

Appendix E  
**Biology of Decision Species**

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## Appendix E

# Biology of Decision Species

This appendix contains brief summaries of the biology and status of decision species evaluated in Chapter 4 of the environmental impact report/environmental impact statement (EIR/EIS). All species addressed in Table 4-1 of that chapter are included here. Table 4-1 is reproduced here, as Table E-1. Decision species include special-status species as defined in Chapter 4 and other species determined by DFG to have some potential for adverse effects from the Program.

**Table E-1. Decision Species Potentially Affected by Hatchery and Stocking Programs**

Common Name	Scientific Name	Status (federal)	Status (state)
Crayfish, Shasta	<i>Pacifastacus fortis</i>	FE	SE
Shrimp, California Freshwater	<i>Syncaris pacifica</i>	FE	SE
<i>Lampreys</i>			
Lamprey, River	<i>Lampetra ayresii</i>	(none)	SSC
Lamprey, Kern Brook	<i>Lampetra hubbsi</i>	(none)	SSC
Lamprey, Klamath River	<i>Lampetra similis</i>	(none)	SSC
<b>Anadromous or Estuarine Non-Salmonid Fish</b>			
Sturgeon, Green (Southern DPS)	<i>Acipenser medirostris</i>	FT	SSC
Smelt, Delta	<i>Hypomesus transpacificus</i>	FT	ST
Smelt, Longfin	<i>Spirinchus thaleichthys</i>	(none)	ST, SSC
Eulachon	<i>Thaleichthys pacificus</i>	FPT	SSC
Goby, Tidewater	<i>Eucyclogobius newberryi</i>	FE	SSC
<b>Freshwater and Estuarine Fish</b>			
Chub, Owens Tui	<i>Gila bicolor snyderi</i>	FE	SE
Chub, Goose Lake Tui	<i>Gila bicolor thalassina</i>	(none)	SSC
Chub, Arroyo	<i>Gila orcuttii</i>	(none)	SSC
Hardhead	<i>Mylopharodon conocephalus</i>	(none)	SSC
Dace, Owens Speckled	<i>Rhinichthys osculus</i> ssp. 2	(none)	SSC
Dace, Santa Ana	<i>Rhinichthys osculus</i> ssp. 3	(none)	SSC
Sucker, Owens	<i>Catostomus fumeiventris</i>	(none)	SSC
Sucker, Modoc	<i>Catostomus microps</i>	FE	SE, FP
Sucker, Santa Ana	<i>Catostomus santaanae</i>	FT	SSC
Cui-ui	<i>Chasmistes cujus</i>	FE	(none)
Stickleback, unarmoured three-	<i>Gasterosteus aculeatus williamsoni</i>	FE	SE, FP
Perch, Sacramento (within native range only)	<i>Archoplites interruptus</i>	(none)	SSC

