MOUNTAIN WHITEFISH
Prosopium williamsoni (Girard)

Moderate Concern. Status Score = 3.4 out of 5.0. Mountain whitefish persist in some fragmented water bodies in California, but their overall abundance and distribution are reduced from historic levels and may be continuing to decline. Population estimates are generally lacking throughout their range, as are comprehensive distribution surveys, so their overall status remains uncertain.

Description: Mountain whitefish are silvery, large-scaled (74-90 on lateral line) salmonids with a prominent adipose fin, a small ventral mouth, a short dorsal fin (12–13 rays), a cylindrical body and a forked tail. Gill rakers are short (19–26 on the first gill arch), with small rakers. They have 11-13 anal fin rays, 10-12 pelvic fin rays (with a conspicuous axillary process at the base), and 14-18 pectoral fin rays. Their sides are silvery and their backs are olive green to dusky. Scales on the back are often outlined in dark pigment. Breeding males develop distinct tubercles on the head and sides. Juveniles are elongate and silvery with 7–11 dark, oval parr marks.

Taxonomic Relationships: Mountain whitefish are sometimes placed in a separate family, the *Coregonidae* (Moyle 2002), from other salmonids and are regarded as one species throughout their extraordinarily wide range. However, a thorough genetic analysis may reveal a number of distinct population segments within this range. The Lahontan population in California and Nevada is the one most isolated from other populations and may eventually be recognized as a distinct taxon.

Life History: Mountain whitefish are usually observed in loose shoals of 5–20 fish, close to the bottom. As their subterminal mouths and body shape suggest, they are bottom-oriented predators on aquatic insects (Moyle 2002). Juveniles feed on small chironomid midge, blackfly, and mayfly larvae but their diet becomes more diverse with increasing size. Adults feed on mayfly, caddisfly, and stonefly larvae during summer (Ellison 1980). In Lake Tahoe, they consume snails, a variety of insect larvae, crayfish, and amphipods (Miller 1951). Most feeding takes place at dusk or after dark, but they will feed during the day on drifting invertebrates, including terrestrial insects (Moyle 2002). The invertebrate diet and feeding patterns of mountain whitefish are slightly different than those of trout species with which they typically share habitat (Behnke 2002).

According to Moyle (2002), "Growth is highly variable, depending on habitat, food availability, and temperature. Growth of fish from a small alpine lake (Upper Twin, Mono County) was… 11 cm SL at the end of year 1, 13.5 cm at year 2, 15 cm at year 3, 17 cm at year 4, and 20 cm at year 5. Fish from rivers at lower elevations seem to be 25-30 percent larger at any given age after the first year. Young reared in tributaries to Lake Tahoe were largest in the Truckee River (8.6 cm FL at 10 months) and smallest (7.3-7.8 cm) in small tributaries (Miller 1951). Large individuals (25-50 cm SL) are probably 5-10 years old. The largest whitefish in California come from lakes; one measuring 51 cm FL and weighing 2.9 kg came from Lake Tahoe. In Fallen Leaf Lake, the population sampled by gill nets was on average 31 cm FL, with the largest fish being 44 cm long (Al-Chokhachy et al. 2009). Rogers et al. (1996) have developed a standard length-weight relationship for mountain whitefish, based on data from 36 populations throughout their range.

Spawning takes place in October through early December and is preceded in streams by upstream or downstream movements to suitable spawning areas, possibly by homing to historical spawning grounds. Movement is often associated with a fairly rapid drop in water temperature, with spawning occurring at 1-11°C (usually 2-6°C). Spawning takes place in riffles where depths are greater than 75 cm and substrates are coarse gravel, cobble and rocks less than 50 cm in diameter. From lakes, most whitefish migrate into tributaries to spawn, although some spawning may take place in gravel in shallow water. Whitefish do not dig redds, but instead scatter eggs over gravel and rocks, where they sink into interstices. The small eggs are not adhesive. Spawning behavior is not well documented, but they seem to spawn at dusk or at night, in groups of more than 20 fish. They are 2-4 years old when they mature, although age of maturity depends on sex and size. Fecundity varies with size, from 770 to over 24,000 eggs per female, with an average of around 5,000 eggs. The embryos hatch in 6-10 weeks in early spring. Newly hatched fish are carried downstream into shallow (5-20 cm) backwaters, where they spend their first few weeks. As fry grow larger, they move into deeper and faster water, where there are rocks or boulders for cover. Fry from lake populations move into the lake fairly soon after hatching and seek out deep cover, such as beds of aquatic plants (Moyle 2002). Egg hatching and fry survival is highly correlated with temperature, and maximum growth of mountain whitefish fry occurs between 13-14°C (Brinkman, Crockett, and Rogers 2013).

