BIGEYE MARBLED SCULPIN
Cottus klamathensis macrops (Rutter)

Status: Moderate Concern. There is no immediate extinction risk for bigeye marbled sculpin. However, populations may have experienced long-term declines and are subject to the negative effects of fragmentation and intensive land use (agriculture, grazing, logging) within their limited range.

Description: All subspecies of marbled sculpin (*Cottus klamathensis)* have large, dorsally flattened heads with two chin pores; large, fan-like pectoral fins with four elements; and small pelvic fins that are positioned ventrally between the pectorals (Moyle 2002). Marbled sculpin are distinguished from other *Cottus* species by 7-8 dorsal fin spines, joined dorsal fins, an incomplete lateral line with 15-28 pores, and relatively smooth skin (Daniels and Moyle 1984). A few prickles can sometimes be found below the lateral line. They also lack palatine teeth and have only one preopercular spine. Fin ray counts are: 18-22 in the second dorsal fin, 13-15 in the anal fin, 14-16 in the pectoral fin, and 11-12 (principal rays) in the caudal fin (Moyle 2002). All other sculpin species in California possess a split dorsal fin and more than 7 dorsal spines. Marbled sculpin are generally green-hued with a dark circular spot at the posterior end of the dorsal fin and alternating dark and light spots on the pectoral fin rays. Fish from the Klamath River are generally lighter and more marbled than those from the Pit River (Moyle 2002). Other marbled sculpin characteristics include: a wide interorbital region, a wide head and blunt snout, a maxillary rarely extending beyond the anterior half of the eye, and unjoined preoperculer mandibular canals, but these characteristics are shared with one or more other species (Daniels and Moyle 1984). The subspecies *C. klamathensis macrops* is distinguished from other marbled sculpins by having few (if any) axillary prickles, a short preopercular spine (<1 percent of SL), a large orbit diameter, and a long predorsal length (Daniels and Moyle 1984). They tend to be rather plain in patterning with relatively inconspicuous barring on the body and fins.

Taxonomic Relationships: *Cottus klamathensis* was first described by Gilbert (1897) from the Klamath River system. Rutter (1908) then described *Cottus macrops* from the Fall River, a large tributary to the Pit River, and noted that it closely resembled *C. klamathensis*. Robins and Miller (1957), upon review of specimens and recent collections, concluded that the two species were not sufficiently different to warrant separate species designations and considered *C. macrops* synonymous with *C. klamathensis*. Daniels and Moyle (1984), however, on the basis of meristic and mensural differences in fish from the Pit and Klamath river systems, concluded that *C. klamathensis* could be divided into three subspecies: (1) *C. k. klamathensis* (upper Klamath marbled sculpin), the nominate subspecies found in the Upper Klamath River drainage; (2) *C. k. polyporus* (lower Klamath marbled sculpin), found in the lower Klamath River, in some of its larger tributaries, and possibly in the Trinity River system; and (3) *C. k. macrops* (bigeye marbled sculpin), found in the Pit River system downstream from the confluence of the Fall River to the Pit 7 Reservoir, and in three tributaries: Hat Creek (downstream of the Rising River system), Burney Creek (downstream of Burney Falls), and the Fall River system (with the exception of Bear Creek). However, bigeye marbled sculpin may constitute a separate species due to its distinctive morphology, ecology and behavior (Moyle 2002).

Life History: Bigeye marbled sculpin grow quickly, attaining 35% of their maximum length in their first year and live about five years (Daniels 1987). Growth occurs from spring to early fall. Average sizes are 39 mm at the age of 1 year, 55 mm at 2 years, 62 mm at 3 years, 70 mm at 4 years, and 79 mm at 5 years. Although fish over 80 mm are rare, one specimen was recorded at 111 mm. Marbled sculpin attain sexual maturity after 2 years, during the winter (Moyle 2002). Spawning occurs from late February to March. Fecundity is low, with females producing 139-650 large eggs each. Adhesive eggs are deposited in clusters in nests under flat rocks. Eggs from different females may be present in the same nest. Nests are usually guarded by males (Daniels 1987). Embryos number from 826-2,200 per nest. Larvae measure 6-8 mm upon hatching, are benthic, and likely rear close to their nests (Moyle 2002). Because bigeye marbled sculpin have low fecundity, mature late and live relatively long, they are well-adapted to relatively stable environments such as spring-fed rivers (Daniels 1987).

