TOMALES ROACH
***Lavinia symmetricus* ssp.**

Status: Moderate Concern. Although apparently in no immediate danger of extinction, the Tomales roach has a limited range that is degraded by extensive habitat alteration, primarily from water diversion infrastructure and grazing.

Description: Tomales roach are a small (adult size typically 50-100 mm SL, up to 120 mm SL), bronzy cyprinid, very similar in appearance to the Russian River roach. Like roach from the Russian River, Tomales roach differ from Central California roach in having a trim, slender body, a somewhat pointed snout, a slender caudal peduncle and long fins. Tomales roach have a mean of 9 dorsal fin rays, 7 anal fin rays and 54 lateral line scales (Hopkirk 1973). For a more general description of roach morphology, see the Central California roach account in this report.

Taxonomic Relationships: The Tomales roach was first collected in Walker and Lagunitas creeks, Marin County, in 1910 but was not described until 1914, when Snyder assigned it to *Hesperoluecus venustus*. The Venus roach (*H. venustus*), as described by Snyder (1913, 1917), encompassed roach populations from the Russian River and the streams entering San Pablo, Suisun, San Francisco and Tomales bays. It is no longer considered a valid taxon because recent genetic analysis demonstrates that it consists of forms from different evolutionary lineages (Aguilar et al. 2009). Current systematic classification places roach from tributaries to San Pablo, Suisun, and San Francisco bays in *L. s. symmetricus*, the Central California roach, while the Russian River roach and the Tomales roach are considered to be undescribed lineages (Aguilar et al. 2009, Jones 2001). Tomales roach are probably descendants of roach that colonized Walker Creek through Lagoon Pass, the headwater divide that separates Walker Creek (Tomales Bay) and San Antonio Creek (San Pablo Bay).

Using morphological characters, Hopkirk (1973) found that roach from the Tomales Bay region should be given subspecific status. Moyle et al. (1989) agreed with this assessment and suggested that Tomales roach are an undescribed subspecies of *L. symmetricus*. Subsequently, a mitochondrial DNA genetic assay of the genus *Lavinia* supported the distinctiveness of the Tomales roach (Jones 2001). In the most comprehensive genetic study of *Lavinia* to date, Aguilar et al. (2009) used both nuclear microsatellite (nDNA) and mitochondrial DNA (mtDNA) markers to supply insight into both the relationships between populations (phylogenetics) and the distinctiveness of individual populations (taxonomy). The mtDNA analysis identified roach from Lagunitas and Walker creeks to be a highly supported clade. Microsatellites, however, were not as definitive, with one analysis finding "elevated" bootstrap support for grouping roach from the Tomales region into a distinct taxon, while another analysis (using the program STRUCTURE) found that, although distinguishable, roach from Lagunitas and Walker creeks clustered with Monterey roach.

Jones (2001) found that populations of roach from Lagunitas and Walker creeks share nuclear DNA allele frequencies but were reciprocally monophyletic for mitochondrial DNA haplotypes. Although the sample size was small (n=5), these results

indicate that there is little genetic exchange between the two populations; however, a much larger sample would be required to validate this assumption. The genetics of roach from Pine Gulch Creek in the Bolinas Lagoon watershed have not been studied. Murphy found the Pine Gulch population to be morphologically "identical" to those from Tomales Bay streams and proposed that roach from Olema Creek (tributary to Lagunitas Creek) had colonized Pine Gulch Creek through the San Andreas Fault rift valley that the two watersheds share.

Roach are also found in Salmon Creek (CDFG 2001), which drains to the Pacific Ocean just north of Tomales Bay. The dynamic geologic history of the Coast Ranges has provided ample opportunity for transfer of roach from either the Tomales watershed to the south or from the Russian River watershed to the north. As in most coastal drainages, the possibility also exists that freshwater fishes may have had the opportunity to move between watersheds during times of lower sea levels via direct fluvial connections which were submerged as sea level rose. There has been no study of roach from Salmon Creek but, because of its proximity to the Tomales watershed, these fish are tentatively placed in the Tomales roach taxon until biochemical investigation resolves their identity.

Life History: No life history studies have been done specifically on Tomales roach but, presumably, their life history is similar to that of roach from adjacent watersheds studied by Fry (1936). For a general description of roach life history, see the Central California roach account in this report.

