MONTEREY HITCH
***Lavinia exilicauda harengus* (Girard)**

Status: Moderate Concern. Although Monterey hitch are in no apparent danger of extinction, the status of populations remains uncertain across major portions of the species' range.

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 (see next paragraph) 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, but 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).

Monterey hitch, *Lavinia exilicauda harengus,* differs morphologically from Sacramento hitch, *Lavinia exilicauda exilicauda,* by being deeper-bodied and having smaller dorsal and anal fins (Miller 1945b).

Taxonomic Relationships: Hitch from the Monterey basin were first described by Girard (1856a) as *Lavinia harengus*. In 1913, Snyder, apparently unaware of Girard's description, described another *Lavinia* species from the Pajaro and Salinas rivers, which he called *Lavinia ardesiaca*. Miller (1945b) showed that not only was *L. ardesiaca* preoccupied by *L. harengus* but also that *harengus* did not differ sufficiently from the type species, *L. e. exilicauda*, from the Sacramento system to warrant full species designation. Miller (1945b pg. 198) concluded that "although *harengus* and *exilicauda* are very similar and have been synonymized (Jordan et al. 1930) it seems best to retain *harengus* as a subspecies." Miller also discovered that Snyder's collections contained many hitch/roach hybrids which were likely fertile and able back cross with either parent species. Avise et al. (1975) proved Miller correct when their allozyme analysis found that 8% of *Lavinia* examined from the Pajaro River were F_1 hybrids and 5% were backcrossed individuals. Analysis using microsatellites supports the subspecific classification of *L. e. harengus* (Aguilar et al. 2009).

Hitch have also been documented to hybridize with Sacramento blackfish (*Orthodon microlepidotus*), but the offspring are likely sterile (Moyle and Massingill 1981). In the past, they hybridized with the now extinct thicktail chub (*Gila crassicauda*) (Miller 1963).

Life History: Stream populations of Monterey hitch have a much shorter life cycle than the better studied lake and reservoir populations of Clear Lake, as well as Sacramento hitch. Smith (1982) found that Monterey hitch could mature in their second summer of life, as small as 49 mm SL for males and 54 mm for females. Spawning takes place after high flows have subsided, typically May-June, but can extend into early August. Early reproduction is clearly advantageous for fish living in rivers with highly variable flow

regimes. Smith (1982) documented rapid (1-2 years) recolonization of stream reaches that had dried up during a drought by both juvenile and adult hitch from upstream refuges. With an extended spawning season (May-August) and no need to make long migrations to find suitable spawning habitats, Monterey hitch can quickly establish large local populations.

Habitat Requirements: Monterey hitch can occupy a wide variety of habitats, although they are most abundant in lowland areas with large pools or in small reservoirs that mimic such conditions. Smith (1977) found they were most abundant in low-gradient sites in the Pajaro River basin that had permanent water and large pools in summer. The water as these sites tended to be clear, warm in late summer (18-28°C), and moderately deep (ca. 1 m maximum depth on average). Bottom substrates were mostly a mixture of sand and gravel and the presence of cover (e.g. fallen trees, overhanging bushes) was an important factor. In other parts of California, hitch prefer water temperatures of 14-18°C for spawning. However, Smith (1982) witnessed Monterey hitch spawning at temperatures as high as 26°C during early summer months.

When the sandbar forms at its mouth in early summer, the Salinas River lagoon can substantially convert to fresh water with a lens of salt water near the bottom. Monterey hitch apparently tolerate such brackish conditions, as indicated by the fact that they have been captured in the lagoon from water with salt concentrations as high as 9 ppt (Habitat Restoration Group et al. 1992).

Distribution: Monterey hitch are widely distributed in the Pajaro and Salinas river systems, both tributary to Monterey Bay. Within the Pajaro watershed, Monterey hitch are found below reservoirs on lower Uvas, Llagas and Pacheco creeks. They also occur throughout the San Benito watershed and in the deeper pools of the Pajaro River, especially upstream of the San Benito River confluence (Smith 1998). Depending on conditions, hitch may seasonally inhabitant Salinas and Pajaro lagoons (Casagrande et al. 2003, Smith 2007). Hitch have been documented in highly altered habitats in the lower Salinas watershed, including the old Salinas River channel, lower Gabilan Creek, known as the Reclamation Ditch, and Temladero slough (J. Casagrande, pers. comm. 2009). These habitats all depend on agricultural return water to maintain summer flow. In a 2002 fisheries survey of 17 stream sections of the Salinas River and its major tributaries, hitch were found at only one site in the mainstem, near Ardo (Casagrande et al. 2003); however, sample sites were biased towards steelhead habitat (J. Casagrande, pers. comm. 2009). Hitch are thought to occur in both San Antonio and Nacimiento reservoirs and in the river stretches directly below them (J. Smith, J. Casagrande pers. comm. 2009); however, recent surveys have not been performed to validate their presence.

