SACRAMENTO HITCH
Lavinia exilicauda exilicauda (Baird and Girard)

Status: Moderate Concern. Sacramento hitch exist mainly as scattered, small, populations over a fairly broad geographic area and appear to be in long-term decline. The status of remaining populations needs systematic investigation.

Description: Hitch are deep-bodied cyprinids with a terminal, slightly upturned mouth that can grow to over 350 mm SL. The body is moderately elongated and thick, almost oval shaped in cross section (Hopkirk 1973, Moyle 2002). The head is relatively small and conical. The caudal peduncle is narrow. Scales are fairly large, 54-62 along the complete, decurved lateral line. Sacramento hitch have 10-13 dorsal fin rays, 11-14 anal fin rays, and 17-26 gill rakers. The pharyngeal teeth are long, narrow and slightly hooked, while the surfaces are relatively broad and adapted for grinding food (Moyle 2002). Young fish are silver and have a dark, triangular blotch on the caudal peduncle. As fish age, they become duller in color with the dorsal area turning brownish-yellow (Moyle 2002).

Taxonomic Relationships: Hitch are most closely related to California roach (*Lavinia symmetricus*) and they interbreed in some areas (Avise et al. 1975). Hitch can also hybridize with Sacramento blackfish, although hybrids are apparently sterile (Moyle and Massingill 1981). Three subspecies of hitch exist in California: Clear Lake hitch, *L. e. chi*, Monterey hitch, *L. e. harengus*, from the Pajaro and Salinas rivers and the type subspecies, Sacramento hitch, *L. e. exilicauda*. For a more detailed review of hitch systematics, see the Clear Lake hitch account in this report.

Life History: Sacramento hitch are omnivorous and feed upon zooplankton and insects, usually in open waters or at the surface of streams (Moyle 2002). In streams, they feed on filamentous algae, aquatic insects and terrestrial insects. Small (5-7 cm SL) hitch will feed, like trout, on drift at the heads of pools during the summer. Hitch feed mostly during the day (Moyle 2002). In rivers, they tend to stay in fairly limited areas and have considerable capacity to find velocity refuge in side pools (Jeffres et al. 2006). Myrick and Cech (2000) found they had difficulty sustaining swimming at velocities greater than 0.3 m/sec.

Growth is not well studied but appears to be related to summer temperatures. In San Luis Reservoir, Merced County, hitch reach 11-15 cm by the end of their first year and 15–30 cm by the end of the second year, when they mature. Subsequent increases are 20–50 mm/year, with a maximum size of around 35-40 cm. Hitch in Beardsley Reservoir, on the middle fork Stanislaus River (Tuolumne County), in contrast, are only 40–50 mm FL by the end of the first year and 9–11 cm FL by the end of their second, with subsequent increments of 20–40 mm/year. In Putah Creek, they average about 65 mm FL at the end of their first year and reach 200–250 mm in 3–4 years. Females grow faster and larger than males. Scale analysis indicates that hitch live 4–6 years, but it is likely that analysis of the bony structures of larger fish would yield greater ages (Moyle 2002).

Females usually mature in their second or third year; males mature in their first,

second, or third year. Hitch are rather prolific: females from Beardsley Reservoir contained 3,000–26,000 eggs, with a mean of 9,000, but much higher fecundities (50,000-60,000 eggs) are likely in warmer habitats which contain large fish.

Spawning takes place mainly in riffles of streams tributary to lakes, rivers, and sloughs after flows increase in response to spring rains, although spawning requirements are in need of further documentation. When they are present in ponds and reservoirs with Sacramento blackfish, the two species often hybridize, presumably because they are forced to share spawning areas.

Spawning occurs in groups, with vigorous splashing. A spawning female is closely followed by 1–5 males, which fertilize eggs immediately after their release. Fertilized eggs sink into gravel interstices before absorbing water and then swell to about 4 times their initial size; swelling lodges embryos in the gravel. Hatching takes place in 3–7 days at 15–22°C and larvae become free-swimming in another 3–4 days. Young-of-year hitch spend the next 2 months shoaling in shallow water or staying close to beds of aquatic plants, especially among emergent tules, before moving out into more open water at about 50 mm FL. In permanent streams and ponds, larval and postlarval hitch aggregate around aquatic plants or other complex cover in shallow water. They are most active during the day (Moyle 2002).