Habitat Requirements: No habitat requirement studies have been done specifically on Tomales roach, but their habitat requirements are assumed to be similar to roach from adjacent watersheds studied by Fry (1936) and from San Francisco Bay tributaries studied by Leidy (1987, 2004). The streams occupied by Tomales roach flow through watersheds that are heavily grazed, with flows regulated by dams, so they mostly live in highly altered habitats that include warm, aggraded, reaches with little riparian vegetation (e.g., Walker Creek). In Walker Creek, their most common associates are prickly sculpin (*Cottus asper*), threespine stickleback (*Gasterosteus aculeatus*), and rainbow trout (*Oncorhynchus mykiss*).

Distribution: Tomales roach are restricted to the western Marin County drainages of Lagunitas Creek and Walker Creek. Roach of uncertain taxonomic affinity have also been reported from Pine Gulch Creek, tributary to Bolinas Lagoon (Murphy 1948c) and Salmon Creek (CDFG 1996). However, a 1997 survey for freshwater shrimp (*Syncaris pacifica*) in Pine Gulch creek recorded no roach (Fong 1999).

Murphy (1948c) speculated that Tomales roach were descendents of roach from San Pablo Bay drainages. The headwater divide between Walker Creek (Tomales Bay tributary) and San Antonio Creek (San Pablo Bay tributary), known as Lagoon Pass, consists of a high, marshy valley. During heavy rain events, a surface water connection between the two drainages forms and provides a colonization route which could be used by fluvial fishes. The Sacramento sucker (*Catostomus occidentalis*), another native fish that frequents headwater habitats, is the only other fluvial fish in the Tomales system and is thought to have also gained access to the basin via this same intermittent connection (Murphy1948c).

Trends in Abundance: There is little indication that Tomales roach in Walker and Lagunitas creeks are less abundant than in the past, but no estimates of their abundance exist. No recent records of roach in Pine Gulch Creek could be found and its current status is uncertain.

Nature and Degree of Threats: While roach are very resilient fish, they tend to decline in or disappear from streams that are: (1) dewatered by diversion for residences, pasture, vineyards and other uses, (2) heavily altered by channelization (often in urban settings) and, (3) invaded by alien predators such as green sunfish (*Lepomis cyanellus*) (Table 1).

Roach are tolerant of the aggraded, shallow, open, and warm stream habitats which characterize much of Walker Creek, so they are the dominant species in the watershed. Conversely, steelhead numbers are much reduced from historic levels and coho salmon are nearly extirpated (Emig 1984). Current land use in the watershed is almost exclusively agricultural (pasture), with the exception of residential development in the town of Tomales. In contrast, Lagunitas Creek is a largely forested watershed with an extremely high density of rural residences and a higher proportion of salmonids in the fish assemblage. Due to considerable differences in land use and physical habitats between the Walker and Lagunitas watersheds, threats to roach populations in these two watersheds may also be very different. Genetic evidence (Jones 2001) suggests that there is very little movement (genetic exchange) between these two populations.

Dams. Dams of all sizes have multiple effects on roach: they create impassible barriers to upstream movement of small fishes (such as roach); impoundments generally support populations of predators that outcompete or eliminate roach and other native fishes; dams alter natural hydrographs and the tailwaters they create may or may not be beneficial to roach; small dams divert water from streams, increasing the likelihood of large portions of streams drying more quickly or completely, particularly during drought periods; and dams block dispersal routes, effectively isolating roach populations so that, when local extinctions occur, suitable habitats cannot be recolonized naturally.

In the Lagunitas watershed, Lake Lagunitas was built in 1872, followed by Alpine Lake in 1918, and then Bon Tempe in 1948. Peters Dam was built in 1953 to form Kent Lake and Nicasio Reservoir was formed by the construction of Seeger Dam (1960) on Nicasio Creek. In 1982, Peters Dam was raised 45 feet, doubling the volume of the reservoir behind it. Soulajule Reservoir, in the Walker Creek watershed, was created in 1978. Generally, environmental flows are required below these dams to support fishes, especially steelhead and coho salmon; however their impact(s) to warm water-tolerant fish such as roach remain unknown.

