SACRAMENTO SPLITTAIL

Pogonicheilus macrolepidotus
USFWS: None
CDFG: None

Species Account

Status and Description. The Sacramento splittail was listed as a federally threatened species on February 8, 1999 (Federal Register 1999) and it was delisted on September 22, 2003 (Federal Register 2003). The USFWS made a final determination that listing was not warranted on October 7, 2010 (Federal Register 2010). Sacramento splittails are large fish in the cyprinid family (Cyprinidae) and are one of two species in the genus, *Pogonichthys*; the other species *P. ciscoides* became extinct from Clear Lake, Lake County, in the early 1970s (CDFG 1995). Sacramento splittail reach 12 inches in length (30 centimeters, with a maximum size of 40 centimeters) (CDFG 1995). Early larvae are 6 millimeters long and 7-8 millimeters in total length when they complete yolk-sac absorption and become free swimming (Sommer 2000). Sacramento splittail are distinctive in having the upper lobe of the tail fin larger than the lower lobe. They are elongate in shape with a blunt head and may have small barbels (whisker-like sensory organs) on either side of the sub-terminal mouth. They possess 14-18 gill rakers, and their pharyngeal teeth are hooked and have narrow grinding surfaces. The species has 9-10 dorsal rays, 16-19 pectoral rays, 8-9 pelvic rays, and 7-9 anal rays (USFWS 2002). The lateral line usually has 60-62 scales, but ranges from 57-64. Sacramento splittail are colored silver on the sides and have olive gray backs. Adults develop a nuchal hump (i.e., protuberance on the fish's nape). During the breeding season, the tail, pectoral, and pelvic fins exhibit a red-orange hue and males develop small white nuptial tubercles in the head region (USFWS 2002).

Photo courtesy of California Dept of Fish and Game

Range, Populations and Activity. Historically, the Sacramento splittail resided throughout the Sacramento-San Joaquin River drainage in California's Central Valley (USFWS 2002). They were found as far north as Redding at the Battle Creek Fish Hatchery in Shasta County on the Sacramento River and as far south as the Friant Dam on the San Joaquin River. In the past, Sacramento splittail have been collected in the Feather River as far upstream as Oroville, the American River as far upstream as Folsom, the Merced River at Livingston, the San Joaquin River at Fort Miller (where Friant Dam is presently), southern San Francisco Bay, and at the mouth of Coyote Creek in Santa Clara County (CDFG 1995). Until the mid-1980s, splittail were common in San Pablo Bay and Carquinez Strait following high winter flows (USFWS 2002).

Sacramento splittail were found in the San Joaquin River below its confluence with the Merced River and large numbers of juveniles were caught in 1986 in the San Joaquin River, 10-12 kilometers above the junction with the Tuolumne River (CDFG 1995). In the 1980s, successful spawning was recorded during wet years in the lower Tuolumne River at Modesto, 11 kilometers upstream from the river mouth (CDFG 1995). Splittail have been caught in the San Luis Reservoir (Caywood 1974), which stores water pumped from the Delta.

Currently, native populations are restricted to the San Francisco Bay Delta, Suisun Bay, Suisun Marsh, Napa River, Petaluma River, and other parts of the Sacramento-San Joaquin Estuary (Caywood 1974, Moyle 1976). In the Delta, they are most abundant in the north and west portions, although other areas may be used for spawning (CDFG 1995). In the Sacramento River system, splittail are rare in the main river channel upstream of the Delta, although large individuals are caught in the lower river during the spring (CDFG 1995). In many years, spawning occurs in the reach of the Sacramento River below the confluence with the Feather River (CDFG 1995), and during wet years, in the shallow flooded areas of the Yolo and Sutter bypasses (Meng and Moyle 1995).