Trends in Abundance: Monterey hitch are locally abundant in the Pajaro River system but have been extirpated from some reaches, especially in the main river, due to habitat alteration and reduced water quality (Smith 1982, 2007). As noted, the most recent steelhead-oriented survey of the Salinas River found hitch in only a single location (Casagrande et al. 2003). Current status of the Salinas system populations is uncertain, although they would be expected to occur in habitats below dams (J. Smith, pers. comm. 2009). Long-term population trends in both systems are unknown; populations are likely

fewer and more fragmented than they were historically, although hitch may have expanded their range upstream where large dams have tempered seasonal variation in flows (Smith 2007).

Nature and Degree of Threats: Monterey hitch exist in a rapidly changing environment where flows are often tenuous and intermittent as the result of intensive agricultural land use, an arid climate, and increasing human demand for water. This is compounded by the fact that the majority of Monterey hitch habitat occurs on private lands, where there is little formal protection for aquatic organisms (Table 1).

Major dams. In the Salinas drainage, Nacimiento and San Antonio reservoirs impound large amounts of water and change flow regimes below their dams. These reservoirs impound water for flood control and release it for groundwater recharge and diversion for irrigation, although the effects of artificial flow regimes on native fishes, such as hitch, is poorly understood. In the Pajaro River, reservoirs attenuate high winter flows and provide permanent summer flows. This altered hydrologic regime appears to benefit hitch, as they have expanded their range upstream into Pacheco, Uvas and Llagas creeks below the reservoirs, into what was roach habitat prior to reservoir construction (Smith 2007). The reservoirs themselves may also be utilized by hitch, although their use of such habitats may be limited by interactions with alien species. Water diversion reduces flows in some areas, potentially limiting habitat suitability for hitch.

Agriculture. The Salinas Valley is one of the most intensively farmed areas in California. The valley also experiences the worst non-point-source water quality problems in the state due to farm and urban drainage systems. Consequently, alteration of the natural hydrology and stream morphology in this region has been severe, especially in downstream portions of the valley. One of the consequences of large-scale habitat degradation has been the extirpation of three native fish species: the thicktail chub (*Gila crassicauda*), Sacramento perch (*Archoplites interruptus*) and tule perch (*Hysterocarpus traski*) (Moyle 2002). Recently, large fish kills (which included hitch) have been documented in what is referred to as the Reclamation Ditch system. This system is comprised of 13 miles of ditches, built in the early 20th century to drain marshland near Salinas (Casagrande et al. 2003). Pesticide applications to protect crops also impact aquatic systems in such intensively farmed agricultural landscapes. In 2001, Monterey County - which encompasses both the Salinas Valley and lower Pajaro Valley - ranked fourth in the state for the total pounds of pesticide applied (California Department of Pesticide Regulation 2001).

Sedimentation from agricultural fields also detrimentally affects hitch habitats. The California Wildlife Action Plan (CDFG 2005) states: "Runoff problems are particularly severe on steeply sloping, erosion-prone soils, where strawberries, artichokes, and vineyard grapes are commonly grown. On sloped agricultural fields near Elkhorn Slough, soil erosion after heavy rain is estimated to be from 30 to 140 times greater than from natural lands" (Caffrey et al. 2002). Agricultural water consumption also threatens aquatic and riparian habitats. Irrigated agriculture accounts for about 70 percent of the Central Coast's water use (DWR 2005a). Over the past century, increased production of water-intensive crops like strawberries and lettuce has contributed to further impairment of aquatic habitat quality and altered ecosystem function.

	Rating	Explanation
Major dams	Medium	Stream flow alterations from multiple dams; potential benefits from perennial flow releases below dams
Agriculture	Medium	Monterey streams have been highly altered and degraded by intensive agriculture
Grazing	Medium	Grazing contributes to habitat degradation, stream incision and to intermittent streams drying more quickly and completely
Rural residential	Medium	Residential water withdrawal is a principal cause of decreased summer streamflow
Urbanization	Medium	Urbanized areas reduce habitat through stream alteration, fragmentation, channelization, water removal and pollution
Instream mining	Medium	Gravel mining alters habitats
Mining	Low	Of little direct effect, although legacy effects of mercury mines make most fish unsafe to eat
Transportation	Low	Many streams are crossed by roads and culverts (passage barriers)
Logging	Low	Little contemporary logging in the Monterey basin
Fire	Low	May cause local extirpations in small watersheds
Estuary alteration	Medium	Pajaro and Salinas lagoons may provide seasonal hitch habitat but both are heavily impacted by agriculture
Recreation	n/a	
Harvest	n/a	
Hatcheries	n/a	
Alien species	Medium	Hitch face competition from introduced cyprinids and sunfish and predation from introduced predators

Table 1. Major anthropogenic factors limiting, or potentially limiting, viability of populations of Monterey 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 low due to limited data. See methods section for descriptions of the factors and explanation of the rating protocol.