Common Name	Scientific Name	Status (federal)	Status (state)
Trout, Coastal Cutthroat	<i>Oncorhynchus clarkii clarkii</i>	(none)	SSC
Trout, Lahontan Cutthroat	<i>Oncorhynchus clarkii henshawi</i>	FT	(none)
Trout, Paiute Cutthroat	<i>Oncorhynchus clarkii seleniris</i>	FT	(none)
Trout, Volcano Creek Golden	<i>Oncorhynchus mykiss aguabonita</i>	(none)	SSC
Trout, Eagle Lake Rainbow	<i>Oncorhynchus mykiss aquilarum</i>	(none)	SSC
Trout, Kern River Rainbow	<i>Oncorhynchus mykiss gilberti</i>	(none)	SSC
Trout, Goose Lake Redband	<i>Oncorhynchus mykiss</i> ssp. 1	(none)	SSC
Trout, McCloud River Redband	<i>Oncorhynchus mykiss</i> ssp. 2	(none)	SSC
Trout, Warner Valley Redband	<i>Oncorhynchus mykiss</i> ssp. 3	(none)	(none)
Trout, Little Kern Golden	<i>Oncorhynchus mykiss whitei</i>	FT	(none)
Steelhead (Klamath Mountains	<i>Oncorhynchus mykiss irideus</i>	(none)	SSC
Steelhead (Northern California	<i>Oncorhynchus mykiss irideus</i>	FT	SSC
Steelhead (Central Valley DPS)	<i>Oncorhynchus mykiss irideus</i>	FT	(none)
Steelhead (Central California Coast	<i>Oncorhynchus mykiss irideus</i>	FT	(none)
Steelhead (South/Central	<i>Oncorhynchus mykiss irideus</i>	FT	SSC
Steelhead (Southern California	<i>Oncorhynchus mykiss irideus</i>	FE	SSC
Salmon, Coho (Southern	<i>Oncorhynchus kisutch</i>	FT	ST, SSC
Salmon, Coho (Central California	<i>Oncorhynchus kisutch</i>	FE	SE
California Tiger Salamander	<i>Ambystoma californiense</i>	FT	SCE, SSC
Northwestern Salamander	<i>Ambystoma gracile</i>	(none)	(none)
Long-toed salamander	<i>Ambystoma macrodactylum</i>	(none)	(none)
Santa Cruz long-toed salamander	<i>Ambystoma macrodactylum croceum</i>	FE	SE, FP
California Giant Salamander	<i>Dicamptodon ensatus</i>	(none)	(none)

Common Name	Scientific Name	Status (federal)	Status (state)
Pacific Giant Salamander	<i>Dicamptodon tenebrosus</i>	(none)	(none)
Southern Torrent Salamander	<i>Rhyacotriton variegatus</i>	(none)	SSC
Rough-skinned Newt	<i>Taricha granulosa</i>	(none)	(none)
Red-bellied Newt	<i>Taricha rivularis</i>	(none)	(none)
Sierra Newt	<i>Taricha torosa sierrae</i> (= <i>Taricha sierrae</i> )	(none)	(none)
Coast Range Newt (Monterey Co. &	<i>Taricha torosa torosa</i>	(none)	SSC
Western Tailed Frog	<i>Ascaphus truei</i>	(none)	SSC
Western spadefoot	<i>Spea</i> (= <i>Scaphiopus</i> ) <i>hammondii</i>	(none)	SSC
Western Toad	<i>Bufo boreas</i>	(none)	(none)
Arroyo Toad	<i>Bufo</i> (= <i>Anaxyrus</i> ) <i>californicus</i>	FE	SSC
Yosemite Toad	<i>Bufo</i> (= <i>Anaxyrus</i> ) <i>canorus</i>	FC	SSC
Woodhouse's Toad	<i>Bufo woodhousii</i>	(none)	(none)
California Treefrog	<i>Hyla</i> (= <i>Pseudacris</i> ) <i>cadaverina</i>	(none)	(none)
Pacific Treefrog	<i>Hyla</i> (= <i>Pseudacris</i> ) <i>regilla</i>	(none)	(none)
Northern Leopard Frog (native	<i>Rana</i> (= <i>Lithobates</i> ) <i>pipiens</i>	(none)	SSC
Lowland Leopard Frog	<i>Rana</i> (= <i>Lithobates</i> ) <i>yavapaiensis</i>	(none)	SSC
Northern Red-Legged Frog	<i>Rana aurora aurora</i>	(none)	SSC
California Red-Legged Frog	<i>Rana draytonii</i>	FT	SSC
Foothill Yellow-Legged Frog	<i>Rana boylei</i>	(none)	SSC
Mountain Yellow-Legged Frog	<i>Rana muscosa</i>	FE	SSC
Mountain Yellow-Legged Frog	<i>Rana muscosa</i> (includes <i>R. sierrae</i> )	FC	SSC
Cascades Frog	<i>Rana cascadae</i>	(none)	SSC
Oregon Spotted Frog	<i>Rana pretiosa</i>	FC	SSC
<b>Reptiles</b>			
Western Pond Turtle	<i>Clemmys marmorata</i>	(none)	SSC
Common Garter Snake	<i>Thamnophis sirtalis</i>	(none)	(none)
Mountain Garter Snake	<i>Thamnophis elegans elegans</i>	(none)	(none)
Sierra (Western Aquatic) Garter	<i>Thamnophis couchii</i>	(none)	(none)
Two-striped Garter Snake	<i>Thamnophis hammondii</i>	(none)	SSC
Giant Garter Snake	<i>Thamnophis gigas</i>	FT	ST
San Francisco Garter Snake	<i>Thamnophis sirtalis tetrataenia</i>	FE	SE, FP
South Coast Garter Snake	<i>Thamnophis sirtalis</i> ssp.	(none)	SSC