Habitat Requirements: Mountain whitefish in California inhabit clear, cold streams and rivers at elevations of 1,400–2,300 m. While they are known to occur in a few natural lakes (e.g. Tahoe), there are few records from reservoirs. In streams, they are generally associated with large pools (<1 m deep) or deep runs. They prefer deep water or large pools as opposed to other salmonid species that seek cover and shade where possible (Behnke 2002). Deinstadt et al. (2004a) notes, "...deeper pool habitat sustains moderate densities of large (> 300mm) mountain whitefish" (pg. 51). In lakes, they typically live close to the bottom in fairly deep water (Al-Chokhachy et al. 2009).

Environmental tolerances of mountain whitefish in California are poorly understood but they are largely found in waters with summer temperatures < 21°C. More northern populations have been reported to have temperature preferences of 10-18°C, depending on season (Ihnat and Bulkley 1984). Spawning has been recorded at temperatures of 1-11°C but 2-6°C is typical, which corresponds with optimal temperatures of less than 8°C for development of embryos (Northcote and Ennis 1994, Brinkman, Crockett, and Rogers 2013). Behnke (2002) and Mebane et al. (2003) noted that mountain whitefish were somewhat more tolerant of adverse water quality (low dissolved oxygen, higher turbidity) than other salmonids and, therefore, likely more resilient in response to environmental change. More recent research has shown that the upper lethal thermal tolerance of mountain whitefish is actually very similar to that of bull trout (23.6°C compared to 23.5°C), and much lower than the brown, Lahontan cutthroat, and rainbow trout (24.7, 28.5and 26.2°C, respectively) with which they are likely to overlap with in California waters (Dunham, Shroeter, and Rieman 2003, Brinkman, Crockett, and Rogers 2013).

Distribution: Mountain whitefish, as the taxon is broadly recognized, are found in western North America, from California to Alaska. They are distributed throughout the Columbia River watershed (including Wyoming, Montana, Oregon, Washington, Idaho, British Columbia, and Alberta), the upper reaches of the Missouri and Colorado rivers, the Bonneville drainage, and the Mackenzie and Hudson Bay drainages in the Arctic. In California and Nevada, they are present in the lower, Little, and Upper Truckee, East Fork Carson, and East and West Walker river drainages on the east side of the Sierra Nevada and in the Humboldt River drainage in Nevada. It is not known if any mountain whitefish reside in the West Fork Carson River drainage in either California or Nevada (Deinstadt et al. 2004 b). Their range includes both natural lakes (e.g., Tahoe, Independence, Cascade, and Fallen Leaf) and streams. Distribution of mountain whitefish in California is difficult to assess because they have not been the focus of studies in the region; sampling efforts mostly target trout species that support important recreational fisheries in the region (W. Somer, CDFW, pers. comm. 2016).

Mountain whitefish used to be present throughout the greater Lake Tahoe basin before construction of several dams in the 1960s and 1970s. South Fork Prosser Creek, just a short distance from the Independence Lake drainage, supported small numbers of mountain whitefish, but they were gone by 1983, perhaps as a long-term consequence of the construction of Prosser Reservoir in 1962 (CDFW 2015 database). They are also absent from Sagehen Creek, Nevada County after construction of Stampede Reservoir (Decker and Erman 1992, Moyle unpubl. data, W. Somer, CDFW, pers. comm. 2016). Nearly annual surveys conducted on the Upper Truckee River from the mouth of Lake Tahoe upstream have only occasionally turned up mountain whitefish, and the fish have only been encountered in lower reaches of the Upper Truckee River and Lake Tahoe itself, suggesting that this population may spend only a portion of their lives in the river (M. Maher, CDFW, pers. comm. 2011, US Forest Service 2013). Of 25 creeks sampled in the Tahoe basin, only Taylor Creek and the mainstem Upper Truckee River near its mouth into Lake Tahoe had mountain whitefish (US Forest Service 2013). They are absent from the Susan River and from Eagle Lake (Lassen Co.), which contain other Lahontan drainage fishes.

