

NORTHERN CALIFORNIA BROOK LAMPREY *Entosphenus folletti* (Valdykov and Kott)

Status: High Concern. The northern California brook lamprey has a very limited known distribution and aquatic habitats within their range are heavily altered by agriculture and grazing. Their actual distribution and abundance is unknown.

Description: This lamprey is a non-predatory species that has an adult size of 17-23 cm in total length (Vladykov and Kott 1976b, Renaud 2011). Adult disc length is 6.6–7.8% of total length and the trunk myomere count is 61-65. The following description of dentition is from Renaud (2011, p. 27): “supraoral lamina, 3 unicuspid teeth, the median one smaller than the lateral ones; infraoral lamina, 5 unicuspid teeth; 4 endolaterals on each side; endolateral formula, typically 2–3–3–2, the fourth endolateral can also be unicuspid; 1–2 rows of anterials; first row of anterials, 2 unicuspid teeth; exolaterals absent; 1 row of posterials with 13–18 teeth, of which 0–4 are bicuspid and the rest unicuspid (some of these teeth may be embedded in the oral mucosa); transverse lingual lamina, 14-20 unicuspid teeth, the median one slightly enlarged; longitudinal lingual laminae teeth are too poorly developed to be counted. Velar tentacles, 8–9, with tubercles. The median tentacle is about the same size as the lateral ones immediately next to it...Oral papillae, 13.” Ammocoetes are described in Renaud (2011).

The northern California brook lamprey is similar to the Pit-Klamath brook lamprey, with which it co-occurs, but is somewhat larger (most are >19 cm TL), has a larger oral disk (<6% of TL vs >6% of TL), and has elongate velar tentacles without tubercles. There are also minor differences in various tooth counts (Renaud 2011). According to Vladykov and Kott (1976b, p. 984): “The body and fins of *E. folletti* are more darkly pigmented than those of *E. lethophagus*. The entire caudal fin of the former is strongly pigmented, except for a narrow unpigmented margin, and it has a dark second dorsal fin. In the latter the caudal fin has broader unpigmented margin and its second dorsal is less pigmented.” The region around the vent is darkly pigmented in *E. folletti* but pale in *E. lethophagus*, a potential distinguishing characteristic in the field.

Taxonomic Relationships: Non-predatory lampreys in the Klamath and upper Pit River systems are derived from Pacific lamprey (Renaud 2011). The northern California brook lamprey was described by Vladykov and Kott (1976b) based on specimens from Willow and Boles creeks, tributaries to the Lost River, Modoc County. However, the species was not recognized by the American Fisheries Society (AFS, Robins et al. 1991) because of unpublished doubts of its validity. Lang et al. (2009) listed it as a recognized species, as did Beamish (2010). The AFS then recognized it as a species based on Renaud’s (2011) analysis of lamprey species worldwide (Page et al. 2013). Beamish (2010), using gill pore papillae as a diagnostic character, suggests that *E. folletti*, as currently recognized, may represent more than one species and included in his analysis both specimens from the Lost River and from Fall Creek above Copco Reservoir in California. While evidence increasingly supports the diversity of lamprey species in the upper Klamath and Pit River basins, including northern California brook lamprey, a thorough analysis is needed using additional specimens and additional genetic and morphological studies. Further studies are almost certain to find *E. folletti* in Oregon, given its presence in two distantly separated areas in California, so the common name “northern California brook lamprey” may not be appropriate for the species. Shapovalov et al. (1981) named it the Modoc brook lamprey, a name which reflects its likely distribution as being

coincident with the Modoc Plateau region in California and Oregon, as well as with the territory of the Modoc people.

Life History: Nothing is known about the life history of this lamprey but it is presumably similar to other brook lampreys in the genus *Entosphenus*.

Habitat Requirements: Little specific information is available on its habitats, but the northern California brook lamprey is known only from a few, small, cool tributary streams that have areas with fine substrates and beds of aquatic plants.

Distribution: The northern California brook lamprey is known from only Willow and Boles creeks above Clear Lake Reservoir and from Fall Creek, a tributary to Copco Reservoir. It is almost certainly found in similar habitats in Oregon, as well as in the Lost and Klamath river basins.

