SANTA ANA SPECKLED DACE
***Rhinichthys osculus* ssp.**

Status: Critical Concern. Santa Ana speckled dace are highly vulnerable to extinction within the next 50 years because their small, fragmented, populations are restricted to areas that are increasingly prone to catastrophic fire, debris flows, intensive water consumption, pollution, invasive species, and expanding urbanization and suburban development.

Description: Speckled dace are small cyprinids, usually measuring 8-11 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. Larvae have deep bodies, small eyes, overhanging snout and are characterized by 35-41 myomeres and distinctive coloration (Feeney and Swift 2008). Distinctive coloration in larvae includes large spots located on the sides of the bottom portion of the caudal peduncle and a wedge-shaped patch of spots on top of the head. Larvae have functioning eyes, mouth, and gas bladder by the time the notochord flexes at about 7-9 mm TL. A noticeable band of pigment running just below the lateral midline is visible at about 9 mm. The terminal mouth of larvae becomes subterminal at about 9.7 mm. The pectoral fins remain unpigmented until the later stages of larval development. Later stages also develop a distinctive spot on the base of the caudal fin. Scales appear when dace reach 13 mm FL (Jhingran 1948). Once fully developed, 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). Most fish larger than 3 cm have distinctive dark speckles on the upper and sides of the body, a dark lateral band that extends to the snout, and 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 tiny tubercles on the head and pectoral fins.

Taxonomic Relationships: The genus *Rhinichthys* is widely distributed and abundant in North America and has eight recognized species. However, most species are highly variable and may encompass complexes of unrecognized species or subspecies (Moyle 2002). Early taxonomists described different forms as separate species but later lumped them together when the variable nature of each species was discovered. For example, Jordan and Evermann (1896) described 12 separate species, which were later collapsed into a single species (Hubbs et al. 1974). However, subspecies, many of which were formerly recognized as full species, continue to be recognized on the basis of their location and isolation, provided formal scientific names exist for them. Although widely distributed, evidence continues to mount in support of the concept that isolated speckled dace populations throughout the west have long independent evolutionary histories, with distinctive adaptations to local environments. Relationships among various lineages still await resolution using modern molecular and morphometric techniques. In Oregon, speckled dace collected from five river basins exhibited high levels of divergence (0.82) among locations, and high genetic diversity (0.2, nucleotide diversity) within basins (Pfrender et al. 2004). Similarly, Oakey et al. (2004) found that speckled dace collected throughout the western United States were significantly different among sub-basins, consistent with the idea that local populations are characterized by long isolation from other populations. Based on the findings of their phylogenetic studies, Pfrender et al. (2004) proposed that populations within different basins should be considered to be Evolutionarily Significant Units for the purposes of management.

The Santa Ana speckled dace is one form that is thought to merit subspecies or, perhaps, full species designation due to its distinctive morphology (Cornelius 1969, Hubbs et al. 1979) and genetics. Although the subspecies has not yet been formally described, electrophoretic analysis supports the conclusion that this form is very different from other speckled dace (T.R. Haglund, University of California, Los Angeles, pers. comm. 1996, T. Metcalf, Calif. State Univ., San Bernardino, pers. comm. 2008). Initial mtDNA sequence analysis strongly suggests that Santa Ana speckled dace are genetically distinct from other speckled dace in California (T. Metcalf, unpubl. data, 2008). This form is apparently more closely related to speckled dace in the Colorado River basin than dace in northern California, as a result of a split in clades approximately 3.6 mya (Oakey et al. 2004, Smith and Dowling 2008). Furthermore, speckled dace in the Los Angeles basin (Santa Ana and San Gabriel rivers) were found to be only distantly related to those in the Owens or Amargosa rivers. Smith and Dowling (2008) indicate that populations of speckled dace in the Los Angeles basin have been isolated long enough (through the Pleistocene) to develop distinctive morphological characters. The long phylogenetic branch lengths associated with speckled dace from the Los Angeles basin suggests that these fish have undergone rapid molecular evolution. Oakey et al. (2004) also determined that speckled dace from the Santa Ana and San Gabriel rivers formed a monophyletic lineage.

Life History: Little has been published on the life history of Santa Ana speckled dace so this account is largely based on information from other dace populations. Their variability in body shape has allowed speckled dace to exploit a wide variety of habitats. The Santa Ana dace has a fairly streamlined body form (for a speckled dace) that indicates adaptation for living in flowing water (Moyle 2002). Although speckled dace are usually found in loose groups in appropriate habitats, such as rocky riffles, they avoid large shoals except while breeding. They can be active both day and night. Their activity is also mediated by stream temperature; they will remain active all year if stream temperatures exceed 4°C, which would be typical of streams inhabited by Santa Ana dace (Moyle 2002).