Common Name	Scientific Name	Status (federal)	Status (state)
<b>Birds</b>			
Bald Eagle	<i>Haliaeetus leucocephalus</i>	(none)	SE, FP
Osprey	<i>Pandion haliaetus</i>	(none)	WL
Willow Flycatcher (except southwestern subspecies)	<i>Empidonax traillii</i>	(none)	SE
Southwestern Willow Flycatcher	<i>Empidonax traillii extimus</i>	FE	SE
Notes:			
WL = state watch list.			

This appendix also includes a brief discussion of the biology of selected “other species” (i.e., the principal introduced trout species stocked in California: the brown trout, brook trout, introduced rainbow trout, and kokanee [landlocked sockeye salmon]). This information is provided so that the reader may better understand how the nature of interactions between native species and stocked trout depends not only upon the needs of the native species, but also upon the biology of the stocked trout. The appendix concludes with a brief summary of the biology of other organisms incidentally mentioned in Chapter 4, such as phytoplankton, zooplankton, and macroinvertebrates.

## Invertebrates

### Shasta Crayfish (*Pacifastacus fortis*)

Shasta crayfish are found only in Shasta County, California, in the Pit River drainage and two tributary systems, the Fall River and Hat Creek drainages. They live in cool, clear, spring-fed lakes, rivers, and streams, usually at or near a spring inflow source, where waters show little annual fluctuation in temperature and remain cool during the summer. Most are found in still and slowly to moderately flowing waters. The most important habitat requirement appears to be the presence of adequate volcanic rock rubble to provide escape cover from predators (U.S. Fish and Wildlife Service 2007a).

Shasta crayfish is threatened by habitat loss from water diversions, predation, and competition with the exotic signal crayfish (*Pacifastacus leniusculus*) and other species. Two entire populations have

been extirpated since 1978. Many native and introduced fish, amphibians, reptiles, and mammals found in the Pit River region are known to prey on crayfish, although predation on Shasta crayfish has not been documented (U.S. Fish and Wildlife Service 2007a).

## California Freshwater Shrimp (*Syncaris pacifica*)

California freshwater shrimp (CFS) is found in 17 streams and rivers within Marin, Napa, and Sonoma Counties (Eng 1981; U.S. Fish and Wildlife Service 1998). Many of these stream segments are isolated from the others by barriers, dewatered areas, and low-quality habitat. Although the actual historic distribution of the CFS is not known, it potentially included most low-elevation, freshwater drainages in the northern San Francisco Bay area (U.S. Fish and Wildlife Service 2007b).

The CFS is found in pool areas of low-elevation, low-gradient streams, among exposed live tree roots (e.g., willows and alders) of undercut banks, overhanging woody debris, or overhanging vegetation. These streams typically have low summer flows but can transport high flows during the rainy season. Within these low-elevation drainages, the CFS occurs in low-gradient reaches, usually with moderate to heavy overhanging riparian vegetation and a sand and gravel substrate with some mud, silt, and organic debris. Eng (1981) found the shrimp in shallow pools away from the main flow. Furthermore, during winter, shrimp were observed primarily among exposed roots beneath undercut banks or among dense overhanging vegetation, whereas in spring and summer the shrimp were observed primarily on the foliage and branches of bank-side bushes, vines, or sedges that extend into the water (Eng 1981; U.S. Fish and Wildlife Service 1998). Willows, California laurel, blackberry, alder, and sedges are plants commonly observed in reaches of good shrimp habitat. The fine roots of willows provide especially good winter habitat for the CFS. Adults also have been observed on submerged twigs and leaf litter.

