temperature, salinity, and  
31 landward currents. Because estuaries play a critical role in the Bay Shrimp's life history, alteration of  
32 this habitat directly affects its populations.

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## 18 **11B.11 Acronyms**

19	BDAT	Bay Delta and Tributaries Project
20	CALFED	CALFED Bay-Delta Program
21	DFG	California Department of Fish and Game
22	cm	centimeter
23	CVP	Central Valley Project
24	DO	dissolved oxygen
25	mg/L	milligrams per liter
26	mm	millimeter
27	ppt	parts per thousand
28	SWP	State Water Project
29	U.C. Davis	University of California–Davis
30	USFWS	U.S. Fish and Wildlife Service
31	YOY	young-of-year