Sacramento splittail populations are the largest in the Sacramento-San Joaquin estuary, especially the western Delta and Suisun Marsh, where its population is correlated to outflows, presumably because spawning occurs over flooded vegetation. Thus, when outflows are high, reproductive success is high, and when outflows are low, reproduction is low (Daniels and Moyle 1983). In the Delta, splittail populations are estimated to be only 35-60% as abundant as they were in 1940 and over their historic range, the percentage decline is considered much greater (CDFG 1995). Since 1980, populations in the Delta have declined steadily and in 1992 they declined to their record low (Meng and Moyle 1995). Population levels appear to fluctuate widely from year to year; CDFG midwater trawl data for 1967-1990 indicate a decline from the mid-1960s to the late 1970s, a resurgence (with fluctuations) through the mid-1980s, and a decline from 1986 to 1995 (CDFG 1995). Survey data for Suisun Marsh (Meng and Moyle 1995) show a substantial decline in numbers during the period 1979-1991. Data from the CDFG Bay survey and fish salvage operations for the SWP and CVP south Delta indicate that splittail recruitment success is highly variable (CDFG 1995). Large numbers of young fish were observed in 1982, 1983 and 1986, but recruitment was low in 1980, 1984, 1985, and 1987-1990 (CDFG 1995). Since 1985, splittail have been rare in San Pablo Bay, and confined to the upper Bay-Delta areas and isolated areas such as the Petaluma and Napa rivers (CDFG 1995). From 1995 to 1998, the population increased dramatically, which demonstrates how splittail recruitment success fluctuates widely from year to year over time (Sommer *et al*. 1997). In 1999 and 2000, total splittail abundance in the Fall Midwater Trawl Survey declined substantially from the high numbers in 1998 (from approximately 275 to less than 50 fish) (IEP 2001). Nevertheless, the Bay Study midwater trawl study indicated that splittail numbers increased from 1999, but remained well below the exceptionally high numbers of 1998 (IEP 2001).

The spawning period for splittail begins in late January and early February and lasts through July (Wang 1986), with most spawning occurring from February through April (USFWS 2002). The onset of spawning in the upper Delta seems to be associated with increasing water temperature and day length between early March and May (Caywood 1974). Salvage records from SWP pumps show that adults are captured most frequently in December through May, when they are presumably engaged in spawning movements, while young fish are mostly captured from May through September (Meng and Moyle 1995). These records indicate most spawning occurs from February through April, following an upstream migration by adults (CDFG 1995). Older fish tend to reproduce first, followed by younger fish, which often reproduce later in the season (Caywood 1974). Generally, gonadal development is initiated by fall, with a concomitant decrease in somatic growth (Daniels and Moyle 1983). By April, ovaries reach peak maturity and account for approximately 18% of the fish's body weight (CDFG 1995).

Adult splittail migrate upstream from brackish areas to spawn in freshwater in areas subject to flooding (USFWS 2002), such as the lower reaches of rivers (Caywood 1974), dead-end sloughs

(Moyle 1976), and in larger sloughs such as Montezuma Slough (Wang 1986). Splittail probably spawn on submerged vegetation in flooded areas (CDFG 1995). Larvae remain in the shallow, weedy areas inshore in close proximity to the spawning sites for 10 to 14 days and move into the deeper offshore habitat as they mature (Wang 1986, Sommer *et al*. 1997).

Sacramento splittail are relatively long-lived (about five to seven years) and are highly fertile (up to 100,000 eggs per female) (CDFG 1995). Both males and females mature by the end of their second year (Daniels and Moyle 1983), although occasionally males mature by the end of their first year and females by the end of their third year (Caywood 1974). Fish are about 7-8 inches in length when they attain sexual maturity (Daniels and Moyle 1983), and the sex ratio among mature individuals is 1:1 (Caywood 1974).

Meng and Moyle (1995) found a weak stock-recruitment relationship in splittail ($r2 = .22$, $N = 14$), because strong year classes were associated with relatively low adult numbers in years with high outflow in the early spring (1982, 1986). Also, in most years between 1983 and 1995, recruitment was lower than expected, given the strong positive relationship between outflow and abundance of splittail young-of-year (Meng and Moyle 1995).

Splittail are benthic foragers that feed extensively on opossum shrimp (*Neomysis mercedis*), detrital (non-living and detached organic) material, earthworms, clams, crustaceans, benthic amphipods (*Corophium* spp.), insect larvae, oligochaetes, zooplankton (cladocerans and harpactacoid copepods), and terrestrail insects (Daniels and Moyle 1983, CDFG 1995, Sommer 2000).

Habitat Use. Sacramento splittail are primarily freshwater fish, but are tolerant of moderate salinity and can survive in water with salinities of 10-18 parts per thousand (USFWS 2002). In the 1950s, they were commonly caught in Suisun Bay during periods of fast tides, but in recent years, have been found mostly in slow-moving sections of rivers and sloughs, and in dead-end sloughs such as in the Delta and Suisun Marsh (Moyle 1976, Daniels and Moyle 1983). Splittail seem to prefer shallow-water habitat with low-salinity (0-10 parts per thousand) (Meng and Moyle 1995, Sommer *et al*. 1997). Young and Cech (1996) found that splittail have critical salinity maxima of 20-29 parts per thousand. Splittail can also tolerate water temperatures between 7-33 degrees Celsius, with a critical maxima range from 22-33 degrees Celsius (Sommer 2000). They also appear to be tolerant of low dissolved oxygen levels and strong water currents (Sommer 2000).