Water is supplied to agriculture by diversion of surface water, groundwater pumping and through import from other regions via the State Water Project. As of 1995, groundwater provided about 84 percent of the region's water supply and 20 percent of that was considered overdraft, exceeding the amount of incoming water replenishing regional aquifers (DWR 1993, 2003a). As groundwater levels are depleted, flows are also reduced in streams and rivers.

Rural residential. Historically, urban centers in the Monterey region were located along coastal lowlands, with agriculture concentrated in valley-floor areas and grazing lands occupying the surrounding foothills. In recent years, however, growth and

development have expanded from urban centers into adjacent farmlands and rural areas (CDFG 2005). Increasing rural development has elevated human impacts on small streams through habitat alterations, including higher levels of water withdrawal, which are especially acute in summer months when flows are already low.

Urbanization. While Salinas is the principal town in the watershed, the region around Paso Robles is becoming increasingly urbanized. As the human population in the Monterey basin has grown, demand has outstripped water supply, despite the presence of large reservoirs in the Salinas River system. Groundwater is the primary source of water to meet agricultural and urban needs; consequently, salt water intrusion due to over-pumping from groundwater aquifers threatens all coastal water supplies for both municipal and agricultural use. Urbanization also results in stream channelization, pollution input and other impacts that reduce the quantity and quality of hitch habitats.

Fire. While fire is a natural part of the California landscape, wild fires are becoming more severe as consequence of fire suppression, human land use and increasing temperature and aridity. Because hitch populations are increasingly isolated from one another due to human alteration to stream systems (agriculture, dams, reservoirs, introduced fishes), populations affected by fires are more likely to be extirpated without the possibility of natural recolonization.

Alien fishes. Alien fishes, especially centrarchids, are widespread in the watersheds containing hitch, especially in ponds and reservoirs. They represent a threat through predation and competition, especially during periods of drought when hitch may be confined with alien species in small pools. Reservoir populations are also threatened by competition from introduced planktivores such as threadfin shad (*Dorosoma petenense*) and Mississippi silverside (*Menidia audens*), as well as by predators such as white bass (*Morone chrysops*).

Effects of Climate Change: Climate change models indicate that stream temperatures will substantially increase, summer flows will be reduced, and the effects of fire on already dry watersheds will increase (Hayhoe et al. 2004; Thompson et al. 2012). Monterey hitch are well adapted to the warm, arid conditions of the basin's Mediterranean summers, but their dependence on pools in intermittent streams suggests that are particularly susceptible to increasing aridity and stream flow variability associated with climate change, despite their tolerant physiology. They are likely to become extirpated from streams which now currently maintain isolated, disconnected, pools in summer. Under predicted climate change scenarios, these already intermittent streams may dry completely under the dual strains of reduced rainfall and increased human water use across the region. Moyle et al. (2013) found that hitch are "highly vulnerable" to extinction from the added effects of climate change to their already degraded environment.

Status Determination Score = 3.1 – Moderate Concern (see Methods section Table 2). Monterey hitch are apparently still present throughout much of their native range, although few supporting data exist. Existing populations are fragmented, threatened by severe habitat alteration, and are subject to localized extinctions. The status of Salinas River basin populations is particularly uncertain. The Monterey hitch is listed by NatureServe as Vulnerable.

Metric	Score	Justification
Area occupied	2	Only found in Pajaro and Salinas river systems
Estimated adult abundance	5	Population(s) large
Intervention dependence	3	Most stream flows are regulated, directly or indirectly, and require ongoing management
Tolerance	4	High environmental tolerances
Genetic risk	3	Human alteration to river courses has caused incidence of roach/hitch hybridization to increase
Climate change	2	Reduced flows, along with increased water demand, are likely to further dry streams
Anthropogenic threats	3	See Table 1
Average	3.1	22/7
Certainty (1-4)	2	Very little published information

Table 2. Metrics for determining the status of Monterey hitch in California, 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: The greatest management need for Monterey hitch is to conduct comprehensive fisheries surveys of the Salinas River basin that focus on native fishes and include both stream and reservoir habitats. A similar basin-wide survey should also be conducted in the Pajaro basin. Survey goals should include determination of the status and distribution of hitch and other native species, as well as location of important refuge areas to provide suitable habitats and protection during periods of low flow.