Habitat Requirements: Bigeye marbled sculpin are well-adapted to large, clear, cool (< 20°C summer temperatures) spring-fed streams but also adjust to the conditions found in some reservoirs. Brown (1988) found that the acute preferred temperature was about 13°C (range 11-15°C) for fish acclimated at 10°, 15°, and 20°C. Temperatures above 15°C caused stress, particularly when associated with wide temperature fluctuations, and prolonged exposure to temperatures above 25°C was lethal. They are usually found in water with moderate flows (mean bottom velocity = 9.7 ±3.0 (1 S.E.) cm sec^{-1}; mean water column velocity = 23.1 ±4.5 cm sec^{-1}) and depths (mean 64.3 ±7.3 cm). Habitat use does not differ between adults and juveniles with respect to water velocity, but juveniles are found in shallower water. Typically, bigeye marbled sculpin are found in low-gradient runs and pools with abundant aquatic vegetation and coarse substrates, especially cobble, boulder, and gravel (Daniels 1987). In artificial streams, when given a choice of cobble and sand, they always selected cobble (Brown 1988). However, habitat use may shift in the presence of competitors such as Pit sculpin in riffles of the Pit River (Moyle 2002).

Distribution: The bigeye marbled sculpin is distributed throughout the middle reach of the Pit River system (Daniels and Moyle 1982). In this region, it is found in the main river below Britton Reservoir, lower Hat Creek, Sucker Springs Creek, and Clark Creek. It is the dominant sculpin in the sections of Lower Hat Creek and Burney Creek just above Britton Reservoir. The bigeye marbled sculpin also is found in the lower reaches of streams flowing into reservoirs of the lower Pit River, the lower Pit River itself, and Fall River.

Trends in Abundance: Bigeye marbled sculpin are the least abundant of the three sculpins endemic to the Pit River drainage (Moyle 2002). There are no trend data available, but it seems likely that modification of the lower Fall River and the creation of reservoirs (especially Britton Reservoir) has reduced their already limited range. Unlike rough sculpin, they are rarely found in reservoirs (Daniels and Moyle 1982) and populations in various stream reaches are now isolated from one another. Rutter (1908) found them to be the most abundant sculpin in the Fall River, whereas the rough sculpin is most abundant today. Overall, both the range and abundance of bigeye marbled sculpin appear to have declined over the past century.

Nature and Degree of Threats: Bigeye marbled sculpin are adapted to cold spring systems, such as Hat Creek and the Fall River. Land uses or other activities that change or disrupt these habitats are likely to affect marbled sculpin populations (Table 1). The habitat of this sculpin is similar, in large part, to that occupied by rough sculpin and the endemic Shasta crayfish (*Pascifasctus fortis*), both protected species. However, the disappearance of the crayfish from most its habitats in this region may indicate changing conditions, including the invasion of the aggressive signal crayfish (*P. lenuisculus*), that may cause reductions in bigeye marbled sculpin populations (Light et al. 1995). Thus, the apparent decline of Fall River populations may indicate the occurrence of long-term, subtle habitat degradation (Moyle 2002).

Dams. The Fall River, lower Pit River, Hat Creek and numerous tributaries have been almost completely harnessed for hydropower, so native fishes often have to exist in highly regulated and, in some cases, dramatically fluctuating hydrological conditions. The Fall River, for example, ends abruptly at Fall River Mills and is diverted into a penstock. The rocky, high gradient stretch at the mouth of the Fall River is consequently dry much of the year, fragmenting the system and inhibiting fish movement. This reach was quite likely good habitat for bigeye marbled sculpin in the past, with the combination of coarse substrate and cold water. Further fragmentation occurs with the series of four dams and their reservoirs on the Pit River, although some habitat for marbled sculpins is present downstream of the dams where cold-water releases are provided for hydropower production (Moyle and Daniels 1982).

