LONG VALLEY SPECKLED DACE
Rhinichthys osculus ssp.

Status: Critical Concern. Long Valley speckled dace face the possibility of extinction in their native range within the next 50 years because they exist only in a single, thermal-spring complex fed by the chlorinated outflow of a public swimming pool.

Description: Speckled dace are small cyprinids, usually measuring less than 8 mm but occasionally reaching 11 cm SL (Moyle 2002). Although physically variable, they are characterized by a wide caudal peduncle, small scales (47-89 along lateral line) and pointed snout with a small, subterminal mouth. At maturity, the dorsal fin usually has 8 rays and originates well behind the origin of the pelvic fins (Moyle 2002). The anal fin has 6-8 rays. Pharyngeal teeth (1,4-4,1 or 2,4-4,2) are significantly curved with a minor grinding surface. The maxilla usually has a small barbel at each end. The snout is connected to the upper lip (premaxilla) by a small bridge of skin (frenum). As their common name indicates, most fish larger than 3 cm have distinctive dark speckles on the upper and sides of the body, although some fish from highly turbid waters may lack speckles. Dark blotches present on the side can merge, creating what looks like a dark lateral band. A stripe on the head, below the eye, extends to the snout, and there is black a spot on the caudal peduncle. The rest of the body is dusky yellow to olive, with the belly a paler color. Breeding adults of both sexes have fins tipped by orange or red, while males also have red snouts and lips and tubercles on the head and pectoral fins.

Long Valley speckled dace are distinguished by high numbers of pectoral and pelvic fin rays, high lateral line scale count, low lateral line pore count, and the absence of maxillary barbels (Sada et al. 1995). The following mean counts (standard error) are from Long Valley speckled dace collected in Whitmore Hot Springs and at an unnamed spring at Little Alkali Lake (Sada 1989): lateral line scales 61.7 (1.4); lateral line pores 19.0 (5.0); dorsal rays 8.0 (0.0); anal rays 7.0 (0.0); pectoral rays 13.0 (0.4); pelvic rays 7.4 (0.2).

Taxonomic Relationships: Speckled dace from Long Valley are both morphologically distinct (Sada 1989, 1995) and monophyletic (Oakey et al. 2004), suggesting they are a distinct taxon in need of formal taxonomic description. It is not surprising that this population remains undescribed, given the confusing systematics of the naturally variable speckled dace. The speckled dace has long been considered the most widely distributed species in the western United States, with many isolated populations found in small streams and springs. Small morphological differences among speckled dace populations isolated in different watersheds (especially in the endorheic valleys of the Great Basin) led early ichthyologists to describe 12 separate species (Jordan and Evermann 1896). Later, based on the flexible nature and plastic morphology of the species, all speckled dace were collapsed into a single species, *Rhinichthys osculus* (Hubbs et al. 1974). Recently, however, genetic analysis has supported a return to some of the original taxonomy. Today, a number of forms are recognized as separate taxa based on their distinctive morphology, isolation from other dace populations, and because they are genetically distinct. Four such forms are now recognized in the Death Valley system: the Owens speckled dace, the Long Valley speckled dace, the Amargosa Canyon speckled dace, and the Ash Meadows speckled dace.

Gilbert (1893) described *Rhinichthys nevadensis* from Ash Meadows, Nevada, but the subspecific name *R. o. nevadensis* has been assigned to speckled dace in the Amargosa River canyon and Owens Basin as well (La Rivers 1962, Moyle 2002). However, in the early 1980s, research revealed that these three populations are distinct (Williams et al. 1982). As a consequence, Williams et al. (1982) and Deacon and Williams (1984) recommended that the populations from these three areas be placed in separate subspecies. Sada et al. (1995) conducted a morphological and electrophoretic study of all extant speckled dace populations in the Owens and Amargosa river systems, all of which were tributaries to pluvial Lake Manly during the Pleistocene (Miller 1946, Hubbs and Miller 1948). Their results suggest:

1. All the isolated populations in the Owens Valley show genetic and morphological differences from each other but, with one exception, not enough for them to be regarded as separate subspecies.
2. The exception is the Long Valley speckled dace population in Whitmore Hot Spring, which differs enough from other dace populations to be regarded as a separate subspecies.
3. Owens speckled dace are closely related to speckled dace found in the Amargosa River (*R. o. nevadensis*) of Death Valley and probably should be placed within the same subspecies, but each isolated population should be recognized as a distinct taxa for management purposes.
4. To date, no study of the Death Valley system speckled dace complex has been robust enough to assign subspecies names to lineages other than that in Long Valley. Until such studies are completed, the Owens and Amargosa Canyon speckled dace should be treated as distinct populations segments of *R. o. nevadensis.*