Status should be monitored at least once every five years to determine if there is attrition in increasingly isolated hitch populations. If local extirpations are detected, a management plan should be developed to ensure flows in key streams and to restore extirpated populations. Re-regulation of flows below dams to favor native fishes should be part of the management strategy. Consideration should also be given to the reintroduction of hitch into watersheds with suitable habitats in which they were historically present, but have since been extirpated.

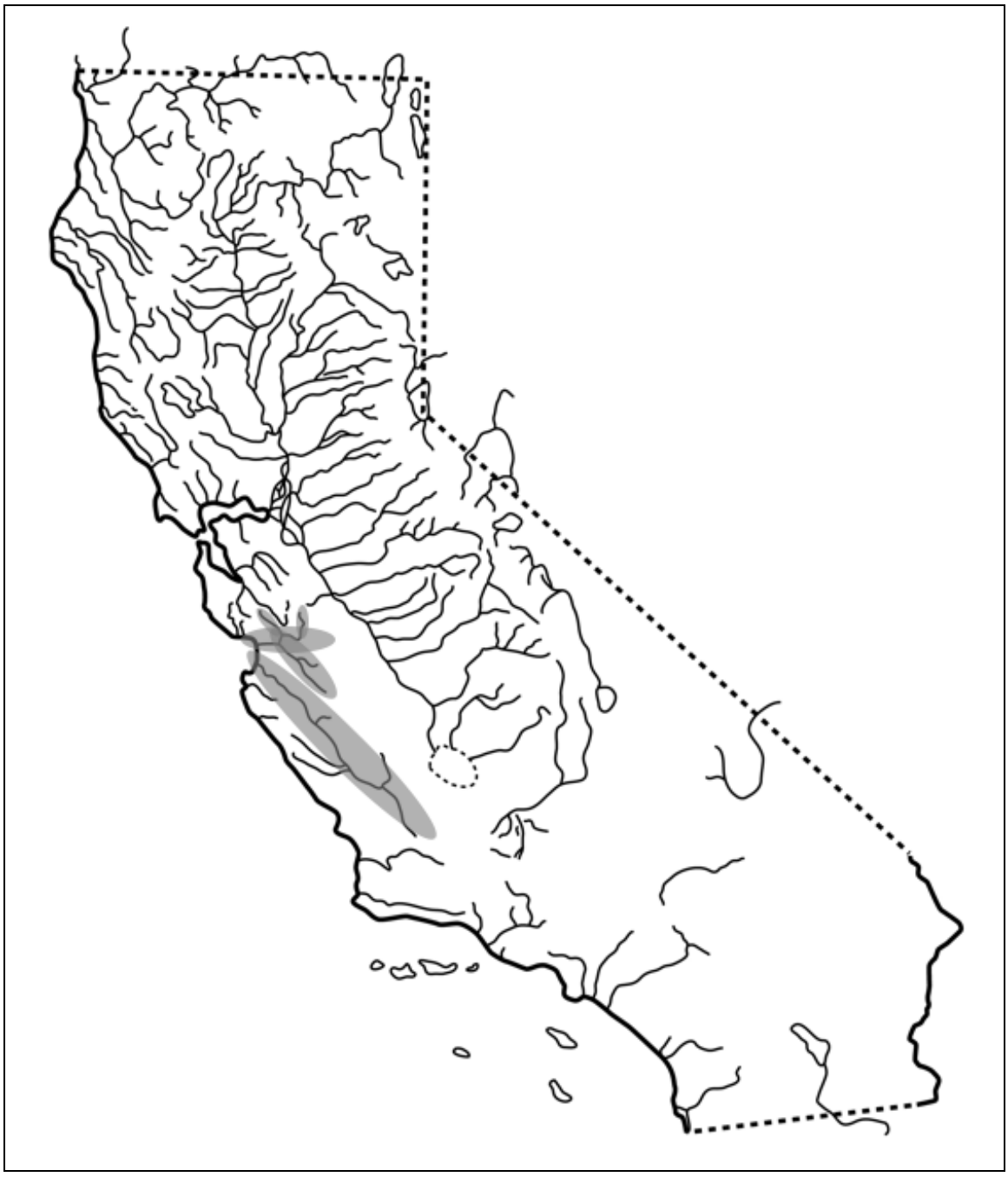

Figure 1. Generalized distribution of Monterey hitch, *Lavinia exilicauda harengus*, in California. Actual distribution is likely fragmented.