Stream surveys by CDFW have indicated that mountain whitefish do not use high-gradient headwaters of streams and tributaries in the Carson River basin (such as those near Silver King Canyon) and are restricted to low-gradient portions of tributaries and larger rivers in California (Deinstadt et al. 2004a). Over one-quarter of streams sampled by electrofishing in the East Fork Carson River drainage had mountain whitefish present in California, and nearly all of 26 streams sampled across the state line in Nevada showed mountain whitefish were present in the drainage near Highway 395 (Deinstadt et al. 2004a).

Trends in Abundance: Mountain whitefish are still present in much of their limited California range, but their populations are disconnected from one another. This represents a marked decline from the 19th century, when they were harvested in large numbers by Native Americans and commercially harvested in Lake Tahoe (Moyle 2002). There are still runs in tributaries to Lake Tahoe, but they are very small, poorly documented, and seemingly shrinking (US Forest Service 2013). Whitefish were apparently already reduced in numbers by the 1950s. They still appear to be present in low-gradient reaches of the Truckee, East Fork Carson, East and West Walker, and Little Walker rivers, albeit at low to moderate densities of approximately 120 – 300 fish per mile (Deinstadt et al. 2004a). Higher densities tended to be found in pool and riffle-pocket water areas, and suggest that the East Fork Carson River may carry more and larger whitefish than the surrounding streams (Deinstadt et al. 2004a). Small populations are also present in the Little Truckee River, Independence Lake and some small streams, such as Wolf and Markleeville creeks, tributaries to the East Fork Carson River. Dams and reservoirs have fragmented their populations in Sierra Nevada rivers and tributaries, and whitefish are generally scarce in reservoirs (Moyle 2002). They disappeared from Sagehen and Prosser creeks 10-20 years after construction of reservoirs that covered their lower reaches (Erman 1973, Moyle, unpubl. data).

However, a population in nearby Independence Lake (a natural lake) did not show an obvious decline in the period from 1997- 2005 (Rissler et al. 2006). In fact, Independence Lake still has an intact native Lahontan species assemblage and mountain whitefish seem to be thriving there, unlike surrounding impounded waters, which is probably due to the presence of non-native trout in many other impoundments (W. Somer, CDFW, pers. comm. 2016). Recent observations suggest that mountain whitefish are less abundant and less widely distributed in California than they once were, although they continue to be common enough in the Truckee, Carson, and Walker rivers to be caught in recreational fisheries (M. Wier, CalTrout, pers. comm. 2016). However, there is some indication from diving and raft electrofishing surveys of dramatic decline in the mountain whitefish population in the Truckee River over the past 20 years (R. Cutter, pers. comm. 2013, USFS 2013). At present, California allows 5 whitefish per day to be taken by anglers.

Overall, indications are that whitefish populations have declined significantly in last 20-30 years. The East Fork Carson and East Fork Walker seem to be the riverine strongholds of the species in California at present, with limited electrofishing data supporting this hypothesis (CDFW 2015 database). While mountain whitefish have been observed in 2015 during Paiute cutthroat trout surveys on lower Silver King Creek, tributary to the East Fork Carson River, there is evidence that mountain whitefish and other native species are in decline throughout the Lake Tahoe Basin, possibly displaced by non-native fishes (USFS 2013, W. Somer, CDFW, pers. comm. 2016). Deinstadt et al. (2004a, pg. 118) concludes, "The absence or comparatively low densities of mountain whitefish may indicate that the historical status of this species is changing."

Factors Affecting Status: Factors affecting the abundance and distribution of mountain whitefish in California are poorly documented (Table 1). The keys to understanding their apparent decline, however, are habitat-related: (1) they live primarily in the larger streams of the northeastern Sierra Nevada and associated lakes, (2) they do not do well in reservoirs or streams that have been impounded, and (3) they require high water quality and generally low water temperatures for persistence. In general, they live in the waters of the eastern Sierra Nevada most likely to be impacted by human activities, especially by expanding development (*e.g.*, in areas surrounding Truckee and Lake Tahoe), dams and diversions, and by highways and railroads.