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 occasionally feed on filamentous algae (Li and Moyle 1976; Baltz et al. 1982; Hiss 1984, Moyle et al. 1991). Their subterminal mouth, pharyngeal tooth structure, and short intestine are characteristic of small invertebrate feeders. 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. Speckled dace have been observed feeding by picking and grazing on cobbles in riffles and pool tail-out habitats in the East Fork San

Gabriel River (J. O'Brien, CDFW, pers. obs.). Preference of forage items may also be influenced by presence of other fishes that share similar habitats, such as sculpin or juvenile steelhead (e.g., Johnson 1985).

Length frequency analyses have determined age and growth patterns. 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 under extreme environmental conditions, high population densities, or limited food supply (Sada 1990). 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 three years where maximum sizes do not exceed 80 mm FL, which is typical of Santa Ana speckled dace. However, in the upper San Gabriel River drainage dace over 110 mm SL are fairly common (J. O'Brien, CDFW, pers. obs.). Elsewhere, dace may reach 110 mm FL and live up to six years (Moyle 2002). Dace reach maturity by their second summer, with females producing 190-800 eggs, depending on size and location (Moyle 2002). Presumably, Santa Ana speckled dace are at the low end of this range, given their relatively small size. Spawning is generally associated with rising water temperatures and/or high flow events, suggesting that Santa Ana speckled dace most likely spawn in March-May. Spawning in lakes occurs primarily over shallow areas of gravel within the lake body itself or upstream in the edges of riffles of inlet streams. Groups of males will clear an area of algae and detritus and then surround a female when she enters the area. Females release eggs underneath rocks or near the gravel surface, while males release sperm (John 1963). Eggs settle into interstices and adhere to gravels. 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. Santa Ana speckled dace were observed spawning within a pool during May, 2010 in Bear Creek, tributary to the West Fork San Gabriel River. A group of three to six males pursued and repeatedly attempted to spawn with several females at the head of the pool from 14:00-15:00 hours. Water temperature was 18°C, turbidity 1.5 NTU, velocity 0.8 m/s, and flow was 9 CFS. Seven days later, spawning activity was no longer observed but eggs were detected on the downstream bottom portion of a small boulder where the spawning activity occurred (J. O'Brien, CDFW, unpublished data).

Habitat Requirements: Santa Ana speckled dace are found mainly in perennial streams fed by cool springs that maintain summer water temperatures below 20°C (Moyle et al. 1995), although speckled dace in other regions of the west tolerate temperatures of 26-28°C. Surveys of trout streams in the Los Angeles basin found dace occupying shallow riffles dominated by gravel and cobble. Their habitat in the West Fork San Gabriel River was described as shallow (average depths of 15-30 cm), gravel-cobble dominated riffles with overhanging riparian vegetation (Deinstadt et al. 1990). Feeney and Swift (2008), however, characterized their preferred habitat as pools in low-gradient streams (0.5-2.5% slope) with sand to boulder substrates in slow-moving waters, noting that they were also found along stream edges by fast-moving water. O'Brien et al. (2011) observed dace in a wide variety of habitats, including riffles, runs, and pools in the San Gabriel River drainage.

Distribution: The ability of speckled dace to colonize new areas and adapt to different environments has resulted in their wide distribution. Speckled dace are the only native fish found in all major drainages in western North America. In California, their native range includes drainages in Death Valley (Amargosa River), Owens Valley, eastern Sierra Nevada (Walker River north to Eagle Lake), Surprise Valley, Klamath-Trinity basin, Pit River basin, including the Goose Lake watershed, Sacramento River basin, as far south as the Mokelumne River, San Lorenzo, Pajaro and Salinas River basins, San Luis Obispo, Pismo and Arroyo Grande Creek basins, Morro Bay, and the San Gabriel and Los Angeles basins (Swift et al. 1993).

Santa Ana speckled dace historically inhabited streams in the upland areas of the Santa Ana, San Gabriel and Los Angeles rivers systems (Moyle et al. 1995). They have since disappeared from many parts of their range, including the middle reaches of the Santa Ana River, Strawberry Creek (Santa Ana River), Mill Creek (Santa Ana River), and most of the Los Angeles River and San Jacinto River basins (Feeney and Swift 2008, G. Abbas, San Bernardino National Forest, pers. comm. 2008). Young-of-year and 2 year old fish were found in City Creek (Santa Ana River) in 2008, a location from which speckled dace were thought to have been extirpated (G. Abbas, pers. comm. 2008). Their current distribution is restricted to the headwaters of the Santa Ana and San Gabriel rivers and in Big Tujunga Creek (Los Angeles River drainage) (Moyle et al. 1995, O'Brien and Stephens 2009). A population was recently documented in Indian Creek, a headwater tributary of the San Jacinto River. Some fish were removed and held in captivity following the Esperanza Fire in 2006 to prevent total loss from flooding. They were reconfirmed as present in 2007 and 2008 (G. Abbas, pers. comm. 2008). Attempts to establish additional populations of Santa Ana speckled dace have been made through introductions into the Santa Clara and Cuyama rivers and into River Springs, Mono County. The introduction into the Santa Clara River is thought to have failed and the status of the other populations is uncertain.