Agriculture. Water is diverted from the Fall River directly, or indirectly, through wells for filling of paddies for wild rice or for flood irrigation of pasture. Excess water is returned to the river and is likely warmer and potentially polluted with agricultural chemicals and manure. The effects of these practices on sculpins and other fishes are not known, but unlikely to be favorable.

Grazing. Grazing is pervasive in the Fall River Valley and, in riparian areas, may degrade aquatic habitats by making them warmer and polluted. Cattle graze river banks in a number of places along the Fall River and Hat Creek. However, water quality in the system remains high, according to a study by the State Water Resources Control Board (http://fallriverconservancy.org/issue/water-quality/).

Logging. The Pit River watershed has a long history of repeated logging on private and public land (Shasta-Trinity National Forest), resulting in heavy sediment loads in tributary streams. This is presumably a major reason the river below tributaries has a distinct chocolate cast to it during periods of high run-off. The heavy loads of sediment coming down much logged and roaded Bear Creek, a tributary to the Fall River, were reduced only after a privately funded meadow restoration project created an area in which sediment could be deposited.

Recreation. The Fall River and Hat Creek are largely protected because of their importance to trout anglers, but heavy use by anglers can result in disturbance of sculpin (and other fish) habitat by wading in shallow water and by disturbing riparian vegetation on the banks; however, impacts to sculpin are unknown.

Alien species. The streams in which marbled sculpin occur are largely managed for wild rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) fisheries. Generally, native rainbow trout have dominated the streams and introduced brown trout have been relatively uncommon. Changes to habitats or management activities that favor brown trout might have negative effects on marbled sculpin by increasing predation, given the more predatory nature and often larger size of brown trout (Moyle 2002). The invasion of aggressive signal crayfish into the spring systems of this region may have resulted in the displacement of marbled sculpin from under-rock shelters, making them more vulnerable to predation, much as has happened with the native, non-aggressive Shasta crayfish. A newer threat is the presence of piscivorous largemouth bass (*Micropterus salmoides*), smallmouth bass (*M. dolomieu*) and spotted bass *(M. punctulatus*) in the Pit River and its reservoirs. Their effects on the native fishes of this system need to be evaluated.

	Rating	Explanation
Major dams	Medium	The complex Pit River hydropower system fragments populations but fishes may benefit from habitat created by some dams
Agriculture	Medium	In the Fall River, water quality may be negatively affected by agricultural effluent and warmer temperatures from return flows
Grazing	Medium	Grazing is common in both the Fall River and upper Pit River drainages
Rural residential	Low	Runoff and effluent from Fall River Mills, Burney, and other communities may affect marbled sculpin habitats, as may diversions
Urbanization	Low	Few urban areas in region
Instream mining	n/a	
Mining	Low	Only known mining is for diatomaceous earth near Hat Creek and Britton Reservoir
Transportation	Low	Most habitats are crossed or paralleled by roads
Logging	Low	Sedimentation of Fall River and other watersheds in species range is an ongoing stressor; may have disproportionate impact on benthic species like sculpins; impacts much greater historically
Fire	Low	Wildfires are common in the region but impacts on bigeye marbled sculpin are unknown
Estuary alteration	n/a	
Recreation	Low	Most areas containing bigeye sculpin are heavily fished by trout anglers
Harvest	n/a	
Hatcheries	n/a	
Alien species	Medium	Predation and competition can reduce populations

Table 1. Major anthropogenic factors limiting, or potentially limiting, viability of populations of bigeye marbled sculpin 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 unlikely as a result; and a factor rated “no” has no known negative impact to the taxon under consideration. Certainty of these judgments is moderate. See methods section for descriptions of the factors and explanation of the rating protocol.