Agriculture. Current land use in the Walker Creek watershed is almost exclusively agricultural, with the exception of residential development in Tomales. Effluent from dairy operations had been a serious problem in the past (CDFG 1959); however, few dairies remain in the watershed and contemporary dairy practices employ much more stringent effluent treatment procedures. Currently, beef is the primary agricultural product (threat discussed under grazing), although at least one vineyard has been established in the watershed (Marin County Watershed Management Plan 2004).

Grazing. A long legacy of intensive grazing in the Walker Creek watershed has altered the hydrology and geomorphology of the basin. Overgrazing severely compacted

soils and removed riparian vegetation, with subsequent stream bank failures and rapid streambed down-cutting in much of the watershed. Sediment delivered to streams resulted in lowering of the water table and a marked increase of complete drying of the streambed in summer months (Kelley 1976). Significant down-cutting of the streambed is common in the upper watershed, where some reaches have incised as much as five feet, while sections of the lower watershed have aggraded as much as four feet (Haible 1976). The CDFW listed severe erosion and siltation as a factor in the decline of salmonid populations in the creek (CDFG 1959) and Walker Creek is currently listed as impaired for sediment/siltation, pathogens, nutrients and mercury under Section 303(d) of the federal Clean Water Act (US EPA 2006). The filling of Lower Keys Creek, which was historically navigable by ships and barges, along with the growth of the depositional delta at the mouth of Walker Creek (UCCE 1995), provide additional evidence of significant sedimentation in the watershed.

Rural residential. The Lagunitas Creek watershed has high densities of rural residences which use significant amounts of water. Roach can persist in intermittent pools but, should increased water demand in summer and early fall cause more widespread or complete drying of streams (particularly in the context of predicted climate change impacts – see Effects of Climate Change section), roach are likely to be extirpated from many stream reaches or even entire watersheds.

Urbanization. Marin Municipal Water District (MMWD) maintains extensive water transfer infrastructure throughout the Lagunitas Creek and Walker Creek watersheds. It is believed that MMWD reservoirs now capture about 40% of the fresh water that historically flowed into Tomales Bay (TBWC, 2003). Much of the captured water is transported out of these watersheds to supply the population centers and residents of central and southern Marin County.

Mining. The legacy of past mercury mining in the Walker and Arroyo Sausal watersheds continues to contribute to persistent water quality problems in this region (Marshall 2008). High winter flows have repeatedly washed large amounts of mercury-rich sediments into streams from the former Gambonini Mine. The Gambonini Mine, which closed in 1970, was declared a superfund site in 1998 and remediation of the site was completed in 2000. However, as of 2001, sediment samples collected in Walker Creek and Tomales Bay contained high concentrations of mercury (Smelser and Whyte 2001). High levels of mercury are also found in Soulajule Reservoir on Arroyo Suasal, a tributary to Walker Creek; a Marin County Health Advisory (2009) warns against eating fish from the reservoir. The effects of mercury on roach populations are unknown.

Instream mining. Sand was mined from the streambed at the confluence of Lagunitas and Nicasio creeks until a short time after the construction of Nicasio Dam in 1960 (Marin County Watershed Management Plan 2004). Commercial gravel mining was never widespread although, in the past, ranchers regularly harvested small amounts of streambed gravel to maintain ranch roads. Such gravel extraction is now rare.

Alien species. Soulajule Reservoir on Arroyo Sausal, tributary to Walker Creek, contains largemouth bass, green sunfish, black crappie, bluegill and channel catfish (CDFG 1978). Escapees from the reservoir during high flow events or through intentional movement, especially centrarchids species, could displace roach in Walker Creek. Similar threats exist below the many dams in the Lagunitas Creek watershed.

	Rating	Explanation
Major dams	Medium	Dams fragment populations and alter flow regimes; multiple dams exist within Tomales roach range
Agriculture	Low	Agricultural diversions, landscape changes and dairy effluent have degraded habitats
Grazing	Medium	Heavy grazing has occurred in Tomales roach range; legacy effects from intensive past grazing and dairy operations remain
Rural residential	Medium	Residential water withdrawal is a potential cause of decreased summer and fall base flows in small streams
Urbanization	Low	Largely rural and agricultural land use
Instream mining	Low	Little instream mining occurs in western portions of Marin County
Mining	Low	Legacy effects from mercury mining in Tomales roach range result in high levels of contamination in fish tissues; impacts to roach are unknown
Transportation	Medium	Roads and road crossings result in increased siltation, channelization, habitat degradation and potential pollutant input
Logging	Low	Substantial legacy effects may still exist; much greater historical impact
Fire	Low	Fire may cause local extirpation, particularly if fire frequency and intensity increase under predicted climate change scenarios
Estuary alteration	Medium	Roach do not use estuarine habitats; however, estuarine marshes may provide freshwater connectivity between adjacent watersheds during flood events, increasing gene flow
Recreation	Low	Impacts likely minimal
Harvest	n/a	
Hatcheries	n/a	
Alien species	Medium	Intolerant of introduced predatory fishes, especially centrarchids such as green sunfish, which exist in upstream reservoirs