Trends in Abundance: Population estimates for Santa Ana speckled dace were not found. However, their abundance is likely a small fraction of what it was in the past and populations have disappeared from two of five streams in which they were historically present (G. Abbas, pers. comm. 2008, Metcalf et al., unpubl. report). Perhaps eight populations remain in their native range, mostly small and isolated from one another. Moyle et al. (1995) declared their numbers so diminished that they were in danger of extinction.

Swift et al. (1993), Moyle et al. (1995), Abbas (pers. comm. 2008) and O'Brien (unpublished observations) indicate the status of specific populations by location, detailed below.

Big Tujunga Creek (Los Angeles River). Dace once inhabited this creek for 10-20 km below Big Tujunga Dam and were thought to be extinct due to drought conditions and establishment of red shiner (*Cyprinella lutrensis*) (Moyle et al. 1995). Red shiners directly compete for food and space with dace and prey on dace eggs. Surveys performed from 2002-2005 found a few (in the 10s) speckled dace at this and other locations in the Los Angeles River basin (Tujunga Wash, Haines Canyon, G. Abbas, pers. comm. 2008).

Surveys by CDFW indicate that dace populations have rebounded since the 2009 Station Fire and dace are common within the Tujunga Wash (O'Brien and Stephens 2009).

Fish Canyon (San Gabriel River). This population was thought to be extinct (Moyle et al. 1995). Only 6-7 fish were seen in 1988. Optimal dace habitat has been infringed upon by a rock quarry operation. However, current quarry operations are focused on restoring the streambed in order to improve dace habitat (G. Abbas, pers. comm. 2008). A few individuals were collected from this site in 2007 by ECORP. Morris dam isolates this population from other dace in the San Gabriel River, preventing genetic flow and recruitment between populations. Some recent (2002, 2006 and 2007) surveys established their presence in this location, while others did not (2005; G. Abbas, pers. comm. 2008). California Department of Fish and Wildlife surveys in 2006 and 2008 found that dace occupied a 0.8 km section of stream within the Angeles National Forest (O'Brien 2006, 2008). The U.S. Forest Service was provided specimens by rock quarry consultant and these are being analysed by Anthony Metcalf at California State University, San Bernardino, to determine genetic relationships (G. Abbas, pers. comm. 2008).

West, North, and East Fork San Gabriel River. These areas constitute the best remaining Santa Ana speckled dace habitat (Moyle et al. 1995). Populations in the West Fork in 1990 likely numbered less than 2000 (Deinstadt et al. 1990). Habitat in the West Fork is vulnerable to high water and sediment releases from Cogswell Reservoir which is managed for flood control. As of 1995, the West Fork was still recovering from major sediment releases from 1981 and 1991. These sediments buried most of the habitat used by dace until they were flushed out by rainfall and dam water releases in 1988. Multiple-pass electrofishing surveys performed in the West Fork in 1993 found 29 dace in a 68 m section of stream (Moyle et al. 1995). Surveys in 2006 found dace in only one of three locations sampled (G. Abbas, pers. comm. 2008). Dace were also abundant upstream of Cogswell Reservoir in 2005. Surveys (2005) of the North Fork found dace in one of the two days of sampling. Suveys (2005) also documented the presence of 100s of speckled dace in Cattle Creek (G. Abbas, pers. comm. 2008). Multiple-pass electrofishing surveys performed by CDFW in the middle portion of the East Fork (Heaton Flat and Shoemaker Canyon) between 1997-2010 indicated an average estimated density (fish/mile) of Santa Ana speckled dace as follows (years in parentheses): 2,143 fish/mile (1997); 4,113 fish/mile (2000); 4,640 fish /mile (2010) (Weaver and Mehalick 2010). A comprehevive survey of the upper San Gabriel River from 2007-2008 found that dace occupy 4.5 km within the North Fork, 19.5 km in the East Fork, and 20 km in the West Fork (O'Brien et al. 2011).