Trends in Abundance: Abundance and population trend information are lacking. Their populations do not seem to be in danger of extinction at this time but face multiple threats as discussed below.

Nature and Degree of Threats: The northern California brook lamprey faces loss of suitable habitat via multiple factors affecting streams in this arid region, similar to those facing the Pit-Klamath brook lamprey.

Major dams. The only populations known are above large reservoirs, which suggests that they are isolated from other populations by dams. Dams and diversions on the upper Klamath and Lost River systems also alter downstream flows and habitats.

Agriculture. Water demands for irrigated agriculture and livestock are high in this region, leading to decreased stream flows. Flood-irrigated pastures introduce nutrients and pollutants from return waters into streams and raise water temperatures.

Grazing. Extensive grazing occurs throughout the known range of northern California brook lamprey. Grazing can degrade aquatic habitats through stream bank trampling, elimination of riparian vegetation, and pollutant inputs from animal wastes.

Alien species. Many alien fish species inhabit the Klamath and Lost river basins (Close et al. 2010). Species that can prey on lamprey include largemouth bass, brown bullhead, channel catfish, brook trout, brown trout, black crappie, and yellow perch (Close et al. 2010).

	Rating	Explanation
Major dams	High	Dams isolate populations and alter downstream habitats
Agriculture	Medium	Agriculture pervasive throughout range
Grazing	Medium	Grazing pervasive throughout range
Rural residential	n/a	
Urbanization	n/a	
Instream mining	n/a	
Mining	n/a	
Transportation	Low	Rural roads affect stream habitats
Logging	Low	Logging occurs in forested lands; impacts unknown
Fire	Low	Wildfires occur throughout range; impacts unknown
Estuary alteration	n/a	
Recreation	n/a	
Harvest	n/a	
Hatcheries	n/a	
Alien species	Low	Alien species uncommon in known stream habitats but are a potential threat

Table 1. Major anthropogenic factors limiting, or potentially limiting, viability of populations of northern California brook lamprey. 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 low. See methods section for descriptions of the factors and explanation of the rating protocol.

Effects of Climate Change: Climate change is expected to increase the frequency of both drought and floods in streams. Because ammocoetes likely rear for several years in soft substrates, large flooding events may disrupt rearing habitats (Fahey 2006) and displace ammocoetes. On the contrary, scouring events may clean sediments from gravels that would otherwise degrade spawning habitats (Stuart 2006 in Fahey 2006). It is likely that the northern California brook lamprey can tolerate, to some extent, shifts toward warmer water temperatures, which are expected to increase due to climate change. Moyle et al. (2013) did not rate climate change vulnerability for this species, but vulnerability should be similar to that of the Pit-Klamath brook lamprey.

Status Determination Score = 2.4 – High Concern (see Methods section, Table 2).

Northern California brook lamprey apparently have limited distribution in small streams subject to degradation. However, their actual abundance and distribution is unknown.

Metric	Score	Justification
Area occupied	2	Known range limited to Lost River and parts of upper Klamath
Estimated adult abundance	2	Numbers unknown but likely small
Intervention dependence	4	Long-term management of grazing practices as well as alien species may be warranted
Tolerance	3	Not known but occurs in degraded streams
Genetic risk	2	Known populations isolated by dams
Climate change	2	Some habitats may dry more extensively or for longer periods; ammocoetes may be displaced by unusually high flows
Anthropogenic threats	2	See Table 1
Average	2.4	17/7
Certainty (1-4)	1	Species is largely unstudied

Table 2. Metrics for determining the status of Northern California brook lamprey 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: Habitat degradation, grazing practices and isolation by reservoirs pose the greatest threats to this brook lamprey, effects likely to be exacerbated by increasing temperatures and more frequent flood events predicted by climate change models. Watershed management strategies exist (e.g. Klamath Basin Restoration Agreement) that address these and other factors that may limit fish populations in the upper Klamath basins. Beyond implementation of these strategies, basic life history studies and population monitoring should occur in order to better understand the status of this species. The following questions should be addressed as part of a status evaluation:

What is the current distribution and abundance in California and Oregon?

Where are most important spawning and rearing grounds located in California?

What are the optimal and preferred environmental tolerances and habitat conditions for each life history stage?



Figure 1. Known distribution of northern California brook lamprey, *Entosphenus folletti*, in California.