Splittail spawn on submerged vegetation in temporarily flooded upland and riparian habitat (USFWS 2002). Typically, seasonally flooded terrestrial shrubs and herbs are preferred over emergent wetland vegetation such as cattails and tules (Caywood 1974). Spawning occurs in the lower reaches of rivers (Caywood 1974), dead-end sloughs (Moyle 1976) and in the larger sloughs such as Montezuma and Suisun Slough (Daniels and Moyle 1983, Wang 1986). Adults and juveniles utilize shallow submerged vegetation for foraging and cover from predators (Sommer 2000). Larvae forage in the shallow, weedy areas inshore near the spawning sites and move into the deeper offshore habitat as they mature (USFWS 2002).

Population Levels and Occurrence in Plan Area. Sacramento splittail are mainly associated with the open water portions of the Coastal Marsh vegetation in the Coastal Marsh Natural Community of the Plan Area. The species can also be expected in open water areas of Freshwater Marsh and

Streams/Sloughs within the Riparian, Streams, and Freshwater Marsh Natural Community. Nine occurrence records of Sacramento splittail were found for Solano County.

In the 1950s, Sacramento splittail were commonly caught by striped bass anglers in Suisun Bay (USFWS 2002). They are year-round residents of the Suisun Marsh, concentrating in the dead-end sloughs that typically have small streams feeding into them. Survey data for Suisun Marsh (Meng and Moyle 1995) show a substantial decline in numbers during the period 1979-1991 (catch per trawl of 7 adults and 15 young-of-year in 1979; 2 adults and 1 young-of-year per trawl in 1991; mean catch in 1979-1983, ca. 188 fish per month; mean catch in 1987-1990, ca. 25 fish per month; 1990-1992, 3-5 fish per month). Although they are most abundant in Suisun Bay and Marsh, they are also common in and around the marshy areas of Sherman Island and Big Break (Meng and Moyle 1995). They also occur in Suisun Slough and Napa Marsh. The Yolo Bypass also represents key spawning and rearing habitat for splittail (Sommer *et al*. 2001).

Dispersal. Adults migrate upstream from brackish areas to spawn in freshwater. Spawning begins by late January and early February and continues through July, with most spawning occurring from February through April (USFWS 2002). Larvae remain in the shallow, weedy areas inshore in close proximity to the spawning sites and migrate into the deeper offshore and more riverine habitat as they mature (Wang 1986).

Threats to the Species. From 1984-1999, the Sacramento splittail declined by 62 percent (Federal Register 1999). The range of splittail has also steadily declined and is largely confined to the Sacramento-San Joaquin estuary, except for occasional forays upstream to spawn. The splittail's long-term survival depends upon conditions in the estuary and the provision of adequate spawning habitat. The continuing decline in splittail numbers can be attributed to a variety of factors, including reduction in valley floor habitats, changed estuarine hydraulics (especially reduced outflow), modification of spawning habitat, climatic variation, toxic substances, introduced species, predation, and exploitation (CDFG 1995, Bennett and Moyle 1996, Federal Register 1999).

The reduction in valley floor habitats was a major factor in the decline of the species. The Sacramento and San Joaquin valleys once had many flood plains that presumably provided valley floor habitat for Sacramento splittail. These habitats were similar to the present-day habitats in the Delta and Suisun Marsh. Almost all of these habitats have since been lost due to modern agricultural practices (Moyle 2002).

The reduction of water flows and changed hydraulics in the Sacramento-San Joaquin Delta appears to have been the preeminent factor in the decline of the Sacramento splittail (CDFG 1995). In the 1980s, deliveries from Central Valley Project, State Water Project, or private organization ranged from 1.5 million acre-feet to 2.8 million acre-feet and deliveries up to 4.2 million acre-feet are planned by 2010 (Federal Register 1999). Changes in timing and amounts of exports affect fish migration and spawning habits, as well as operations of upstream water storage facilities (Federal Register 1999). Daniels and Moyle (1983) found that year-class success of splittail was positively correlated with Delta outflow, and Caywood (1974) found that splittail require winter runoff sufficiently high to flood the peripheral areas of the Delta. Meng and Moyle (1995) indicated a negative relationship between the amount of water diverted from the Delta and abundance of young splittail, and noted that the effect of the diversions was particularly strong during periods of prolonged drought. While the reduction of splittail survival during low outflow-high diversion years

is not well understood, direct entrainment in the CVP and SWP pumps and shifting of splittail populations to the presumably less favorable conditions of the south Delta are likely contributors to low survival (CDFG 1995). Exceptionally high numbers of splittail have been salvaged from the pumping plants in 1982, 1986, and 1993, with no apparent relationship to actual abundance (CDFG 1995). In addition, since 1983, catches of splittail in the fall midwater trawl survey have become more frequent in the south Delta and the Sacramento River and less frequent in Suisun Bay (Meng and Moyle 1995). Therefore, larval and young-of-the-year splittail could have an increased probability of within-delta entrainment and less favorable conditions for growth and survival (CDFG 1995).