Existing populations of the California freshwater shrimp are threatened by introduced fish, deterioration or loss of habitat resulting from water diversion, impoundments, livestock and dairy activities, agricultural activities and developments, flood control activities, gravel mining, timber harvesting, migration barriers and water pollution (U.S. Fish and Wildlife Service 2007b).

## Lampreys

### River Lamprey (*Lampetra ayresii*)

River lamprey is thought to occur throughout Pacific coast streams, but its occurrence in California includes tributaries of San Francisco Bay, such as the Napa River, Sonoma Creek, and Alameda Creek, as well as the Sacramento, San Joaquin, and Russian Rivers (Moyle et al. 1995; Moyle 2002). Although river lamprey are believed to be in decline, the exact status of this species is uncertain. Currently, very little information describing the abundance and distribution of river lamprey is available, perhaps largely in part because the species is often overlooked and seldom studied.

Limited information is available regarding the life history of this species in California. Current accounts are based largely on information from Canadian populations (Moyle 2002). River lamprey is a semelparous (i.e., individuals spawn once and then die) anadromous fish with long freshwater rearing periods. Adults return to fresh water to spawn in fall and winter, but spawning usually occurs from February through March in gravelly riffles in small tributary streams (Moyle 2002). Juvenile river lamprey (ammocoetes) remain in silty backwater habitats, where they filter feed on

various microorganisms for approximately 3–5 years before migrating to the ocean during late spring periods (Moyle et al. 1995; Moyle 2002). Adult lamprey prey on other fish and may reach a total length of around 17 centimeters (cm) (Moyle et al. 1995).

Potential threats to river lamprey include habitat alteration and degradation due to dams, diversions, pollution, channelization/dredging, urbanization, and other factors (Moyle et al. 1995).

## **Kern Brook Lamprey (*Lampetra hubbsi*)**

Kern brook lamprey are endemic to the east side of the San Joaquin Valley in California; Friant-Kern Canal, east of Delano, in Kern County, California, which provides ammocoete habitat but not spawning habitat; and the lower reaches of the Merced River, Kaweah River, Kings River, and San Joaquin River (Moyle et al. 1989; Moyle 2002). Kern brook lampreys may also occur in the upper San Joaquin River between Millerton Reservoir and Kerckhoff Dam, as well as in the Kings River above Oine Flat Dam (Fresno County) (Moyle et al. 1989; Moyle 2002). The abundance of Kern brook lamprey is hard to determine because of the similarity between the lamprey species.

Kern brook lamprey prefer silty backwaters of large rivers in the foothills region. They require slight flow; therefore, reservoirs probably are poor habitats. Ammocoetes are usually found in shallow pools and along the edges of runs where flow is slight, at depths of 30–110 cm, and summer water temperatures rarely exceed 25°C (Moyle et al. 1989). Commonly associated with sand, gravel, and rubble substrates, ammocoetes bury themselves in sand/mud substrate (Moyle et al. 1989). They probably require gravel-rubble substrate for spawning (Moyle et al. 1989).

Threats to Kern brook lamprey include damming and other alterations that reduce silt-laden backwaters required by ammocoetes (Moyle et al. 1989). Diversions have fragmented the population. Ammocoetes and adult lampreys found in several siphons of the Friant-Kern Canal in 1988 were poisoned during an effort to rid the canal of white bass (Moyle et al. 1989; Moyle 2002).

## **Klamath River Lamprey (*Lampetra similis*)**

Klamath River lamprey occurs in the Klamath River as well as lakes and reservoirs in the Klamath River watershed. It is predatory and feeds on native suckers and minnow species. Habitat requirements are the same as for Kern brook lamprey. Threats to Klamath River lamprey habitat include dams, diversions, and pollution (Moyle et al. 1995).