Habitat Requirements: Sacramento hitch inhabit warm, lowland, waters including clear streams, turbid sloughs, lakes and reservoirs. In streams they are generally found in pools or runs among aquatic vegetation, although small individuals will also use riffles. Sacramento hitch prefer shallow (< 1 m deep) stream habitats with smaller gravel to mud substrates. Hitch have high temperature tolerances: fish acclimated to 30˚ C can survive temperatures up to 38° C for short periods of time, although they are usually most abundant in the wild in waters cooler than 25°C in summer (Moyle 2002). However, they prefer temperatures between 27-29°C in the laboratory and May and Brown (2002) found small numbers in agricultural drainage canals at temperatures of 25-29°C. They can tolerate low salinities, up to 9 ppt (Moyle 2002, Leidy 2007).

Spawning takes place over gravel riffles, at temperatures ranging from 14 to 26°C, but spawning on vegetation can also take place (Moyle 2002). When floodplains are available, hitch will use them for rearing although juveniles can become stranded once floodwaters recede (Moyle et al. 2007).

Distribution: Hitch were once found throughout the Sacramento and San Joaquin valleys in low elevation streams and rivers, as well as in the Delta. Today they are absent from the San Joaquin River and the lower reaches of its tributaries from Friant Dam down to the Merced River (Brown 2000, CDFG 2007). Populations have become established through introductions in a few reservoirs, such as Beardsley Reservoir, San Luis Reservoir, and Bass Lake (Fresno County). Sacramento hitch have been carried by the California Aqueduct from San Luis Reservoir to several southern California reservoirs, although it is not known if these are reproducing populations (Moyle 2002).

In the Sacramento River, hitch appear to be spread across much of their native range, up to and including Shasta Reservoir. However, populations are scattered (Moyle 2002) so May and Brown (2002) found hitch only at a few localities, in relatively low numbers. Sacramento hitch are also present in some of the larger tributaries to the San

Francisco Estuary (Leidy 2007) and in a few sloughs in the Delta (see next section).

Trends in Abundance: The abundance and distribution of Sacramento hitch is poorly documented, although evidence suggests that they are much less abundant than they were historically. Their distribution is also fragmented, with largely isolated populations scattered among various streams, lakes, and reservoirs. May and Brown (2002), in a survey of Sacramento Valley streams, found hitch in small numbers at only a few valley floor locations. CDFG (2007) and Brown (2000) recorded no hitch in extensive sampling of the lower San Joaquin River. Leidy (2007) noted that hitch were present in 13 of 65 watersheds tributary to the lower San Francisco Estuary and "locally abundant" in only seven; all sites were heavily influenced by urbanization. In the Delta, once an area of great natural resource abundance (including a diversity of native fishes), Brown and May (2006) recorded only 24 hitch from an eight year seining program that captured over 43,000 fish of a variety of species. Moyle et al. (2007) captured only small numbers of hitch in a 5 year study of the fishes using the tidal sloughs and floodplain of the Cosumnes River and none in the river itself. Likewise, Nobriga et al. (2005) encountered only 174 hitch in a program that captured over 79,000 fish in the Delta. However, similar numbers were taken in extensive sampling of the Delta in 1961-62 (Turner 1966) suggesting little change in their minority status. Nevertheless, Brown and Michniuk (2007) compared electrofishing captures of native fishes in the Delta between 1980-83 and 2001-2003 and found a general decline in native fishes, including hitch. They also determined that hitch seem to be largely confined to the northern Delta. Feyrer and Healey (2002) concluded that hitch had been extirpated from the southern Delta by the time of their study (1993-94).

Nature and Degree of Threats: Sacramento hitch occur in the lowland reaches of rivers and streams most impacted by human use, as well as in some reservoirs. Given that they persist in some urban streams, it appears hitch are capable of surviving in highly altered habitats although their abundance in such extreme environments is likely limited. Best evidence indicates that their populations are localized and fragmented today which, in turn, suggests that they may be particularly susceptible to a combination of anthropogenic stressors (Table 1).