The decrease in riparian marshlands and floodable areas in recent decades is likely to be a major contributor to the decline of splittail. Splittail spawn on flooded vegetation in the lower reaches of rivers and the Delta. The increase in flooded vegetation is presumably one of the factors contributing to splittail year-class success in wet years. The flood basins in the Sacramento and San Joaquin valleys have all been reclaimed or modified for flood control purposes (e.g., Yolo and Sutter bypasses) (Federal Register 1999). Changes in reservoir operations and ramping rates for flood control may affect shallow water spawning habitat along river corridors and exacerbate stranding of splittail. Although splittail will use the Yolo and Sutter bypasses during the winter and spring months for foraging and spawning (Sommer *et al*. 1997), under current water management practices, the bypasses cannot be relied upon to provide habitat for splittail. The bypasses provide accessible and suitable splittail spawning habitat only during wet years where the water remains on the bypasses for an extended period of time (Federal Register 1999).

The prolonged drought from the mid-1980s to mid-1990s led to a natural decrease in outflow and an increase in the proportion of inflowing water being diverted. Splittail populations would be expected to decline from the reduced outflow, due to the reduced availability of spawning and larval rearing habitat. However, the increase in diversions has threatened splittail populations through a combination of further reduction in habitat, especially in the lower Delta and Suisun Marsh, and increased entrainment of larvae, juveniles, and adults (CDFG 1995). Although splittail are known to tolerate fluctuating conditions, historically they did not experience the extreme conditions caused by increased diversion of water nor did they have the reduced populations that make recovery from natural disasters much more difficult (CDFG 1995).

Susceptibility to disease due to toxic substances and poor water quality may be a factor in the decline of splittail (CDFG 1995). The south Delta is dominated by San Joaquin River flow, a large part of which is made up of agricultural drainage that contain pesticides (e.g., chlorpyrifos, carbofuran, and diazinon), salts (e.g., sulfates, selenium), and total dissolved solids and cause poor water quality (Federal Register 1999). Poor water quality may adversely affect splittail, through direct exposure to toxins, which increases vulnerability to disease, and depletion of zooplankton and invertebrate food sources. Splittail may be similarly affected by industrial chemical runoff and heavy metal contaminants released into the Estuary from industrial, urban, and mining enterprises. While the effects of these contaminating compounds on splittail larvae and their zooplankton food resources are not well known, the compounds could adversely affect survival (Federal Register 1999).

Introduced species in the Sacramento-San Joaquin estuary, especially those that are introduced from the ballast water of ships could also threaten populations of splittail. The most recent problem introductions have been several species of planktonic copepods and the Asiatic clam (*Potamocorbula*

amurensis)(CDFG 1995). The copepods seem to be replacing the native copepod (*Eurytemora affinis*) which is a major food source of larval fish and of opossum shrimp, the favored prey of splittail. The Asiatic clam may have a direct effect on splittail populations because it has become extremely abundant in Suisun Bay and appears to be filter-feeding planktonic algae, which is preyed upon by opossum shrimp. However, the Asiatic clam will likely become less abundant in response to increased freshwater outflows and to its discovery as a food source by fishes such as sturgeon, by invertebrates such as the invading mitten and green crabs, and by diving ducks (CDFG 1995). The Chinese mitten crab (*Eriocheir sinensis*) has also been recently introduced to the Delta and has interfered with the ability to effectively salvage splittail at the export facilities by clogging the internal piping (Federal Register 1999).

Predation is thought to be a relatively minor factor affecting the Sacramento splittail (Federal Register 1999). Splittail are preyed upon by introduced striped bass but they have successfully coexisted with them since their introduction in the 1870s (CDFG 1995). However, increased predation by bass and other predators on splittail drawn into Clifton Court Forebay by the changed hydraulics of the Delta may be a contributing factor in their decline. In addition, the artificial enhancement of striped bass populations with hatchery fish (until 1992, when it was halted) may have artificially increased predation rates on splittail (CDFG 1995). Increases in striped bass populations could threaten reduced numbers of splittail (Federal Register 1999).

Exploitation has not been known to be major contributor to the decline of splittail. Some scientific collecting has been conducted for splittail but these activities are not known to adversely affect the species (Federal Register 1999). Striped bass anglers report occasional use of splittail as bait, but this usage is thought to be minimal (Federal Register 1999). A small fishery for splittail used to exist in the Sacramento River (Daniels and Moyle 1983, Caywood 1974).

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