SOUTHERN LONG-TOED SALAMANDER

Ambystoma macrodactylum sigillatum Ferguson 1961

Status Summary

Ambystoma macrodactylum sigillatum is a Priority 2 Species of Special Concern, receiving a Total Score/Total Possible of 66% (73/110). It was not considered a Species of Special Concern during the previous evaluation (Jennings and Hayes 1994a).

Identification

Ambystoma macrodactylum sigillatum is a medium-sized (4.1–8.9 cm SVL) salamander with a broad head and large eyes (Stebbins 2003). The dorsal ground coloration is black or dusky brown with a yellow dorsal stripe that is usually divided into blotches on the body and into fine spotting on the head and tail (Ferguson 1961, Petranka 1998, Stebbins 2003). Small whitish-blue flecks are present on the sides of the body, and the ventral surface is dark brown (Stebbins 2003). The larvae have large bushy gills and a dorsal fin that extends to near the forelimbs (Petranka 1998).

Metamorphosed individuals of this species are unlikely to be confused with any other salamanders within its range. Other subspecies of *A. macrodactylum* have similar body proportions but differ in the size, extent of blotching,

Southern Long-Toed Salamander: Risk Factors

Ranking Criteria (Maximum Score)	Score
i. Range size (10)	5
ii. Distribution trend (25)	15
iii. Population concentration/migration (10)	10
iv. Endemism (10)	3
v. Ecological tolerance (10)	3
vi. Population trend (25)	20
vii. Vulnerability to climate change (10)	10
viii. Projected impacts (10)	7
Total Score	73
Total Possible	110
Total Score/Total Possible	0.66