Dams. Many dams exist on California's Central Valley rivers; these dams fragment watersheds and often create tailwater conditions that are unfavorable to native fishes such as hitch. Dam releases often provide either too little water or too much cold water, as they are generally intended to benfit salmonids (Brown and Bauer 2009). Thus, hitch were common in the San Joaquin River at Friant until Friant Dam was built; they subsequently disappeared from the area (Moyle 2002). On the other hand, tailwater releases below dams can, at times, create improved habitat for hitch (e.g., Mokelumne River, Jeffres et al. 2006) and the reservoirs impounded by dams are often colonized by hitch. Unfortunately, it is unknown why some reservoirs support hitch populations and others do not, nor why some tailwater streams support hitch populations while others do not. Given the fragmented distribution of hitch populations, it does not appear that regulated rivers and their reservoirs can be relied upon to provide population interconnectivity and suitable habitats to support hitch indefinitely.

	Rating	Explanation
Major dams	High	Dams fragment populations and alter flows
Agriculture	High	Agricultural irrigation alters and reduces flows; agricultural return waters are often warm and polluted with fertilizers, pesticides and other compounds
Grazing	Low	Most grazing occurs at higher elevations than primary habitats occupied by hitch
Rural residential	Medium	Rural development increasing in lowland areas within hitch range
Urbanization	Medium	Numerous metropolitan areas within hitch range; alteration of urban streams reduces or eliminates populations
Instream mining	Low	Gravel mining may create beneficial pools for hitch; legacy impacts from gold mining and dredging widespread throughout range
Mining	n/a	
Transportation	Medium	Roads exist along or cross most habitats and contribute to pollution and sediment input along with potential habitat fragmentation (e.g, culverts or other barriers)
Logging	Low	Historic hitch range largely below forested regions of state
Fire	n/a	
Estuary alteration	High	Delta is now mostly unfavorable habitat with many stressors (altered flows, alien species, pollutants, etc.)
Recreation	n/a	
Harvest	n/a	
Hatcheries	n/a	
Alien species	High	Predation by centrarchid basses and other predatory species may be a threat; particularly acute in the Delta

Table 1. Major anthropogenic factors limiting, or potentially limiting, viability of populations of Sacramento hitch. Factors were rated on a five-level ordinal scale where a factor rated "critical" could push a species to extinction in 3 generations or 10 years, whichever is less; a factor rated "high" could push the species to extinction in 10 generations or 50 years whichever is less; a factor rated "medium" is unlikely to drive a species to extinction by itself but contributes to increased extinction risk; a factor rated "low" may reduce populations but extinction is unlikely as a result. A factor rated "n/a" has no known negative impact. Certainty of these judgments is moderate.
See methods section for descriptions of the factors and explanation of the rating protocol.

Agriculture. Much of the Sacramento hitch's historic habitat is now dominated by agricultural land uses. Along with urbanization, agriculture greatly reduces water quality. Sacramento hitch generally disappear from waters highly polluted with agricultural drainage water, such as the lower San Joaquin River, where temperature, nutrient, turbidity and pesticide levels are high.

Urbanization. A large portion of the Sacramento hitch's historic habitat occurred in the lower reaches of streams now dominated by urban and suburban areas. If water quality and quantity is maintained in these areas, hitch can persist in some numbers as the

study of Leidy (2007) demonstrates. However, these are also areas subject to rapid change, aquatic and riparian habitat alteration and simplification, increasing water demand, and chronic input of pollutants. This suggests that hitch persisting in urban streams may be susceptible to extirpation.

Estuary alteration. The Delta is thought to have once been ideal hitch habitat, with diverse deep water areas, abundant invertebrates for food and large areas of cover for juveniles. Today, the Delta supports only a few scattered populations, primarily in areas where there is higher water quality and the presence of cover along banks. In the lower San Francisco Estuary, loss of tidal marshes and decreases in freshwater outflow have largely precluded hitch from moving between rivers, limiting gene flow and recolonization potential.