Santa Ana River. Speckled dace are assumed to be extirpated from most of the Santa Ana River (Moyle et al.1995, Moyle 2002). They were last seen near Rialto in 2001 (G. Abbas, pers. comm., 2008). Only a few specimens (usually <4) were documented in the mainstem in 2000 (Swift 2001) and 2005 (San Bernardino National Forest in G. Abbas, pers. comm. 2008). Recent surveys suggest that their distribution in the basin is largely limited to small areas in headwater streams, as follows:

Lytle Creek (mainstem). "The stronghold area for Santa Ana speckled dace is currently in the mainstem reach from Miller's Narrows downstream to Turk Point (approximately 1.4 river miles). The Forest Service has qualitatively monitored this reach since at least 1999. Santa Ana speckled dace have been there throughout this period with significant population fluctuations in response to drought induced low flows, major flooding (periods of declining population densities), and a couple years of sustained moderate flows (period of rapid population density increases). This reach is currently the species stronghold for this watershed, being the only place where they have persisted, and must be diligently protected from disturbance and enhanced at every opportunity. This stronghold reach is regularly threatened by encroachment into the wash by heavy equipment by a variety of forest users to protect infrastructure including public roads, public utilities and private access routes. There is perennial water above Miller's Narrows in the mainstem up to the confluence with the Middle Fork, but dace were absent here between at least 1999 and 2005.

In 2005, the Forest Service, CDFG [CDFW], and Fontana Union Water Company Consultant Jonathan Baskin conducted a reintroduction of approximately 1000 Santa Ana speckled dace from the lower mainstem of Lytle Creek to the Applewhite Picnic Area on the North Fork of Lytle Creek. In 2007 Southern California Edison reported capture of Santa Ana speckled dace in their diversion works above Miller's Narrows suggesting that some of the fish from the North Fork reintroduction had survived and migrated downstream (3.2 river miles) to this location. With this information we can now consider all of the mainstem above Turk Point occupied by Santa Ana speckled dace.

In 2007, the Forest Service and CDFG [CDFW] conducted a translocation of approximately 1300 Santa Ana speckled dace from the lower mainstem of Lytle Creek to the North Fork at Applewhite Picnic area.

In 2005 and 2006, sustained year-round flows from Turk point down to the Fontana Union Water Company (FUWC) diversion (1.8 river miles) resulted in an expansion of the speckled dace population throughout the reach with juveniles rearing in the settling pond at FUWCs intake structure (adults were also noted in the raceways of the intake structure). With this knowledge we can assume that in years when there are flows below Turk Point, that reach of the mainstem is occupied by Santa Ana speckled dace." (Excerpt from Abbas 2008).

Lytle Creek (forks). The Middle Fork Lytle Creek is a high quality water source for this watershed, consistently producing perennial waters over a 3.2 km reach. Beginning near the national forest boundary with the community of Scotland, there is a reach of the South Fork mapped as intermittent for approximately 0.6 river miles. However this reach has rarely gone dry and also supports a popular trout fishery. In 2007, the U.S. Forest Service and CDFW conducted a reintroduction of approximately 500 Santa Ana speckled dace from the lower mainstem of Lytle Creek to the Middle Fork just a few hundred meters upstream of the Scotland boundary. Surveys by the U.S. Forest Service confirmed the persistence of these fish as of 2008, but no assessment of their movement from the introduction point was conducted. There is high quality habitat available from the forest boundary with Scotland upstream at least 4.1 river km. There are no significant fish passage barriers known within this reach, so the full 4.1 km reach above Scotland is now considered Santa Ana speckled dace habitat.

Cajon Creek (tributary to Lytle Creek). Dace appear to be abundant in this drainage, predominantly congregated upstream and downstream of Interstate 15 (Moyle et al. 1995). Their presence was also documented by surveys in 2005 (G. Abbas, pers. comm. 2008). There have been several recent fires in the area. Hazardous waste spills from trucks and trains using the transportation corridor threaten aquatic habitat in this watershed. The San Bernardino National Forest, CDFW, and BNSF Railroad have been moving fish into headwater tributaries to protect them from highway or railway spills.

City Creek. Dace were seen in September, 2003, following the Bridge Fire. No dace were found following the devastating Old Fire (October, 2003) and subsequent flooding. Several surveys were conducted in 2005, 2006, and 2007 and no dace were found. However, in 2008, a small population was found in the West Fork and reconfirmed in 2009.

East Fork City Creek. Dace were observed immediately after the Bridge Fire in 2003 (G. Abbas, pers. comm. 2008). Fewer dace were seen after the Old Fire in October, 2003, and none after subsequent flooding in December, 2008. No dace were observed in 2004, 2005, 2006 and 2007.