# **Anadromous Non-Salmonid Fish**

## **Green Sturgeon (*Acipenser medirostris*)**

Two distinct population segments (DPSs) exist for the green sturgeon, the southern DPS and the northern DPS (68 FR 4433). The southern DPS includes the spawning populations of green sturgeon south of the Eel River (exclusive), principally including the Sacramento River green sturgeon spawning population. The northern DPS includes Eel, Mad, Trinity, and Klamath Rivers plus several coastal streams in Oregon.

Green sturgeon use both freshwater and saltwater habitat. As adults, green sturgeon live most of their lives in nearshore oceanic waters, bays, and estuaries. Mature adult green sturgeon move into

large, turbulent freshwater rivers to spawn (Moyle et al. 1992a in Moyle 2002). Spawning occurs once the fish are more than 15 years old and is then believed to occur every 2 to 5 years (Moyle 2002). Green sturgeon migrate to fresh water in late February and spawn from March to July, with peak spawning occurring from April to June (Moyle et al. 1995). Each female produces 60,000 to 140,000 eggs (Moyle 2002). Specific spawning habitat preferences are unclear, but eggs likely are broadcast over bedrock or sand to cobble substrates (Moyle et al. 1995). Juvenile green sturgeon live in fresh and estuarine waters for 1 to 3 years before out-migrating to saltwater (Nakamoto et al. 1995; Moyle 2002). It is currently believed that green sturgeon spawn in the Klamath River and Sacramento River basins in California and in the Rogue River in Oregon (National Marine Fisheries Service 2008a).

Juveniles and adults are benthic feeders, and juveniles have been reported to eat mysid shrimp and amphipods in the Sacramento–San Joaquin River Delta (Delta) (Radtke 1966 in Moyle 2002); adults may eat small fish and macroinvertebrates (Moyle 2002).

The main factor believed responsible for decline of the southern DPS green sturgeon is the reduction in spawning habitat to a limited section in the Sacramento River. There are numerous other threats, including insufficient freshwater flow rates at spawning areas, contaminants, entrainment, impassable barriers, influence of exotic species, small population size, elevated water temperatures, and by-catch of green sturgeon in fisheries, that could potentially affect the status of the southern DPS green sturgeon (Biological Review Team 2005; 71 FR 17757).

## **Delta Smelt (*Hypomesus transpacificus*)**

The delta smelt is listed under both the Endangered Species Act (ESA) and California Endangered Species Act (CESA) as a threatened species (58 FR 12854, March 5, 1993). Rearing habitat for juvenile and adult delta smelt typically is found in the estuarine waters of the lower Delta and Suisun Bay where salinity is between 2 and 7 parts per thousand (ppt). Delta smelt tolerate 0-ppt to 19-ppt salinity. They typically occupy open shallow waters but also occur in the main channel in the region where fresh water and brackish water mix. The zone may be hydraulically conducive to their ability to maintain position and metabolic efficiency (Moyle 2002).

Adult delta smelt begin a spawning migration, which may encompass several months, and move into the upper Delta during December or January. Spawning occurs between January and July, with peak spawning during April through mid-May (Moyle 2002). Spawning occurs in shallow edgewaters in the upper Delta channels, including the Sacramento River above Rio Vista, Cache Slough, Lindsey Slough, and Barker Slough. Spawning also was observed in the Sacramento River up to Garcia Bend during drought conditions, possibly attributable to adults moving farther inland in response to saltwater intrusion (Wang and Brown 1993). Eggs are broadcast over the bottom, where they attach to firm sediment, woody material, and vegetation. Hatching takes approximately 9 to 13 days, and larvae begin feeding 4 to 5 days later. Newly hatched larvae contain a large oil globule that makes them semi-buoyant and allows them to stay off the bottom. Larval smelt feed on rotifers and other zooplankton. As their fins and swim bladder develop, they move higher into the water column. Larvae and juveniles gradually move downstream toward rearing habitat in the estuarine mixing zone (Wang 1986).