Effects of Climate Change: Stream flow in the key spring streams occupied by bigeye marbled sculpin (Fall River, Hat and Burney creeks) depends on water percolating into volcanic landscapes, especially the Modoc Plateau (resulting in spring outflows of 1500-2000 cfs into the Fall River). Thus, flows will depend on how climate change affects precipitation patterns and associated water supplies long distances from these rivers, which remains largely unknown. A likely assumption is reduced or more variable flows, but stream temperatures remaining cold (because most flow is subsurface through aquifers). For more seasonal streams, predictions are that stream flow will increase in the winter and early spring and decrease in the fall and summer (Knox and Scheuring 1991, Field et al. 1999, CDWR 2006); however, this may not have much effect on core bigeye marbled sculpin populations, given that they mostly occupy larger, perennial, spring-fed streams. However, three factors suggest some vulnerability of bigeye sculpin to climate change: (1) they are a cold water-dependent species; (2) temperatures are likely to increase in below-dam habitats; and (3) the effects of changes in precipitation (likely less or more variable) and possible impacts to the lava-dominated watersheds that feed the region's spring systems are unknown. Potential climate change-induced alterations to operation of hydroprojects may also affect habitats in unknown ways. Moyle et al. (2013) rated bigeye marbled sculpin as being on the cusp between high and moderate vulnerability to extinction due to the added impacts of climate change, with low certainty.

Status Determination Score = 3.0 - Moderate Concern (see Methods section Table 2)**.** The bigeye marbled sculpin does not seem to be at risk of extinction at present, despite fairly large-scale changes to streams in its native range. This sculpin is largely protected by its occupation of spring-fed rivers with expansive subsurface catchments. NatureServe ranks bigeye marbled sculpin in California as Vulnerable to extirpation due to a restricted range, few populations, recent declines and/or other factors. They estimate the global abundance of the subspecies at 2500-10,000 with recent declines of 10-30%, but there seems to be no firm basis for this conclusion. The rationale for this status determination is detailed in Table 2.

Metric	Score	Justification
Area occupied	1	Endemic to the Pit River drainage
Estimated adult abundance	4	There appear to be multiple, fairly large populations
Intervention dependence	3	Population persistence may eventually require habitat improvements (management of flows, removal of alien species)
Tolerance	2	Bigeye marbled sculpin prefer constant (flow), cold (< 20°C summer temperatures), low gradient habitats
Genetic risk	4	Populations may become isolated due to dams and reservoirs
Climate change	3	Spring-fed streams probably a refuge, but high uncertainty
Anthropogenic threats	4	See Table 1
Average	21/7	3.0
Certainty (1-4)	2	Little information specific to bigeye marbled sculpin is available

Table 2. Metrics for determining the status of bigeye marbled sculpin, 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: One of the biggest challenges to management of bigeye marbled sculpin is lack of data on abundance, genetic structure, and distribution in relation to hydroprojects. Periodic status surveys (about every 5 years) should be made of the endemic fishes and invertebrates of Fall River and Hat Creek to ensure the unique fauna remains self-sustaining. Future studies should also include genetic analyses of marbled sculpin subspecies to test whether any should be elevated to separate species status. Other recommendations are to protect and/or enhance aquatic habitats through active management of water and land use practices, including the lava catchments that feed the area's spring systems. For instance, changes in management of hydroelectric projects or trout fisheries should take into account habitat requirements and other needs of native fauna, including bigeye marbled sculpin. Water released from dams should mimic natural flow regimes in scale and periodicity. Recent changes to Pit River dam releases, as part of a FERC relicensing agreement, were implemented to more closely match natural flow regimes, including increased summer/fall base flows, increased flows during winter and spring months and intermittent freshet pulse flows (spikes) to flush substrates and vegetation. Agricultural and grazing practices should buffered from riparian areas sufficiently to protect against nonpoint source pollution and streambank destabilization.

Figure 1. Distribution of bigeye marbled sculpin, *Cottus klamathensis macrops* (Rutter), in California.