Mill Creek. Dace were found here in the 1980s, but not in 1990 (Moyle et al. 1995). They were thus thought to be extirpated (Moyle et al. 1995), but a few were observed in a small pool created by a human-made grade control structure in 2007 (G. Abbas, pers. comm. 2008). However, dace were not seen in 2008 and are now assumed to be extirpated from Mill Creek (G. Abbas, pers. comm. 2008).

Plunge Creek. Speckled dace were observed in 2001 (9 individuals) and 2005 (G. Abbas, pers. comm. 2008). Dace were collected in 2004 to protect them from potential flooding. They were returned to the stream after the threat of flooding passed (G. Abbas pers. comm. 2008).

Silverado Canyon (Santa Ana watershed). Although dace were found in 1987, none were found in the same or nearby areas in 1990 (Moyle et al. 1995) or 2005 and 2007 (G. Abbas, pers. comm. 2008, J. O'Brien 2007).

Santiago Creek (Santa Ana River tributary). Surveys in 2005 did not find speckled dace within the mainstem or tributaries (Harding Canyon Creek, Silverado Creek; G. Abbas, pers. comm. 2008, J. O'Brien 2006-2009).

San Jacinto River. Dace were recorded in 15-30 km of stream but not since the mid-1980s (T. Haglund, in Moyle et al. 1995). Large portions of the river and the lower portion of its tributaries are now dry in the summer. Surveys in 2005 did not find speckled dace in the mainstem or in the North and South forks (G. Abbas, pers. comm. 2008).

Strawberry Creek (tributary to San Jacinto River). A small population was found in 1992 by the U.S. Forest Service (C. Swift pers. comm. in Moyle et al. 1995). Surveys did not detect dace in 2005 or 2006 (G. Abbas, pers. comm. 2008). Several surveys following the 2003 Old Fire and Christmas Flood did not find dace. They are presumed extirpated from Strawberry Creek.

Indian Creek (tributary to San Jacinto River). In 2006, Santa Ana speckled dace found in Indian Creek were relocated to the Riverside-Corona RCD for captive breeding after the Esperanza Fire (G. Abbas, pers. comm. 2008). Fish survived the fire and the population is recovering. The population has been able to sustain itself following the fire due to the lack of large flood events.

Nature and Degree of Threats: Threats to the Sana Ana speckled dace and their habitats include: 1) dams and diversions; 2) habitat loss and degradation, especially factors associated with urbanization; 3) grazing; 4) agriculture; 5) mining; 6) recreation;

7) wildfires; and 8) alien species (Swift et al. 1993, Moyle et al. 1995, Moyle 2002, Swift 2005; see Table 1).

Dams and diversions. Virtually all Santa Ana speckled dace streams contain one or more dams and diversions, so flows are generally depleted and natural flow regimes altered. Cogswell Dam on the West Fork San Gabriel River and Big Tujunga Dam on Tujunga Creek are particularly problematic for speckled dace because they block movement of fishes and capture large amounts of sediment, which often bury preferred habitats when released from the dam.

Agriculture. Agriculture is a greatly reduced threat from the past because much of the agricultural land in the Santa Ana speckled dace's range has been urbanized. However, runoff from remaining dairy and citrus operations is a source of pollution in some streams.

Urbanization. Most portions of the Los Angeles, Santa Ana and San Gabriel rivers not in public lands are highly urbanized. Extensive river channelization and impoundment has occurred in the middle and lower reaches of all rivers for flood control. These alterations result in the loss of ecological value by changing streams from riparian corridors to canals. Urbanization has also caused water quality degradation in these rivers. The Los Angeles River (lowest reach) is identified as impaired for pH, ammonia, lead, coliform, trash, scum algae, total dissolved solids and turbidity (http://ceres.ca.gov/wetlands/geo_info/so_cal/los_angeles_river.html).
The State Water Resources Control Board lists sections of the Santa Ana River as impaired by heavy metals, pathogens, bacteria, and nutrients (www.waterboards.ca.gov). The board also lists sections of the San Gabriel River as impaired by bacteria, pH, and heavy metals (lead, copper). While water quality impairment is of concern in portions of the Santa Ana speckled dace's occupied range, it is important to note some of these areas (e.g., the lowest reach of the Los Angeles River, which is an extremely altered concrete-lined channel) are no longer suitable habitat for most fishes, regardless of water quality issues.

Mining. Speckled dace in Cattle Creek (tributary to the East Fork San Gabriel River) may be adversely influenced by mining operations (Moyle et al. 1995). A rock quarry in Fish Canyon is encroaching on speckled dace habitat. However, the mining company is in the process of restoring fish habitat. Suction dredging in San Gabriel and Cajon Wash and Lytle Creek may have negatively affected habitats used by dace and other aquatic species; however, suction dredging is currently banned in California streams and the CDFW is prohibited from issuing dredging permits for an indeterminate period of time (http://www.dfg.ca.gov/suctiondredge/).