Major dams. Whitefish inhabit the larger streams of the eastern Sierra Nevada, which have been dammed or impounded for agricultural or municipal water delivery. Dams may block movements of whitefish to favored spawning and feeding grounds and create unfavorable conditions both above reservoirs and below them, especially poor water quality. For example, when Farad Dam (Nevada) on the Truckee River was blown out by high flows in 1997-98, the river below it recovered rapidly, with higher flows creating more complex habitat and cooler summer temperatures that favored whitefish and trout. Erman (1986) noted that mountain whitefish abundance dropped in Sagehen Creek following the flooding of its lower reaches by Stampede Reservoir, and they may now be absent from this drainage altogether. In contrast, Carson and Walker rivers, with smaller impoundments, have populations that are still self-sustaining and perhaps stable (W. Somer, CDFW, pers. comm. 2016). It is possible that flow releases to support trout fisheries below dams also improve conditions for mountain whitefish in certain areas, such as the Little Truckee River.

Agriculture. Pasture and alfalfa fields line streams occupied by mountain whitefish, especially in the lower reaches of the West and East Walker rivers in California, as well as in Nevada. Attendant diversions and warm, often polluted, return water may impact whitefish populations, which generally require cold, high quality water. Diversions may also reduce stream flows and corresponding water quality required by whitefish, restricting their ability to seek out deep holding water in rivers and streams.

Grazing. Watersheds in which mountain whitefish occur in California were extensively grazed in the past. Continued open range and allotment grazing may contribute to increased sedimentation and water temperatures, as well as degradation of riparian and stream habitats.

Urbanization. The Truckee River and tributaries to Lake Tahoe have been altered in many ways by urban and suburban sprawl, along with associated road and highway networks; however, the effects and potential impacts of such developments on whitefish are not quantified.

Transportation. The Truckee and Carson rivers have roads and railroads along one or both banks. The effects of long-standing changes are not documented but they reduce natural meandering and contribute pollutants to the streams.

Logging. Mountain whitefish watersheds in California were heavily logged in the 19th century. While logging is less intense than it once was, continued timber harvest operations, including use of roads, may contribute to increased sedimentation and higher water temperatures.

Harvest. Over-exploitation in the past presumably depleted whitefish numbers although this threat is largely gone, in part because few anglers target them today, despite their edibility.

Alien species. Whitefish coexist in many areas with alien brown, brook, and rainbow trout and it is possible that these trout may limit whitefish populations by preying on their fry and juveniles or by competing with them for food and space. In recent years, smallmouth bass have spread into some parts of the Truckee River system, which may present a new predation threat. In lakes where invasive lake trout are present such as Lake Tahoe, Lake Cascade, and Fallen Leaf lakes, mountain whitefish are preyed upon frequently, and this predation pressure may have changed their distribution over time to be less benthic-focused (Vander Zanden et al. 2003).

Factor	Rating	Explanation
Major dams	Medium	Construction of major dams and associated reductions in water quality and flow, and increases in temperature, have had documented negative impacts.
Agriculture	Medium	Each watershed inhabited by mountain whitefish currently has some kind of diversion or flow modification for agricultural purposes, reducing availability of cold, clean water.
Fire	Low	More frequent large fires are likely within species range in the future and may increase siltation of spawning habitat.
Grazing	Low	Degradation of watersheds from open range grazing increases siltation and temperatures, reducing habitat quality.
Rural/ residential development	Low	Much of the range of mountain whitefish is relatively rural; residential diversions and groundwater pumping may reduce coldwater habitat.
Urbanization	Low	Despite rapid urbanization of the Tahoe/Truckee basins, impacts of increasing sprawl on aquatic species are not well understood. Much of the range of mountain whitefish is relatively rural.
Instream mining	Low	Gravel mining and gold dredging could alter habitat.
Mining	Low	Remnant mines could negatively impact water quality through contaminant seepage; these impacts are not well documented.
Transportation	Low	Roads are present along many streams, and may negatively impact water quality via runoff of contaminants.
Logging	Medium	Most watersheds used by mountain whitefish have been subject to extensive logging in the past; most impacts are likely legacy.
Estuarine alteration	N/A	
Recreation	Low	Some riparian areas damaged by recreational use.
Harvest	Low	Some recreational harvest; poaching may occur.
Hatcheries	N/A	
Alien species	Medium	Mountain whitefish are prey for non-native trout species, especially lake trout, where they are present and predation pressure may shift their distribution and behavior. Competition with non-native trout species may limit abundance.

Table 1. Major anthropogenic factors limiting, or potentially limiting, viability of populations of mountain whitefish in California. 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 due to limited studies of the species in California. See methods for explanation.