The Whitmore Hot Springs population represents the last extant population of Long Valley speckled dace. This is the only speckled dace population known with a private fixed allele (the D allele of the PEPA locus) (Sada et al. 1995). This is possibly the result of long isolation within the 700,000 year-old Long Valley Caldera (Hill et al. 1985). The speckled dace populations of the entire Death Valley system (the Owens, Amargosa and Mojave river drainages) form a monophyletic clade (Oakey et al. 2004). However, Long Valley dace are clearly differentiated within this grouping. Oakey's results, using mtDNA restriction site mapping, paired with geologic evidence, suggests that Long Valley speckled dace may retain haplotypes from an earlier period.

Life History: Little work has been conducted on the life history adaptations of speckled dace in Long Valley. The following general description is gathered from dace populations in other locations. The subterminal mouth, pharyngeal tooth structure, and short intestine of the speckled dace are characteristic of small invertebrate feeders. Speckled dace generally forage on small benthic invertebrates, especially taxa common in riffles including hydropsychid caddisflies, baetid mayflies, and chironomid and simuliid midges, but will also feed on filamentous algae (Li and Moyle 1976; Baltz et al. 1982; Hiss 1984, Moyle et al. 1991). Not surprisingly, diet varies according with prey availability and speckled dace, in general, prey opportunistically on the most abundant small invertebrates in their habitat, which may change with season (Moyle 2002). Preference of forage items may also be influenced by the presence of other fishes that share similar habitats.

Speckled dace are usually found in loose groups in appropriate habitats although they avoid large shoals, except while breeding. Their activity is also mediated by stream temperatures and they apparently stay active all year if water temperatures remain above 4°C (Moyle 2002). Slight changes in growth rates are also positively correlated with changes in temperature, as seen in the Colorado River (Robinson and Childs 2001). Life expectancy is approximately 3 years where maximum sizes do not exceed 80 mm FL, but dace may reach 110 mm FL and live up to six years (Moyle 2002). By the end of their first summer, dace grow to 20-30 mm SL (Moyle 2002), growing an average of 10-15 mm/yr in each subsequent year. Females tend to grow faster than males. However, growth rates can decrease in the presence of extreme environmental conditions, high population densities, or limited food supply (Sada 1990). Dace reach maturity by their second summer with females producing 190-800 eggs, depending on size and location (Moyle 2002). Females release eggs underneath rocks or near the gravel surface while males release sperm (John 1963). Eggs settle into interstices and adhere to the gravel. At temperatures of 18-19°C, eggs hatch in 6 days but larvae remain in the gravel for another 7-8 days (John 1963). Fry in streams congregate in warm shallow areas, often in channels with rocks and emergent vegetation.

When extreme conditions such as floods, droughts, or winter freezing eliminate local populations, speckled dace from nearby areas can readily recolonize or repopulate available habitats if accessible (Sada 1990, Pearsons et al. 1992, Gido et al. 1997).

Habitat Requirements: Speckled dace from the Owens Basin are known to occupy a variety of habitats ranging from small, cold-water streams to hot spring pools, although they are rarely found in water exceeding 29˚C. After conducting morphometric analysis of both extant and museum specimens, Sada (1989) theorized that Long Valley speckled dace were a deep-bodied form adapted to spring habitats. Despite the large variety of habitats apparently suitable for speckled dace in the Owens Basin, their disappearance from numerous localities suggests that they are quite vulnerable to habitat modifications and to invasion by alien fishes. Their present habitat is the shallow (<50 cm), clear outflow of a single spring, including two open pools in a marshy area. The narrow, nearly invisible, channel flows through a dense growth of bulrush, which provides cover for the fish.

Distribution: The entire native range of this dace lies within the 700,000 year-old Long Valley volcanic caldera, just east of Mammoth Lakes, Mono County, including Hot Creek and various isolated springs and ponds. The formation of the caldera likely led to their isolation long before other populations of the northern Owens Basin were isolated from one another. Long Valley speckled dace have been extirpated from all but one of their historic collection sites, including Hot Creek. The sole remaining population within the native range is in Whitmore Hot Springs (Sada 1989). Whitmore Hot Springs has been developed and is operated as a swimming pool by Mono County. Spring discharge of approximately 2 cfs is lightly chlorinated and feeds an alkali marsh of roughly 1 acre. In 1989, dace occupied 250 yards of stream and two large shallow ponds that did not exceed half a meter in depth. The dace population here appears to be heavily parasitized in some years (Sada 1989, S. Parmenter, CDFW, pers. comm. 2009). Surveys in 2002 and 2009 by CDFW found this population to be relatively stable (S. Parmenter, CDFW, pers. comm. 2009).