Transportation. The watersheds occupied by speckled dace have some of the highest road densities in California, due to intense urbanization in southern California. Roads exist along most speckled dace streams and impacts likely include increased siltation, pollutant input (chemical and solid (trash) wastes), as well as barriers to upstream movement. Non-paved U.S. Forest Service and other roads in the mountainous areas are also of concern, given the friable soils in this region that easily erode into streams as well as their facilitation of access for intensive human recreational use.

Fire. Fire frequency, duration and intensity have increased in southern California in the last 20+ years, increasing the risk of debris torrents and landslides. Recent wildfires and subsequent debris torrents in southern California destroyed speckled dace habitat in 2004, 2006 and 2008 (Metcalf et al. unpubl. data, G. Abbas, pers. comm. 2008). Predictions are that fire frequency, intensity, and duration will continue to increase over the next century, due to increasing temperatures and changes in precipitation patterns (Fried et al. 2004, Lenihan et al. 2008, Westerling and Bryant 2008). Catastrophic fires can accelerate the delivery of fine sediment to streams, thereby degrading the permeability of stream substrates. Fires also remove riparian vegetation along streams, increasing the amount of solar radiation input into streams and, correspondingly, water temperatures. Streams scoured during flood events after large fires generally cannot be reoccupied by natural upstream movement due to barriers (natural and artificial), stream channelization, and other factors that have altered the lower portions of nearly all rivers occupied by dace.

Recreation. Heavy recreational use in streams, including camping, dam building for waterplay, swimming, and off-road vehicle use, may displace fish from optimal habitats and further stress fish in suboptimal habitat. Swift (2003) expressed concern over the impacts of recreational activities on fish populations in the Santa Ana River as did O'Brien in the San Gabriel River (O'Brien et al. 2011). There is also concern over recreational impacts in Lytle and Mill creeks. Large portions of the San Gabriel River drainage are heavily utilized for water play, swimming, and bathing; many artificial impoundments have been built to facilitate these activities, leading to fragmentation of dace habitats (J. Weaver, CDFW, pers. obsv. 2009).

Alien species. Alien fish species are common in the reservoirs and highly altered stream reaches of the Los Angeles, Santa Ana and San Gabriel rivers. Brown trout (*Salmo trutta*), hatchery-stocked rainbow trout (*Oncorhynchus mykiss)* and red shiners can directly compete with or prey on speckled dace (Moyle et al. 1995, http://www.dfg.ca.gov/news/stocking). Bass (*Micropterus* spp.) may also prey on native cyprinids and are present in Tujunga Creek below Tujunga Dam (O'Brien pers. obs. 2012). Bullfrogs (*Lithobates catesbeiana*) and alien crayfishes may also prey on dace at various life stages. Alien aquatic vegetation can also reduce the quality of speckled dace habitat. Giant reed (*Arundo donax*) has altered aquatic habitats in some sections of the Santa Ana River so that it is no longer suitable for native fishes, including speckled dace (Bell 1997). Stream reaches where giant reed dominates the riparian vegetation are characterized by increases in pH and ammonia and decreases in dissolved oxygen. Although efforts are underway to remove *A. donax* from many streams in southern California, it is very difficult to remove (http://www.smslrwma.org/invasives/Arundo/ADRegionalMap.html) and is present in all watersheds where Santa Ana speckled dace are found.

	Rating	Explanation
Major dams	High	Dams and reservoirs are found in all major drainages
Agriculture	Medium	Agricultural runoff is a source of pollution in some streams but most areas are now urbanized
Grazing	Low	Present at low intensities in some watersheds
Rural Residential	Low	High historical threat; now greatly reduced since dace are now confined to upper portions of watershed, often on public lands
Urbanization	Medium	Urbanization and suburbanization has degraded watersheds containing dace; much higher historical threat as dace have already been largely eliminated from urban stream reaches and are now confined to upper portions of watershed, often on public lands
Instream mining	Low	Mining activities can displace dace from preferred habitat; effects mostly localized
Mining	Low	Rock quarry in Fish Canyon is encroaching on habitat
Transportation	High	Roads exist along most speckled dace streams, negatively affecting habitats through pollution and sediment inputs, along with channel constriction and barriers to instream movement
Logging	Low	Forest thinning and other practices require roads; most are unimproved, serve as sources of sediment input and provide corridors for recreational access
Fire	High	Fire frequency, duration and intensity are increasing, resulting in more frequent debris torrents and landslides
Estuary Alteration	n/a	
Recreation	Medium	Heavy recreational use may displace and stress fish as well as fragment and alter habitats
Harvest	n/a	
Hatcheries	n/a	
Alien species	High	Alien aquatic species and invasive giant reed and tamarisk threaten most populations

