

fragmentation and isolation caused by urban development.

B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

In the past, the larvae of non-native tiger salamanders could legally be used as bait by fishermen in California. The extent of the use of the Sonoma County California tiger salamander is unknown. The California Code of Regulations (2002) now specifies that no salamander may be used as bait and excludes the California tiger salamander from a list of salamanders, newts, toads, and frogs that may legally be taken and possessed under authority of a sportfishing license. The success of these present regulations in avoiding or reducing recreational harvest of the California tiger salamander is unknown.

Tiger salamanders are generally thought to make good pets by amateur herpetologists (Porras 2002). The Sonoma County California tiger salamander does not appear to be particularly popular among amphibian and reptile collectors. However, Federal listing could raise the value of the species within wildlife trade markets, and increase the threat of unauthorized collections above current levels (K. McCloud, Special Agent, Service, pers. comm., 2002). Even limited interest in the species could pose a serious threat to the DPS.

C. Disease or Predation

Disease

Relatively little is known about the diseases of wild amphibians (Alford and Richards 1999). The specific effects of disease on the Sonoma County California tiger salamander are not known and the risks to the animal have not been determined. However, it is known that mass mortalities of amphibians from disease are not uncommon, and may be either a natural phenomenon of the biology of species or induced by anthropogenic agents (Corn 1994). In California, large numbers of dead and dying California tiger salamanders were observed in a pond in the Los Alamos Valley in Santa Barbara County, but the cause was not determined (S. Sweet, pers. comm., 1998).

Worthylake and Hovingh (1989) described repeated die-offs of tiger salamanders (*A. tigrinum*) at Desolation Lake in the Wasatch Mountains of Utah. Affected salamanders had red, swollen hind legs and vents, and widespread hemorrhage of the skin and internal organs. The researchers determined that the die-offs were due to infection from

the bacterium *Acinetobacter*, or redleg disease. The number of *Acinetobacter* in the lake increased with increasing nitrogen levels as the lake dried. The nitrogen was believed to come from both atmospheric deposition and waste from sheep grazing in the watershed (Worthylake and Hovingh 1989). *Acinetobacter*, which appears to affect amphibians whose immune systems have been weakened by stress (Corn 1994) or another bacterial infection, was also the suspected cause of larval tiger salamanders deaths in Arizona (Collins *et al.* 1988, as cited in Corn 1994). *Acinetobacter* is common in soil and animal feces.

Lefcort *et al.* (1997) found that tiger salamanders raised in natural and artificial ponds contaminated with silt were susceptible to infection by the water mold *Saprolegnia parasitica* at a location in Georgia. This fungus first appeared on the feet, spread to the entire leg, and then infected animals died. Die-offs of western toads (*Bufo boreas*), Cascades frogs (*Rana cascadae*), and Pacific treefrogs also have been associated with *Saprolegnia* infections (Kiesecker and Blaustein 1997). *Saprolegnia* is widespread in natural waters and commonly grows on dead organic material (Wise *et al.* 1995). *Saprolegnia ferax* outbreaks have been identified as a cause of high amphibian embryo mortalities in the Pacific Northwest (Kiesecker *et al.* 2001).

Viruses associated with die-offs of tiger and spotted salamanders in Maine and North Dakota have been isolated (B. McLean, National Wildlife Health Center, *in litt.*, 1998). Also, Jancovich *et al.* (1997) isolated a virus, believed to be an iridovirus, as the primary pathogen responsible for a decimating epizootic event affecting the federally endangered Sonoran tiger salamander (*Ambystoma tigrinum stebbinsi*) in Arizona. Iridoviruses have recently been implicated as the cause of amphibian mass deaths worldwide, with novel iridoviruses identified from a number of regions.

Ranaviruses are often highly virulent and cause systemic infections in amphibians. Epizootiology (science that deals with the character, ecology, and causes of outbreaks of animal diseases) of ranaviral disease in amphibians is poorly understood, but dissemination may be partly due to the virus's ability to remain infectious under adverse conditions and for prolonged periods. Likely modes of spread of amphibian ranaviruses may include use of fishing gear, including boats, and through artificial stocking of ponds for recreational fishing. Also, water birds have the potential to mechanically

transfer the virus on their feathers, feet, or bills, or by regurgitation of ingested infected material. Some outbreaks of ranaviral disease in tiger salamanders have been associated with altered habitats and artificial ponds. Due to their highly virulent nature, ranaviruses should be considered a potential threat to amphibian populations, especially those isolated from previous disease outbreaks (and thus lacking specific immunity) and species with low fecundity (Daszak *et al.* 1999).

Kiesecker *et al.* (2001) reported that pathogen outbreaks in amphibian populations in the western U.S. may be linked to climate-induced changes in UV-B light exposure. Their findings indicate that climate-induced reductions in water depth at oviposition (laying of eggs) sites have caused high mortality of embryos by increasing their exposure to UV-B radiation and, consequently, their vulnerability to infection. Furthermore, they speculate that climate changes since the mid-1970s related to El Niño/Southern Oscillation cycles and elevated sea-surface temperatures could be the precursor for pathogen-mediated amphibian declines in many regions.

Pathogen outbreaks have not been documented in Sonoma County California tiger salamanders. Nevertheless, disease must be considered a potential future population threat because of the relatively small, fragmented remaining Sonoma County California tiger salamander breeding sites, the many stresses on these sites due to habitat losses and alterations, and the many other potential disease-enhancing anthropogenic changes which have occurred both inside and outside of the range of this DPS. An amphibian pathogen could eliminate one or more breeding sites of this animal.

Predation

Predation and competition by introduced or non-native species potentially affect all of the known Sonoma County California tiger salamander breeding sites. Bullfrogs prey on California tiger salamanders (P. Anderson 1968; Lawler *et al.* 1999). Morey and Guinn (1992) documented a shift in amphibian community composition at a vernal pool complex, with California tiger salamanders becoming proportionally less abundant as bullfrogs increased in number. Lawler *et al.* (1999) found that less than 5 percent of California red-legged frog (*Rana aurora draytonii*) tadpoles survived to metamorphosis when raised with bullfrog tadpoles. Moyle (1973) attributed disappearance of both