Long Valley speckled dace were translocated from Whitmore Hot Springs to an undisclosed location near Bishop (S. Parmenter, CDFW, pers. comm. 2009). On average, six additional fish from the Whitmore Springs population are translocated to the refuge population annually in an effort to minimize genetic drift.

In 1988, Sada discovered a population in an unnamed spring at Little Alkali Lake but this population was subsequently extirpated. Dace occupied an estimated 600 meters of stream between the spring source and the lake. Fish were not believed to occupy the spring source, where water temperatures exceeded 28˚C, or Little Alkali Lake itself. When last surveyed in 1999, large numbers of western mosquitofish (*Gambusia affinis*) were observed but speckled dace appeared to be absent (S. Parmenter, CDFW, pers. comm. 2009). Speckled dace were last sampled in Hot Creek in 1962 but were likely extirpated due to alterations to the system, including the creation and operation of Hot Creek Hatchery, as well as introduction of non-native trout to the stream (Sada 1989). Non-native trout are also abundant in Crowley Lake, which is connected to Hot Creek via the upper Owens River.

The Bureau of Land Management and CDFW are cooperating in an ongoing project to restore the unnamed spring tributary to Little Alkali Lake to expand the range of Long Valley speckled dace. To date, three fish barriers have been constructed and experiments are under way to eradicate mosquitofish by a combination of mechanical removal and spring diversion under freezing temperatures (S. Parmenter, CDFW, pers. comm. 2014).

Trends in Abundance: There are few data available on the historic abundance of this dace. However, the extirpation of all but one of the historically identified populations means that it is undoubtedly much less numerous than it once was. According to the US Fish and Wildlife Service (1998), it is continuing to decline.

Nature and Degree of Threats: The major causes of decline of the Long Valley speckled dace are multiple and compounded by the fact that the remaining small, isolated, populations of dace are particularly vulnerable to genetic drift and to stochastic events.

Grazing. Reduction in riparian vegetation and trampling of stream banks and springs by cattle has impacted much of their limited habitat (e.g., Whitmore Springs, Little Alkali Lake) by increasing sediment input into pools and channels, increasing solar input, and reducing habitat complexity and cover.

Recreation. The water source that supports remaining speckled dace habitat, Whitmore Hot Springs, is now a public swimming pool. The effluent maintains sufficient flows to support this population, at least in the short-term, but a spill of over-chlorinated water could extirpate them. Whitmore Hot Springs is operated by the county of Mono as a public facility, and public health laws require disinfection.

Hatcheries. Hot Creek Trout Hatchery, a CDFW facility, likely contributed to the extirpation of dace in Hot Creek and its adjacent springs through diversion of water and construction activities in the 1960s. Based on potential habitat, it is likely that the Hot Creek population was historically one of the largest populations of this dace.

Alien species. Alien fishes, especially western mosquitofish, largemouth bass (*Micropterus salmoides*), and various sunfish (*Lepomis spp.*) have been implicated in extirpating other isolated dace populations. In 1988, the only extant populations of Long Valley speckled dace were found in springs where no other fish species were present. Subsequently, the population in the unnamed spring at Little Alkali Lake became extirpated, concurrent with the discovery of mosquitofish in the spring system (S. Parmenter, CDFW, pers. comm. 2009), along with heavy damage by grazing. The single remaining population could easily be extirpated by introduction of another fish species into its limited habitat.

In addition, a population of introduced tiger salamanders exists within three miles of Whitmore Hot Springs (S. Parmenter, CDFW, pers. comm. 2009), walking distance for adult salamanders. Colonization of the springs by these predatory amphibians could eliminate the last remaining natural population of Long Valley speckled dace. Their limited habitat is also threatened by invasion of cattail (*Typha* spp.), which can significantly reduce open water habitat by rapidly colonizing shallow pools and marshes with a solid mass of plant stems.