Effects of Climate Change: Moyle et al. (2013) rated mountain whitefish as "highly vulnerable" to extinction in California in the next 100 years as the result of climate change severely altering their already limited habitats. Climate change effects are likely to be substantial for this species because it relies on sufficient flows of cold water from snowmelt in the otherwise relatively arid Eastern Sierra region. Even small decreases in flows, increases in temperatures and changes in timing of spring runoff could eliminate of further fragment populations that are already constrained by dams, diversions or other factors. Increasing temperatures in the Sierra can decrease thermally suitable habitat, increase direct temperature-related mortality, lower dissolved oxygen content, and potentially increase predation from, and competitive advantages in more tolerant, invasive, warm water species, (Brinkman, Crockett, and Rogers 2013) especially in the Truckee River. In fact, mountain whitefish may be disproportionately affected by climate change compared to other salmonids because they are constrained to low gradient sections of rivers and do not effectively colonize high-gradient headwater streams that could provide thermal refuges. These factors may in fact jeopardize the persistence of the species at the southern portion of its range (Brinkman, Crockett, and Rogers 2013).

Status Score = 3.4 out of 5.0. Moderate Concern. Mountain whitefish are locally abundant in some areas, although their overall abundance and distribution are reduced from the past. Little is known about their abundance, distribution and population trends, but survey information indicates mountain whitefish are a declining species.

Metric	Score	Justification
Area occupied	4	Present in three watersheds and several lakes.
Estimated adult abundance	4	Numbers appear to be declining in many streams so this number may be high.
Intervention dependence	4	Populations persist but intervention will be needed if their decline continues.
Tolerance	3	Whitefish appear to be more physiologically tolerant than many salmonids, live at least 5 years and are iteroparous; however, they require high water quality and low temperatures.
Genetic risk	4	Genetics have not been studied but most populations are isolated from one another.
Climate change	2	Whitefish are likely to be negatively affected by decreased flows, warmer temperatures and increased diversions but persist in lakes.
Anthropogenic threats	3	4 Medium threats.
Average	3.4	24/7.
Certainty (1-4)	2	Grey literature, survey data, and professional judgment.

Table 2. Metrics for determining the status of mountain whitefish in California, where 1 is a poor value and 5 is excellent. Each metric was scored on a 1-5 scale, 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. Certainty of these judgments is moderate. See methods for explanation.

Management Recommendations: It is clear that mountain whitefish in California would benefit from a thorough study of their biology including systematics, genetics, distribution, abundance, environmental tolerances, and habitat requirements of all life stages. Existing fish surveys in eastern Sierra Nevada streams where mountain whitefish occur are generally focused on trout species, especially non-native species, and the popular recreational fisheries they support. While mountain whitefish are sometimes captured during these surveys (Deinstadt et al. 2004a, Deinstadt et al. 2000b), few efforts have been made, thus far, to assess their distribution or population trends, although there is some evidence of a potential downward shift in abundance. A shift in fisheries management toward native species restoration and recovery is occurring within their range but is currently focused on Lahontan cutthroat trout, which are a listed species (threatened) under the federal Endangered Species Act of 1973. Because of their low tolerance for high water temperatures and poor water quality, they also are a good indicator of 'health' of the Carson, Walker, and Truckee rivers, as well as of Lake Tahoe and other natural lakes. As such, perhaps the best recommendation to benefit mountain whitefish populations is to advocate that they become an integral part of ongoing management and restoration efforts currently focused on other salmonids. Specific recommendations include: (1) basic research on their biology and distribution, (2) monitoring of existing populations at least once every 5 years, (3) habitat restoration in degraded (simplified) stream reaches in which they are known to live, and (4) maintenance or enhancement of flows in regulated rivers so that temperatures remain below 21° C and high water quality is maintained throughout the year. Of particular importance are the ongoing Truckee River Operating Agreement negotiations. These negotiations focus on providing reliable water for communities in California and Nevada from the Carson, Truckee, and Walker Rivers but also provide an important opportunity to enhance habitat for native fishes, including mountain whitefish (W. Somer, CDFW, pers. comm. 2016).

It is also important to continue to educate the public as to the value of native fishes such as mountain whitefish. For example, in 2010, California Trout and partners from the U.S. Forest Service Lake Tahoe Basin Management Unit, Tahoe Resource Conservation District, CDFW, U.S. Fish and Wildlife Service, and local schools helped rear and release mountain whitefish and speckled dace (*Rhinichthys osculus*) into Lake Tahoe tributaries to promote awareness and conservation of native fishes. Such educational outreach programs could be expanded with partners where possible to increase public awareness of native fishes in the Tahoe Basin.

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