From 1969 to 1981, the mean delta smelt Towntnet Survey (TNS) and Fall Midwater Trawl (FMWT) indices were 22.5 and 894, respectively. Both indices suggest the delta smelt population declined abruptly in the early 1980s (Moyle et al. 1992b). From 1982 to 1992, the mean delta smelt TNS and



FMWT indices dropped to 3.2 and 272 respectively. The population rebounded somewhat in the mid-1990s (Sweetnam 1999); the mean TNS and FMWT indices were 7.1 and 529, respectively, during the 1993–2002 period. However, delta smelt numbers have trended precipitously downward since about 2000 (U.S. Fish and Wildlife Service 2008c).

Currently, the delta smelt population indices are two orders of magnitude smaller than historical highs, and recent population abundance estimates are up to three orders of magnitude below historical highs (Newman 2008). The median TNS index during the period from 2000 through 2008 fell similarly to 1.6 and has also dropped to its lowest levels during the last four years with indexes of 0.3, 0.4, 0.4, and 0.6 during 2005 through 2008, respectively. It is highly unlikely that the indices from 2004 to 2007 can be considered statistically different from one another (Sommer et al. 2007), but they are very likely lower than at any time prior in the period of record. The total number of delta smelt collected in the 20-millimeter (mm) survey decreased substantially during the years from 2002 to 2008 (4,917 to 587 fish) compared with the period 1995 through 2001 (98 to 1,084 fish) (U.S. Fish and Wildlife Service 2008c).

Severe alterations in the composition and abundance of the primary producer and primary/secondary consumer assemblages in the Delta have been implicated in the recent decline of Delta smelt and other native fish species (U.S. Fish and Wildlife Service 1996; Kimmerer 2002).

## Longfin Smelt (*Spirinchus thaleichthys*)

Historically, longfin smelt populations were found in the Klamath, Eel, and San Francisco estuaries and in Humboldt Bay. From recent sampling, populations reside at the mouth of the Klamath River and the Russian River estuary. In the Central Valley, longfin are rarely found upstream of Rio Vista or Medford Island in the Delta. Adults concentrate in Suisun, San Pablo, and North San Francisco Bays (Moyle 2002).

Longfin smelt are anadromous, euryhaline, and nektonic (free-swimming). Adults and juveniles are found in estuaries and can tolerate salinities from 0 ppt to pure seawater. The salinity tolerance of longfin smelt larvae and early juveniles ranges from 1.1 to 18.5 ppt. After the early juvenile stage, they prefer salinities in the 15–30 ppt range (Moyle 2002). Longfin smelt in the San Francisco estuary spawn in fresh or slightly brackish water (Moyle 2002:236). Prior to spawning, these fish aggregate in deepwater habitats available in the northern Delta, including primarily the channel habitats of Suisun Bay and the Sacramento River (Rosenfield and Baxter 2007). Catches of gravid adults and larval longfin smelt indicate that the primary spawning locations for these fish are in or near the Suisun Bay channel, the Sacramento River channel near Rio Vista, and (at least historically) Suisun Marsh (Wang 1991; Moyle 2002; Rosenfield and Baxter 2007). Moyle (2002) indicated that longfin smelt may spawn in the San Joaquin River as far upstream as Medford Island. In the Delta, longfin smelt spend most of their life cycle in deep, cold, brackish-to-marine waters of the Delta and nearshore environments (Moyle 2002; Rosenfield and Baxter 2007). They are capable of living their entire life cycle in fresh water, as demonstrated by landlocked populations.

Prespawning adults are generally restricted to brackish (2–35 ppt) or marine habitats. In the fall and winter, yearlings move upstream into fresh water to spawn. Spawning may occur as early as November, and larval surveys indicate it may extend into June (Moyle 2002). The exact nature and extent of spawning habitat are still unknown for this species (Moyle 2002), although major aggregations of gravid adults occur in the northwestern Delta and eastern Suisun Bay (Rosenfield and Baxter 2007).

Embryos hatch in 40 days at 7°C and are buoyant. They move into the upper part of the water column and are carried into the estuary. High outflows transport the larvae into Suisun and San Pablo Bays. In low outflow years, larvae move into the western Delta and Suisun Bay. Higher outflows are reflected positively in juvenile survival and adult abundance. Rearing habitat is highly suitable in Suisun and San Pablo Bays in part because juveniles require brackish water in the 2–18 ppt range. Longfin smelt are pelagic foragers that feed extensively on copepods, amphipods, and shrimp (U.S. Fish and Wildlife Service 1996; Moyle 2002).