	Rating	Explanation
Major dams	n/a	
Agriculture	Low	Little agriculture near extant populations
Grazing	High	Cattle continue to seriously degrade dace habitats
Rural residential	Low	Few residences nearby
Urbanization	Low	Past water delivery infrastructure built by LADWP (e.g., Crowley Lake, diversions, pipelines) may have altered historic dace habitats
Instream mining	n/a	
Mining	Low	No known impacts but mining present in region
Transportation	Low	No known impacts but roads border dace habitats
Logging	n/a	
Fire	Low	Grass fires can destroy protective vegetation
Estuary alteration	n/a	
Recreation	Critical	Whitmore Hot Springs, the source of water for remaining dace habitat, is a public swimming pool; chlorine release is a potentially severe threat
Harvest	n/a	
Hatcheries	High	The creation of Hot Creek Trout Hatchery probably led to extirpation of the population in Hot Creek
Alien species	Critical	No Long Valley speckled dace are found in habitats where alien fishes occur

Table 1. Major anthropogenic factors limiting, or potentially limiting, viability of populations of Long Valley speckled dace. 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: The thermal spring systems which Long Valley speckled dace inhabit are fed by aquifers dependent on snow melt for recharge. One major predicted impact of climate change in the eastern Sierra Nevada is the reduction in snow pack due to warmer temperatures. This will have the least effect in the southern Sierra Nevada because the range reaches its highest elevations in this area, so snow pack is expected to remain consistent. Thus, snowmelt is likely to maintain flows in most Owens Valley streams. However, it is possible that snow pack will be reduced in the portion of the Sierra Nevada spanning from Bishop to June Lake; this region is most proximate to remaining Long Valley speckled dace habitats and snow pack retention will likely be critical to maintaining stream flows and aquifer recharge in Long Valley. In any case, climate change predictions indicate that snow will not persist as long into the hotter months and stream flows will likely be reduced in late summer or early fall. A hotter, drier, future climate, paired with an ever-increasing human demand for decreasing water resources in the Owens Basin, suggest that dace habitat may be threatened by drying conditions in the future. Moyle et al. (2013) regarded the Long Valley specked dace as "critically vulnerable" to extinction from climate change, along with the other substantial threats this dace faces.

Status Determination Score = 1.0 – Critical Concern (see Methods section, Table 2). The Long Valley speckled dace now exists as a single population in shallow pools fed by the chlorinated outflow of a public swimming pool. The Long Valley speckled dace is listed as "Endangered" by the American Fisheries Society (Jelks et al. 2008) and as "declining" by the US Fish and Wildlife Service (Owens Basin Wetland and Aquatic Species Recovery Plan 1998).

Metric	Score	Justification
Area occupied	1	Only one small population occupying a single thermal spring system
Estimated adult abundance	1	Fluctuates widely but was very small when the authors sampled in July, 2010
Intervention dependence	1	Refuge populations must be established; prevention of over-chlorinated releases from Whitmore Hot Springs resort critical
Tolerance	1	Extremely vulnerable to competition from alien fishes
Genetic risk	1	Bottlenecking a distinct possibility
Climate change	1	Shallow pools fed by a thermal spring are vulnerable to rises in air temperature
Anthropogenic threats	1	See Table 1
Average	1.0	7/7
Certainty (1-4)	3	Good recent data

Table 2. Metrics for determining the status of Long Valley speckled dace, 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 Long Valley speckled dace is one of the most critically imperiled non-listed fishes in California and requires intensive and ongoing management, monitoring and would benefit from additional protections and provisions afforded by either a state or federal listing (or both).

Without additional protection, this species is likely to go extinct in the wild. Actions required include:

1. Whitmore Hot Springs should be managed for Long Valley speckled dace and other spring organisms, with dace populations monitored annually.
2. A thorough survey of all potential habitats within the Long Valley Caldera should be conducted and all existing habitats given special protection (e.g., fenced from grazing).
3. The extant refuge population near Bishop should be maintained, ensuring adequate gene flow by translocation individuals from Whitmore annually.
4. Populations should be established at additional sites in Long Valley, as recommended by Sada (1989) and the Owens Basin Wetland and Aquatic Species Recovery plan (USFWS 1998). Priority reintroduction locations are:
    a. The spring system at Little Alkali Lake, but only after mosquitofish have been removed. A low head fish barrier should also be installed to inhibit recolonization of the spring system from the lake.
    b. The Hot Creek and Little Hot Creek conservation areas, as stated in the Owens Basin Wetland and Aquatic Species Recovery plan (USFWS 1998).
5. Non-native fish should be eradicated from springs which historically supported speckled dace in order to facilitate re-introduction.
6. Consider the creation of artificial refuges, such as small ponds on existing spring systems, recognizing that such ponds have limited life spans and must be actively managed.
7. Alien tiger salamander populations near Whitmore Hot Springs should be exterminated.

Figure 1. Distribution of Long Valley speckled dace, *Rhinichthys osculus* ssp., in California.