Table 1. Major anthropogenic factors limiting, or potentially limiting, viability of populations of Tomales roach. 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.

Effects of Climate Change: Tomales roach are well adapted to the warm, arid conditions of California's Mediterranean climate; however, their frequent dependence on intermittent pools suggests that they are also particularly susceptible to increasing aridity associated with climate change. Roach are one of the few native fish that are able to endure life in isolated summer pools in intermittent streams where temperatures are high, dissolved oxygen levels are low and most other fishes cannot survive. John O. Snyder (1905) observed roach were able to persist when "nothing remains of the stream but a few small disconnected pools." However, increasing water demands, coupled with predicted climate change impacts, may lead to more widespread drying of stream segments and elimination of roach populations. As a result, Moyle et al. (2013) rated Tomales roach as "highly vulnerable" to extinction by 2100 as the result of climate change.

Status Determination Score = 3.1 - Moderate Concern (see Methods section Table 2). Tomales roach do not appear to be in immediate danger of extinction, although fragmentation and isolation of existing populations, along with long-standing habitat alterations, may be limiting their distribution and abundance. Predicted outcomes of climate change may pose additional risks. The status of peripheral populations (e.g. Pine Gulch Creek, Salmon Creek) remains uncertain. The Tomales roach is listed by NatureServe as "G5T2T3, Critically Imperiled."

Metric	Score	Justification
Area occupied	2	Known populations confined to Walker and Lagunitas watersheds
Estimated adult abundance	4	Two large populations in the mainstems of Walker and Lagunitas creeks but isolated peripheral populations may be quite small
Intervention dependence	3	Survey of Pine Gulch Creek needed; monitoring of other populations required to establish trend information
Tolerance	4	Remarkably resilient fish
Genetic risk	3	Little threat to genetic integrity of large populations (e.g., Walker and Lagunitas mainstem populations); uncertainty about genetic integrity of peripheral populations
Climate change	3	Climate change, along with increasing human demand for water, may lead to more widespread drying of streams, possibly extirpating roach from stream reaches or entire watersheds
Anthropogenic threats	3	See Table 1
Average	3.1	22/7
Certainty (1-4)	2	Little published information

Table 2. Metrics for determining the status of Tomales roach, 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: Studies are needed to address gaps in knowledge of the life history, taxonomy and habitat requirements of Tomales Roach, as well as the water budget in their limited stream habitats. Understanding the relationship between anthropogenic water use and stream flow is of utmost importance in developing effective management strategies for all native fishes; this is especially true in the intensively managed streams of western Marin County.

Opperman and Merenlender (2004) studied and provide management recommendations for nearby Russian River tributaries, including maintaining live trees (live woody debris) both in riparian areas and in-channel to create habitats that roach prefer. These recommendations would likely also benefit native fishes in Marin County watersheds. The following are regionally-specific management recommendations to ensure the persistence of Tomales roach:

Riparian fencing. Installation of exclusion fencing to prevent cattle from direct access to stream habitats has been a very successful restoration technique in Marin County watersheds and should be encouraged wherever cattle and other livestock have unimpeded access to streams. Off-site water sources (guzzlers) should be part of grazing mitigation efforts.

Support for local watershed groups. Citizens involved in the Lagunitas Creek watershed have provided much in the way of stream restoration and other watershed stewardship practices through nonprofit groups such as the Salmon Protection and Watershed Network (SPAWN) and Trout Unlimited. The Marin Municipal Water District has been an active partner with these organizations.