Table 1. Major anthropogenic factors limiting, or potentially limiting, viability of populations of Santa Ana speckled dace 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 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 most noticeable and widespread impacts of climate change on aquatic habitats in southern California will be continued increase in water temperatures and changes to the timing, frequency and duration of drought and flooding events. Water temperatures will increase by approximately 0.7°C by 2099, based on conversion factors developed by Eaton and Scheller (1996). Although this increase is seemingly small (and is probably an underestimate), it may be significant to fish already exposed to summer temperatures above 20°C. For example, elevated temperatures may stress fish so that autoimmune function is repressed, making them more susceptible to disease. White spot disease infections have already been detected in speckled dace collected from the East Fork San Gabriel River (Warburton et al. 2001).

Elevated air temperatures associated with climate change will change the periodicity and magnitude of peak and base flows in 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, Stewart et al. 2004, Stewart et al. 2005, CDWR 2006, Knowles et al. 2006). Hydrographs that mimic natural flow regimes more closely may actually benefit speckled dace populations, as their populations can reestablish themselves faster than those of alien fish species (Gido et al. 1997, Valdez et al. 2001, Propst and Gido 2004). However, decreases in summer base flows may further isolate speckled dace populations. Dace in Cajon Creek, North Fork Lytle Creek, West Fork City Creek, Silverado Canyon and the San Jacinto River become isolated by the presence of dry stream reaches during most of the year, preventing repopulation and genetic mixing between stocks (Moyle et al. 1995). Fire frequency, intensity and duration will almost certainly increase in southern California over the next century due to increasing temperatures and changes in precipitation patterns (Fried et al. 2004, Lenihan et al. 2008, Westerling and Bryant 2008), further threatening the stability and quality of speckled dace habitats. Moyle et al. (2013) considered Santa Ana speckled dace to be "critically vulnerable" to the effects of climate change.

Status Determination Score = 1.6 - Critical Concern (see Methods section Table 2). The Santa Ana speckled dace is in danger of extinction in the next 50 years (Table 2). Santa Ana speckled dace are a Region 5 U.S. Forest Service Sensitive Species in the three southern California national forests to which they are native (Angeles, San Bernardino, Cleveland). However, it is now considered extirpated from the Cleveland National Forest (Santiago Creek; see above). The California Natural Diversity Database ranks speckled dace as secure at the global scale (G5) but the Santa Ana subspecies as Imperiled (T1S1; www.natureserve.org). It is considered Threatened by the American Fisheries Society (Jelks et al. 2008). Listing of the Santa Ana speckled dace under the Federal Endangered Species Act was denied after being petitioned in 1994 because it had not been described as a separate taxon from other speckled dace in the southwest (61FR4722). Recent genetic and phylogenetic studies show this form to be distinct from other speckled dace in California (Oakey et al. 2004, Smith and Dowling 2008, Metcalf, unpubl.), so it merits further taxonomic investigation and publication of findings in the peer-reviewed literature. Extinction is likely unless special protection is afforded (Swift et al. 1993, Moyle et al. 1995, Moyle 2002). The range of this form has been dramatically diminished due to urbanization in the Los Angeles region, resulting in fragmentation and reduction of populations.

Metric	Score	Justification
Area occupied	3	Distribution restricted to the headwaters of the Los Angeles, Santa Ana and San Gabriel rivers
Estimated adult abundance	2	Most populations are small (50-100 individuals)
Intervention dependence	1	Captive breeding and intensive management of streams is needed
Tolerance	2	Appears to need cooler water than most speckled dace; water quality conditions now often exceed tolerances of speckled dace in general
Genetic risk	1	Small, isolated populations are vulnerable to genetic drift and bottlenecks
Climate change	1	Because most populations are in small streams in an already dry region there is extreme range-wide vulnerability to climate change
Anthropogenic threats	1	Many factors with high degree of threat (Table 1)
Average	1.6	11/7
Certainty (1-4)	3	Information is largely from experts who work closely with Santa Ana speckled dace

Table 2. Metrics for determining the status of Santa Ana 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: Endangered species listing of this distinctive dace at the federal level has been denied for reasons of taxonomy, so a high priority for the Santa Ana speckled dace is to have it formally recognized as a distinct taxon. Beyond that, funding should be secured to complete genetic and morphological studies and to publish the results in peer-reviewed literature.