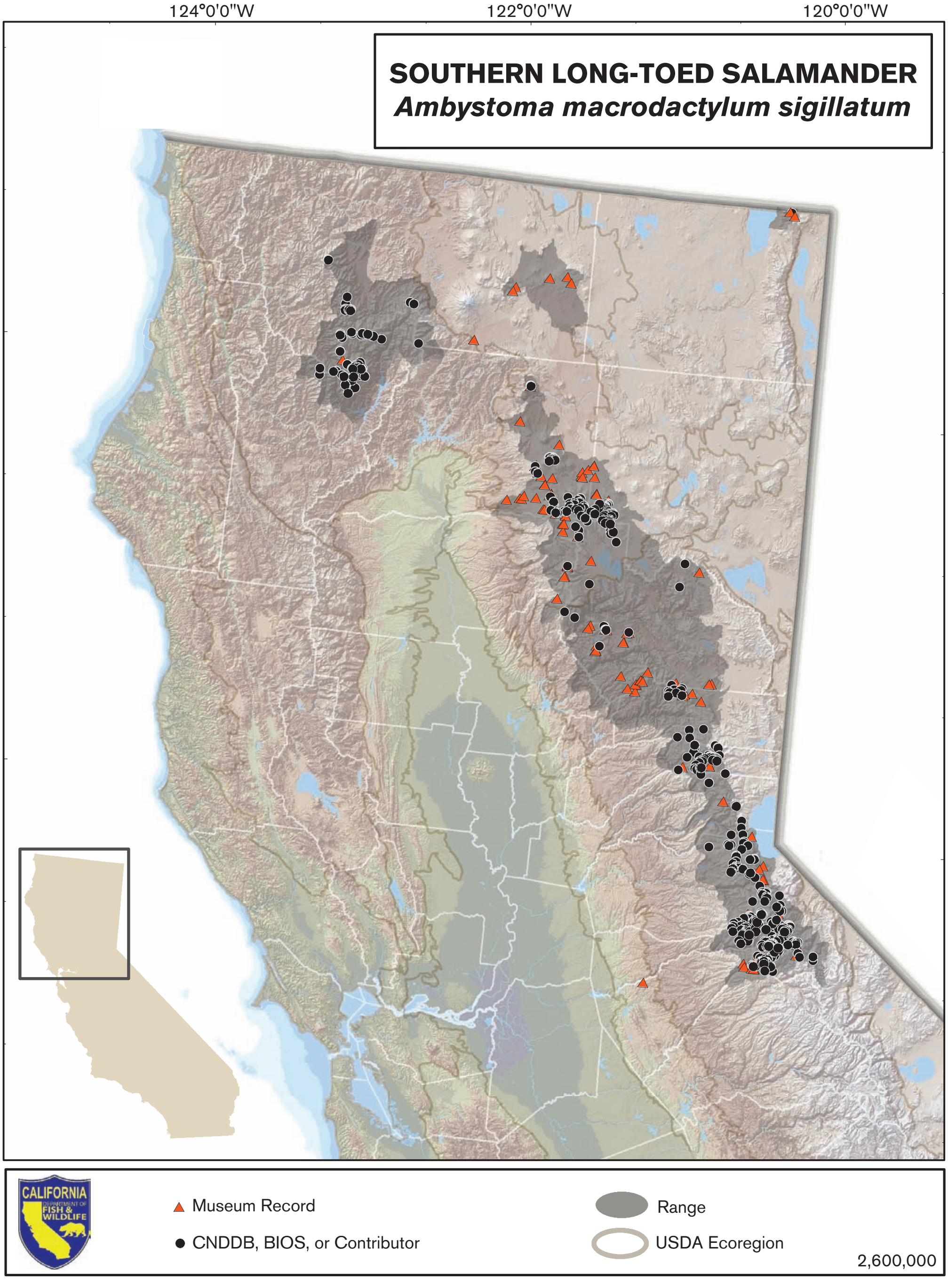

PHOTO ON PREVIOUS PAGE: Southern long-toed salamander, Butte County, California. Courtesy of Robert Hansen.

and coloration of the dorsal stripe, and their ranges do not overlap in California. Differentiating larvae from co-occurring newts (*Taricha granulosa, T. torosa*) requires careful attention. Newt larvae generally have small, narrow heads and few gill rakers (5–7 on the anterior side of the third gill arch), whereas *A. macrodactylum* larvae have broad heads and 9–13 gill rakers on the anterior side of the third arch (Stebbins 2003).

Taxonomic Relationships

Ambystoma macrodactylum sigillatum is one of five currently recognized subspecies of long-toed salamander (Petranka 1998, Stebbins 2003). *Ambystoma macrodactylum* has been widely recognized as a distinct species since its initial description by Baird (1854). Since this time, a number of different species and subspecies have been described. The current five-subspecies arrangement stabilized after the work of Ferguson (1961), which described *A. m. columbianum* (eastern long-toed salamander) and *A. m. sigillatum*, as well as the work of Russell and Anderson (1956), which described the geographically isolated *A. m. croceum* (Santa Cruz long-toed salamander) from Santa Cruz and Monterey Counties. Ongoing genetic studies indicate that several of these subspecies may warrant full species status (Savage 2008). *Ambystoma macrodactylum sigillatum* was described based on the size, color, and pattern of the dorsal band, as well as vomerine tooth counts (Ferguson 1961). Although it intergrades morphologically with *A. m. columbianum* at the northern edge of its range (Ferguson 1961), ongoing genetic analyses support recognition of *A. m. sigillatum* as a distinct species (Savage 2008).

Life History

Ambystoma macrodactylum sigillatum is a pond-breeding salamander that often has a prolonged larval stage. The life history of this taxon varies widely depending on elevation and climate (Petranka 1998). Here we have summarized data for *A. m. sigillatum*, where possible, and described the variation present across the species where the life history is highly variable and/or uncertain.

Adults emerge from hibernation and migrate to breeding habitat after the first thaw. Mating begins shortly after adults enter the breeding habitat, usually in May or June, with lower-elevation populations usually being able to breed earlier than higher-elevation populations (Anderson 1967, Howard and Wallace 1985). Elsewhere in the *A. macrodactylum* range, primarily at low elevations where the climate is mild, breeding is not delayed by winter freezes, so reproduction starts with the onset of fall rains (Ferguson 1961, Nussbaum et al. 1983). As in other *Ambystoma* species, mating follows a pattern of courtship and spermatophore deposition. Females oviposit on vegetation, rocks, sticks, or directly on the pond bottom 2–3 days following courtship and mating (Anderson 1961, Stebbins 2003). The eggs are laid singly or in clumps of up to 100 eggs (Petranka 1998, Stebbins 2003). The pattern of egg deposition varies geographically in this species: *A. m. sigillatum* tends to lay eggs singly or in long loose clusters in relatively deep water (Anderson 1967), although this is variable. Eggs hatch in 2–5 weeks, with longer incubation periods required at higher elevations and lower water temperatures (Anderson 1967, Nussbaum et al. 1983, Petranka 1998). The larval period can be as short as 50 days in temporary pools at lower elevations but may last 2 years in the highest elevations in permanent pools (Nussbaum et al. 1983, Pilliod and Fronzuto 2005). Size at metamorphosis varies widely from 2.3 to 4.8 cm SVL (Howard and Wallace 1985). This species is able to tolerate a relatively wide range of water temperatures, with larvae overwintering under the ice at near freezing temperatures but then selecting the warmest areas available throughout the summer (up to 24.5°C). Presumably these temperatures allow for more rapid larval growth and development (Anderson 1968b).