Balancing water needs. Merenlender et al. (2008) developed GPS-based water resource analysis tools that seek to quantify and balance water needs and water resources on a watershed scale. These tools were created to aid in sustaining instream flows, while simultaneously enhancing water security for local landowners and vineyard operators. This powerful software can be used to evaluate various water-policy scenarios, estimate the cumulative effects of water extraction methods on the natural hydrograph across a large spatial scale (including temporal variation) and provide information for watershed-level planning required to recover environmental flows. In order to ensure minimum base flows, especially in stretches of stream not fed by environmental releases from dams, use of such tools could be of great value.

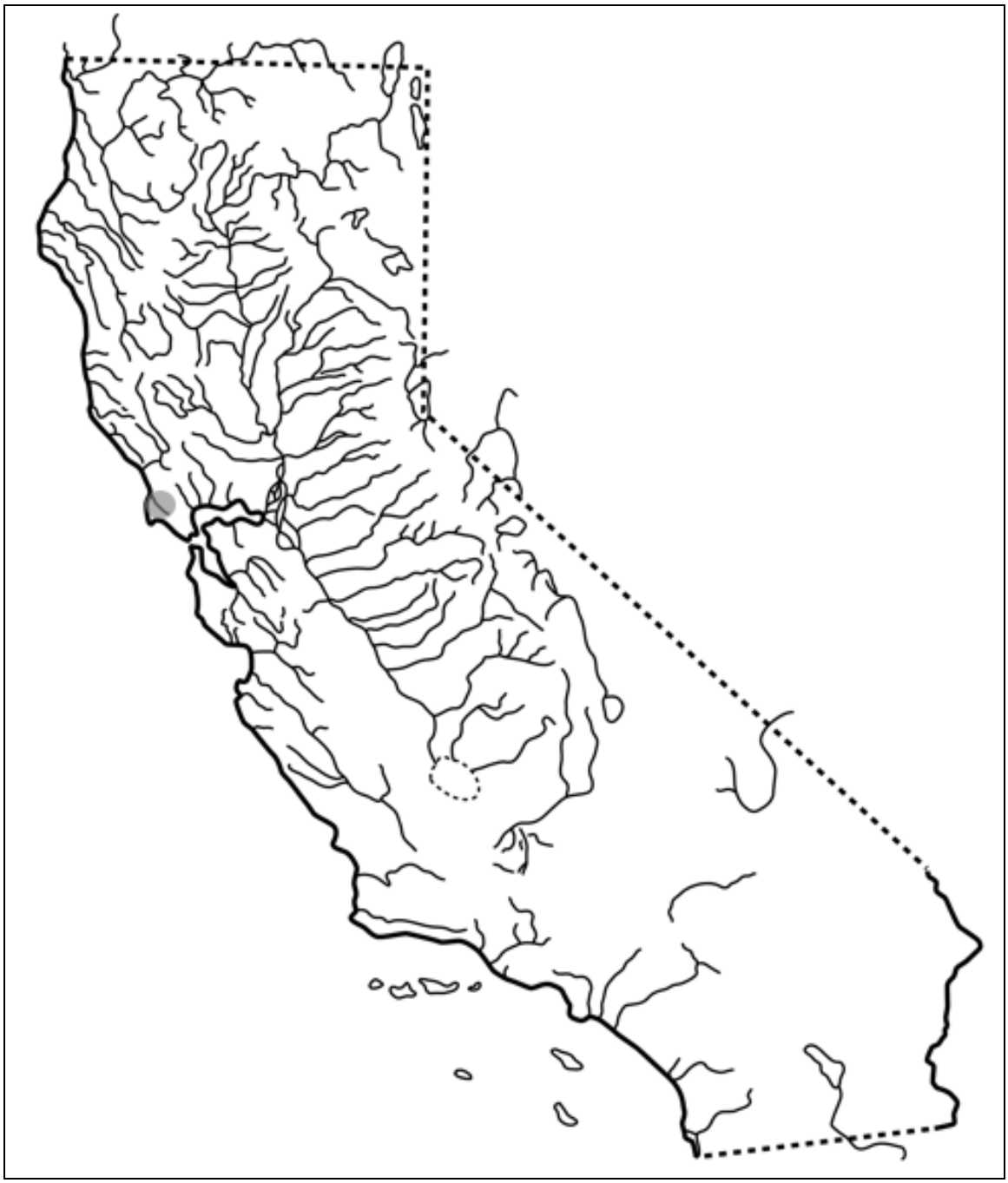

Figure 1. Distribution of Tomales roach, *Lavinia symmetricus* ssp., in California.