A multi-pronged recovery process is needed to prevent the extinction of Santa Ana speckled dace, including:

- Provide special protection for all streams and watersheds occupied by speckled dace and from which Santa Ana speckled dace have been observed in the past 20 years.
- Establish a rigorous (annual) monitoring program for streams that are known to contain dace in order to generate population estimates and trend data. Establish a periodic (every 3-5 years) monitoring program for streams in which dace have been observed within the past 20 years.
- Develop a Santa Ana speckled dace recovery plan to prioritize stream restoration and other actions needed to sustain dace populations (see recommendations below).

Stream restoration. Stream channelization, impoundments and pollution have degraded aquatic habitats in the middle and lower reaches of all major southern Californa drainages. Efforts (e.g., Los Angeles River Revitalization Project) should be made to reestablish the ecological function of these streams. Associated actions may include daylighting (unearthing and removing river channels from underground canals), riparian planting, volunteer stream clean up projects, and managing flows to mimic natural flow regimes. Water treatment should be improved for any water discharged into streams. The reestablishment of wetlands along streams could help meet multiple goals by removing toxins, increasing seasonal water retention, and increasing the biodiversity of riparian corridors.

Captive breeding program. A captive breeding program should be evaluated for potential benefits to dace and include assessments of possible donor stocks from multiple populations, following a genetic management plan.

Reintroduction of extirpated populations. Streams where dace have been lost due to flooding and other causes should be considered for repopulation from captively reared fish or fish salvaged or captured from adjacent healthy populations. Many of the lower sections of streams become mostly dry in the summer, leaving dace isolated in pools. These fish can be (and have been) moved to upstream areas in order to repopulate areas where they have been flushed out or extirpated due to other causes.

Expand range into suitable habitats with barriers. Expanding the range of the species in historically and currently occupied drainages is most desirable (e.g. South Fork of Lytle Creek, North and East Fork San Gabriel River, Cajon Wash, etc.), but transplants into streams outside the range should be considered if they provide suitable habitat and impacts to other native fishes and invertebrates are deemed minimal.

Manage wildfire. Measures such as brush thinning and prescribed burning should continue to be used and monitored to determine their efficacy in minimizing impacts from wildfire in national forests (Keeley 2002, Keeley et al. 2004). Prescribed burning confined to small areas can reduce the chances of inadvertently burning entire watersheds, minimize fire intensity, and decrease the potential for flooding and debris flows in subsequent years.

Minimize impacts of alien species. Alien fish planted into reservoirs should be prevented from moving into streams, possibly with the use of screens or gates. Bass, brown trout and red shiners should, where feasible, be eradicated from streams where they are established. Efforts should continue to remove giant reed throughout the range of Santa Ana speckled dace.

Minimize impacts from agricultural and urban areas. Settling ponds, wetlands, or other wastewater treatment options should be used where point sources of pollution are identified. Living riparian buffers (riparian vegetation, wetlands) should be maintained or restored along stream channels in order to mitigate the effects of nonpoint source pollution. The use of chemicals (e.g., pesticides for mosquito abatement) that are nontoxic to vertebrates should be used wherever possible.

Limit recreational use. In heavy use areas, recreational use of speckled dace streams should be limited until dace populations recover. Area closures should be implemented if necessary to protect habitat integrity. Priority should be given to the development of educational programs and volunteer stream restoration projects in order to minimize the need for area closures.

Minimize impacts from grazing. If grazing is permitted in speckled dace watersheds, grazing allotments should be closely monitored before, during and after use. Grazing permits should include requirements that reduce impacts to streams and riparian corridors (through the establishment of herd size limits, strict timing and duration of grazing periods, management and enforcement of allotment boundaries and monitoring of landscape response metrics such as minimum vegetative cover, vegetation height, etc).

Alternative (out of stream) water sources should be provided and streams fenced where they are heavily impacted by livestock.

Evaluate mining impacts. Recreational and commercial mining should be evaluated and, where negative impacts are identified, eliminated within the range of Santa Ana speckled dace. The current ban on suction dredging in California should be assessed to determine if, and to what extent, native aquatic fauna and their habitats are benefitting from this protective measure. It is worth noting that recreational mining is increasing in popularity (especially with recent spikes in the value of gold) and occurs in many locations where suction dredging formerly occurred; therefore, impacts are ongoing and benefits from the ban on suction dredging may be difficult to detect in this densely populated region.

Manage conservatively in the face of climate change. The predicted impacts from climate change will exacerbate all existing threats to Santa Ana speckled dace. Fishes native to southern California watersheds are likely to experience severe impacts, given the already hot and arid nature of the mostly desert streams they occupy, coupled with intense urban and suburban expansion in the region. Climate change models should be employed with respect to forecasting and development of long-term best management practices to protect cool water habitats in southern California streams.

Figure 1. Generalized distribution of Santa Ana speckled dace, *Rhinichthys osculus* ssp., in California. Actual distribution is highly fragmented.