Ambystoma macrodactylum sigillatum is a generalist predator, as both larva and postmetamorph, that feeds on a variety of small insects, crustaceans, and spiders (Anderson 1968a). Larvae and males in the aquatic environment will prey on zooplankton, insect larvae, and small snails (Anderson 1968a, Nussbaum et al. 1983). In the lab, larvae are also known to take frog (primarily *Pseudacris*) tadpoles and conspecific larva (Anderson 1968a, Nussbaum et al. 1983). Females apparently do not feed in the aquatic environment, which may simply reflect the short amount of time they spend there during the breeding season (Anderson 1968a).

Habitat Requirements

Ambystoma macrodactylum, as a species, occurs in a larger variety of habitat types than any other salamander in the Northwestern United States (Ferguson 1961, Nussbaum et al. 1983). Suitable habitats for *A. m. sigillatum* include arid grassland and sagebrush communities, dry woodlands, coniferous forests, alpine meadows, and a wide variety of intermediate habitat types (Ferguson 1961, Petranka 1998, Pilliod and Fronzuto 2005). In some areas, this species is abundant in disturbed agricultural areas (Nussbaum et al. 1983). Elsewhere in the range, landscape genetic studies indicate that populations that persist in highly modified habitats do so with increased population isolation, probably increasing susceptibility to local extirpations (Goldberg and Waits 2010).

At high elevations (above 2450 m in the Sierra Nevada and 2100 m in the Klamath Mountains), where breeding occurs late and larval development is prolonged, some populations of *A. m. sigillatum* require permanent water bodies for breeding because larvae overwinter prior to metamorphosis (Anderson 1967; K. Leyse, pers. comm.). If these overwintering sites are shallow (1–2 m in depth), as is common in the Tahoe region of the Sierra Nevada, few larvae seem to survive the winter (K. Leyse, pers. comm., unpublished data). Spring-fed water bodies may increase the likelihood of successful overwintering, though more data are required to verify this. This subspecies also persists far more readily in fishless water bodies (see the “Nature and Degree of Threat” section).

The species is known to utilize hardwood forests, meadows, and granite slopes for upland habitat. Further study on the extent and types of upland habitat that this species requires are needed.

Distribution (Past and Present)

Ambystoma macrodactylum sigillatum ranges from southwestern Oregon (south of the Calapooya divide, Lane and Douglas Counties) through the Trinity Alps, Warner Mountains, Sierra Nevada, and adjacent areas of northwestern California reaching as far south as Carson Pass (Ferguson 1961, Brode 1967, Bury 1970a, Pilliod and Fronzuto 2005). The known elevational range for this taxon is from near sea level to 3000 m (Stebbins 1966, Nussbaum et al. 1983), although the distribution in California is restricted to the higher end of this range. The presence of isolated populations of the species *A. macrodactylum* in Santa Cruz and Monterey Counties, California (*A. m. croceum*), and in southeastern Oregon suggests that the species may have been historically distributed more broadly throughout the west. If so, the present-day range likely reflects a range contraction as climate has changed over the last several thousand years.

Localized, present-day changes in distribution appear to be ongoing in several parts of California. In the historically fishless Klamath–Siskiyou bioregion, *A. m. sigillatum* are 44 times more likely to be present in lakes without fish than lakes that contain fish. Because these fish have been introduced during the last 150 years, it is likely that some lakes where *A. m. sigillatum* does not occur represent localized extirpations as a result of fish predation (Welsh et al. 2006). A similar pattern occurs in the north central Sierra Nevada near Lake Tahoe. Here, *A. m. sigillatum* are present in 92.3% of fishless sites, but only 37.5% of fish-containing sites (Leyse 2005). In the Klamath Mountains, *A. m. sigillatum* was documented at 25 of 118 sites in surveys conducted between 1999 and 2001. Salamanders were present at only 15 of these sites when they were resurveyed in 2008 (K. Pope, pers. comm.). The overall geographic extent of the *A. m. sigillatum* range appears to still be intact, but it is clear that localized extirpations are occurring in several areas.

Trends in Abundance

Abundances of *Ambystoma macrodactylum sigillatum* have declined throughout relatively large areas of the California range. The Klamath Mountain surveys described above documented 4126 individuals at 25 occupied sites in 1999–2001 but only 569 individuals at the 15 occupied sites in 2008 (K. Pope, pers. comm.). Few historical abundance data are available, but overall current abundance of larvae at lower-elevation sites appears to be low (K. Leyse, pers. comm.). Population genetic estimates of population trends suggest that regional populations exchange few migrants and that effective population sizes are small (Savage et al. 2010).