Alien species. Because of their habitat requirements, hitch are generally associated with alien fishes. They have shown some ability to coexist with non-native fishes, including major predators such as the centrarchid basses. However, where aliens are abundant hitch populations are generally small or absent, especially where habitat and water quality conditions are also poor. It is likely that populations in favorable habitats, especially those affording adequate cover, can persist in the face of alien predators although they may disappear when stressed by other factors, such as high temperatures and pollution, which make them more vulnerable to predation. It is also likely that numbers have been reduced in the Delta because of competition from other plankton-feeding fishes, such as threadfin shad (*Dorsoma petenense*) and Mississippi silverside, (*Menidia audens*), along with a general reduction in plankton abundance associated with clam invasions (Nobriga et al. 2005).

Effects of Climate Change: Climate models for Central California provide scenarios that strongly indicate that waters in which hitch occur will become increasingly unsuitable for sustaining populations (Knowles and Cayan 2002, Miller et al. 2003, Carlisle et al. 2010, Null et al. 2012). Generally, the scenarios show streams and lakes becoming warmer by 2100 (2-6 degrees C), while flows will become lower by late summer. Multi-year droughts may become more frequent and major high flow events will occur earlier and be flashier, as less snow accumulates and the incidence of rain on snow events increases, potentially leading to reduced flows during spawning periods. In short, widely accepted scenarios indicate that streams and other habitats will become more variable, with warmer temperatures, especially in summer, and with extreme conditions reached more often. Hitch live in lowland areas that are already highly altered and predicted to experience additional degradation through increased temperatures and poorer water quality as more water is diverted and pollution inputs increase (Moyle et al. 2013). The effects of climate change may be mitigated in some areas if regulated streams are managed specifically for native fishes (e.g., by providing cool spring flows to increase reproductive success). Moyle et al. (2013) indicated that hitch were "less vulnerable" to eventual extinction than many other native fishes from the predicted impacts of climate change if present trends continue, in part, because of their wide distribution and occurrence in larger river systems. However, climate change effects may accelerate apparent ongoing trends of local extirpation.

Status Determination Score = 3.1 - Moderate Concern (see Methods section Table 2). Four primary conclusions can be drawn from this status review: (1) very little is known about the biology, distribution, and status of Sacramento hitch; (2) hitch populations are generally isolated from one another and are usually small, so localized extirpations are likely; (3) hitch have been largely extirpated from the San Joaquin Valley, which once offered an extensive geographic area with many potentially suitable habitats; and (4) what are thought to have been prime hitch habitats outside the San Joaquin Valley (Central Valley lower rivers, portions of Delta and San Francisco Estuary) have been highly altered (especially through dam-regulated flow alterations, urbanization, agriculture, and introduction of alien species) and many areas are now unsuitable for hitch and other native fishes. These factors indicate that Sacramento hitch are a declining species.

Metric	Score	Justification
Area occupied	5	Apparently still widespread across much of historic range; populations fragmented and generally small
Estimated adult abundance	4	Many small populations
Intervention dependence	3	Management needed to prevent declines (habitat restoration, possible reintroductions)
Tolerance	3	Requires fairly high quality water
Genetic risk	4	Limited mixing of populations
Climate change	2	Effects poorly understood but likely negative
Anthropogenic threats	1	See Table 1
Average	3.1	22/7
Certainty (1-4)	2	Overall status poorly understood; hitch not the focus of most studies in which it is mentioned

Table 2. Metrics determining the status of Sacramento hitch, where 1 is a major negative factor contributing to status, 5 is a factor with no or positive effects on status, and 2-4 are intermediate values. See methods section for further explanation.

Management Recommendations: Priority should be given toward design and implementation of a systematic survey of Sacramento hitch abundance and distribution in order to determine their current status. A literature search would provide insights into areas for focused field surveys; however, they are often captured in very small numbers and recorded as incidental species, so literature specific to hitch may be spotty. Once existing populations have been located, studies are needed to determine their population dynamics, life history attributes, genetic structure, and habitat requirements. A monitoring program should be implemented for a select group of hitch populations in order to develop population size and trend information. Refuge areas for hitch and other fishes native to the lowland areas of the Central Valley and Delta, such as Sacramento blackfish (*Orthodon microlepidotus*) and Sacramento tule perch (*Hysterocarpus traskii traskii*), should be identified, isolated (using barriers where possible to prevent invasions of alien species) and, where necessary, restored to provide an expanding network of protected areas. In particular, refuge areas should be established in the North Delta, including the Cache Slough region.

No map is provided because of uncertainties in current Sacramento hitch distribution.