Appendix 11B

Non-Covered Fish and Aquatic Species Descriptions

Appendix 11B
Non-Covered Fish and Aquatic Species Descriptions

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

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

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

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

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

Spawning occurs en masse, with average female fecundity within the Bay-Delta population being between 243,000 and 1.4 million eggs, depending on the size of the spawning female (Stevens et al. 1985). Eggs are semi-buoyant and are distributed throughout the water column by currents (Able and Fahay 1998). A current strong enough to keep the eggs suspended in the water column is an important requirement for spawning habitat. If the current is not strong enough, eggs may settle on the bottom and become smothered (Collette and Klein-MacPhee 2002). After fertilization, eggs hatch within 2 to 3 days, followed by a net movement of the larval fish from upstream locations to downstream, tidal portions of the river (Moyle 2002).

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

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

11B.1.2 Stressors

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

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

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

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

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

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

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

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

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

11B.2 American Shad

11B.2.1 Status, Distribution, Life History, and Habitat Requirements

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

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

Shad have remarkable abilities to navigate and to detect minor changes in their environment (Leggett 1973). Although homing is generally assumed in the Sacramento River and its tributaries, there is some evidence that numbers of first-time spawning (i.e., "virgin") fish are proportional to flows of each river at the time the Shad arrive. When suitable spawning conditions are found, American Shad school and broadcast their eggs throughout the water column. The optimal temperature for egg development is reported to occur at 62°F. At this temperature, eggs hatch in 6 to 8 days; at temperatures near 75°F, eggs would hatch in 3 days (MacKenzie et al. 1985). Egg incubation and hatching, therefore, are coincident with the spawning period.

11B.2.2 Stressors

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

11B.3 Largemouth Bass

11B.3.1 Status, Distribution, Life History, and Habitat Requirements

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

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

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

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

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

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

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

Largemouth Bass prefer warm, quiet waters with aquatic vegetation and low turbidity (Lee et al. 1980; Moyle 2002). The current Bay-Delta invasion of Brazilian waterweed has enhanced the habitat of Largemouth Bass and other centrarchids, to the disadvantage of native species (CALFED Bay-Delta Program 2008). Brown and Michniuk (2007) noted that Brazilian waterweed presence increased catch per unit effort for alien fish species, particularly centrarchids, but did not alter the overall fish species composition. Brazilian waterweed forms thick wall-like stands along the margins of channels and shallow water habitat in the Delta. Water hyacinth creates dense floating mats that can impede river flows and alter the aquatic environment beneath the mats. By reducing water velocities near plants, these species reduce turbidity in the water column. DO levels beneath the mats often drop below suitable levels for other fish species due to the increased amount of decaying vegetative matter produced from the overlaying mat and diel respiration required by aquatic plants. Largemouth Bass are known to tolerate DO levels as low as 1 mg/L and prefer warm, clear water (Moyle 2002). Like Brazilian waterweed, water hyacinth is often associated with the margins of the Delta waterways in its initial colonization, but can eventually cover the entire channel if conditions permit. High levels of infestation by these nonnative aquatic plants appear to be enhancing Largemouth Bass habitat.

11B.3.2 Stressors

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

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

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

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

Within the Delta there has been a growing popularity for Largemouth Bass recreational angling tournaments (Bureau of Reclamation et al. 2009). Tournaments are held year-round with prizes awarded based on weight of individual bass and total weight of up to five bass. Tournament anglers are required to maintain the bass alive, which are then released back into the Delta after completing the weigh-in. The number of bass anglers, the number of tournaments, and the size of individual bass have all been increasing in recent years. Several of the recreational tournaments held recently in the Delta have been televised nationally (e.g., Bass Masters Invitational).

11B.4 Sacramento–San Joaquin Roach

11B.4.1 Status, Distribution, Life History, and Habitat Requirements

The Sacramento–San Joaquin Roach, a California Species of Special Concern, is part of the California Roach complex, which consists of various subspecies (Moyle 2002). The Sacramento–San Joaquin Roach is found in the Sacramento and San Joaquin river drainages, except the Pit River, as well as tributaries to San Francisco Bay (Moyle 2002). Sacramento–San Joaquin Roach are generally found in small, warm, intermittent streams, and are most abundant in mid-elevation streams in the Sierra foothills and in the lower reaches of some coastal streams (Moyle 2002; Moyle et al. 1982). Assuming that the Sacramento–San Joaquin Roach is indeed a single taxon (which is unlikely), it is abundant in a large number of streams although it is now absent from a number of streams and stream reaches where it once occurred (Moyle 2002). When by themselves, Roach tend to be most abundant and occupy the open waters of large pools; in the presence of predatory Pikeminnows, Roach are mostly confined to the edges of pools and to riffles and other shallow-water habitats (Moyle 2002).

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

11B.4.2 Stressors

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

Only two Roach have been salvaged at the SWP and CVP fish salvage facilities between 1959 and 2005 (Bay Delta and Tributaries Project 2010). However, these salvage numbers represent only the actual number of Roach counted, not the actual number of Roach salvaged. Therefore, the number of 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, Townet 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 (McCarraher 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 (McCarraher 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 larave (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, Coyote Creek, the San Joaquin River drainage, the Delta, and Suisun Marsh (Moyle 2002). Tule Perch in the San Joaquin drainage are found mainly in the Stanislaus River, but they are occasionally found in the San Joaquin River near the Delta (Moyle 2002). Tule Perch are often one of the most common fish species found in areas with heavy cover or beds of aquatic plants in the mainstem American and Sacramento rivers (Moyle 2002). Tule Perch have been caught during Suisun Marsh Fisheries Monitoring surveys almost every month of every year from 1979 to 2005 (Bay Delta and Tributaries Project 2010). Salvage of Tule Perch occasionally has been documented at the SWP and/or CVP fish salvage facilities in the Delta. For example, annual salvage of Tule Perch at the Tracy Fish Collection Facility has reportedly ranged from 24 to 228 individuals from 2003 through 2008 (Gartz 2006; Gartz 2007; Aasen 2009). However, these salvage numbers represent only the actual number of Tule Perch counted, not the actual number of Tule Perch salvaged.

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

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

11B.7.2 Stressors

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

11B.8 Threadfin Shad

11B.8.1 Status, Distribution, Life History, and Habitat Requirements

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

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

11B.8.2 Stressors

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

11B.9 Bay Shrimp

11B.9.1 Status, Distribution, Life History, and Habitat Requirements

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

11B.9.2 Stressors

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

11B.10 References

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11B.11 Acronyms

BDAT	Bay Delta and Tributaries Project
CALFED	CALFED Bay-Delta Program
DFG	California Department of Fish and Game
cm	centimeter
CVP	Central Valley Project
DO	dissolved oxygen
mg/L	milligrams per liter
mm	millimeter
ppt	parts per thousand
SWP	State Water Project
U.C. Davis	University of California–Davis
USFWS	U.S. Fish and Wildlife Service
YOY	young-of-year