Nature and Degree of Threat

Trout introductions are the largest threat to remaining populations of *Ambystoma macrodactylum sigillatum*. Welsh et al. (2006) found that the absence of introduced fish was a major predictor of *A. m. sigillatum* presence even after controlling for other environmental variables. Aside from the local effect of fish on individual water bodies, fish introductions appear to affect *A. macrodactylum* populations at the scale of entire watershed basin. In Idaho, basins with higher introduced fish densities had significantly lower densities of *A. macrodactylum* (Pilliod and Peterson 2001). The authors postulated that much of the remaining fishless habitat in fish-containing basins is too shallow for most larvae to successfully overwinter and that the deeper, fish-containing pools no longer acted as stable source populations for the basin. This led to a destabilization of normal source–sink dynamics, causing declines throughout the entire basin. These results suggest that the presence of fish at the basin scale is a significant conservation risk, irrespective of whether patches of fishless habitat remain within the basin (Pilliod and Peterson 2001). Where *A. m. sigillatum* persist in the presence of fish, larval densities are very low both in deeper fish-containing pools and in adjacent fishless pools (K. Leyse, pers. comm.). When larvae are found in fish-containing pools, they tend to hide under rocks or are only captured in overnight trapping, indicating that they may alter their behavior in response to the presence of predators (K. Leyse, pers. comm., though see Tyler et al. 1998). Declines due to the presence of fish have also been documented elsewhere in *A. macrodactylum*'s range (Liss and Larson 1991, Liss et al. 1995, Tyler et al. 1998). In Montana, introduced trout were linked to *A. m. krausei* extirpations. Salamander recolonization following local trout extirpations strongly indicated that trout were the actual causal agent of declines (Funk and Dunlap 1999).

Climate change also poses a threat for *A. m. sigillatum*. Many of the remaining pools that this species utilizes are shallow. Projected shifts to earlier and faster snowmelt in the Sierra Nevada could have complex and possibly negative effects on this species by changing the hydrology of lakes and ponds (Cayan et al. 2008b, Franco et al. 2011, PRBO 2011). As many of these pools appear to be spring fed, any changes to hydrology of the springs could also have severe impacts (Leyse 2005).

Disease and environmental contaminants may also pose threats for remaining populations of *A. m. sigillatum*. Lethal ranavirus infections of *A. m. sigillatum* were recently detected in Lassen Volcanic National Park (Bunck et al. 2009). This species is also susceptible to iridovirus infection and exposure to atrazine, a commonly used herbicide (Forson and Storfer 2006). *Bd* has been detected in a single adult salamander at Carter Meadow in Lassen National Forest, although the load was low. Prevalence of *Bd* appears to be low for this species and no evidence of die-offs or illness due to this pathogen is known (K. Pope and J. Piovia-Scott, unpublished data).

Status Determination

Ongoing serious declines in distribution and abundance are the primary reasons for this Priority 2 status.

Management Recommendations

The presence of relatively deep fishless pools appears to be important to the continued persistence of this species, particularly at the highest elevations. As such, fish stocking should be limited in areas where *Ambystoma macrodactylum sigillatum* occurs. Where stocking does occur, mitigation strategies outlined by Appendix K of California Department of Fish and Wildlife hatchery and stocking program environmental impact report should be followed (ICF Jones and Stokes 2010).

Monitoring, Research, and Survey Needs

Declines due to fish predation have now been amply demonstrated, so continued monitoring on the effects of fish predation is less important than work related to fish removal. If predaceous fish can be successfully removed from areas supporting this species, occasional monitoring should be undertaken to detect unauthorized reintroductions, particularly in areas that experience high human impact and to document recolonization dynamics by the salamanders. An important management question centers on the relative importance of permanent and temporary pools to metapopulation dynamics across elevations. That is, it may be that at lower elevations, temporary fish-free pools are the primary source of successful recruitment, and deeper lakes can therefore be maintained as fishing resources, whereas at the highest elevations, the species can only persist if permanent, fish-free habitats are common. The type and extent of upland habitat utilized by this species is also in need of further study. In particular, the extent of upland habitat that populations require in order to persist has not been studied in this taxon. Climate change could also have different impacts on the upland phase of the life cycle, in addition to the impacts that are projected for the aquatic part of the life cycle. In addition, populations are still under considerable risk from disease, and monitoring efforts focused on detecting the presence of ranavirus and *Bd* should be continued.