The abundance of longfin smelt in the San Francisco estuary has fluctuated over time. However, abundance has been in decline since the early 1980s and was very low during the drought years of the 1990s and recent wet years (Rosenfield and Baxter 2007; Sommer et al. 2007). The decline has been seen in the reduction of longfin smelt captured in the percent of trawls throughout the Bay (Rosenfield and Baxter 2007). The 2007 FMWT had the lowest index (13) recorded since the survey began in 1967. The highest index between 1988 and 2008 was 8,205 in 1995. The index in 2008 was 139 (California Department of Fish and Game 2008).

Severe alterations in the composition and abundance of the primary producer and primary/secondary consumer assemblages in the Delta have been implicated in the recent decline of longfin smelt and other native fish species (U.S. Fish and Wildlife Service 1996; Kimmerer 2002).

## **Eulachon (*Thaleichthys pacificus*)**

The main eulachon population in California is in the Klamath River in Del Norte County, with runs also in the Mad River and Redwood Creek in Humboldt County. The California populations are the southernmost of the species (Moyle et al. 1995).

Eulachon spend most of their life in saltwater, moving up rivers to spawn in large numbers in the spring. In the Klamath River, most eulachon migration takes place in March and April, and the fish seldom penetrate more than 10 to 12 kilometers upstream. The larvae (4–7 mm tail length) stay near the bottom of the water column and are quickly washed to sea by river currents (Moyle et al. 1995).

The factors responsible for the decline of California eulachon populations are unknown. Given the extensive ocean life-phase of the species and the apparently sporadic nature of its abundance in recent years, it is likely that oceanic conditions may be important determinants of the sizes of spawning runs. Yet, it is known that all life stages are sensitive to temperature changes and probably to industrial pollutants. Thus, eulachon are evidently sensitive to a number of environmental factors, and their recent decline in California streams may be due to changes in water quality or spawning habitat in the lower reaches of the rivers they occupy (Moyle et al. 1995).

## **Tidewater Goby (*Eucyclogobius newberryi*)**

The tidewater goby is endemic to California and is found in shallow lagoons and lower stream reaches of coastal streams from San Diego County in the south to the mouth of the Smith River, Del Norte County, in the north (Moyle 2002).

Tidewater gobies are found in coastal lagoons created by inflowing freshwater streams. Gobies prefer water salinities less than 10 ppt and can be found in upper parts of lagoons, closer to the inflowing streams. Their preferred habitat is shallow, well-oxygenated water (less than 1 m [3 feet] deep) (Swift et al. 1989), sand and silt substrate, with temperatures ranging from 8°C to 25°C (46°F

to 77°F) (Moyle 2002). Emergent and submergent vegetation is also necessary to provide refuge from high winter flows and for feeding (Moyle 2002).

While spawning can take place any time of the year, peak nesting activities commence in late April through early May, after lagoons close to the ocean (Swift et al. 1989). Male gobies dig a vertical nesting burrow 10 to 20 cm (4 to 8 inches) deep in clean, coarse sand. Suitable water temperatures for nesting are 18°C to 22°C (75.6°F to 79.6°F) with salinities of 5 to 10 ppt. Male gobies remain in the burrows to guard eggs, which are hung from the ceiling and walls of the burrow until hatching. Larval gobies are found midwater around vegetation until they become benthic (Swift et al. 1989). Although the potential for year round spawning exists, it is probably unlikely because of seasonal low temperatures and disruptions of lagoons during winter storms.

Although widely distributed, tidewater goby populations appear to be declining in response to habitat degradation, such as upstream water diversions, pollution, siltation, and urban development of surrounding lands. Habitat degradation, coupled with the effects of the recent drought and the tidewater goby's relatively short life span (approximately 1 year), have contributed to the decline in the species' abundance throughout California.

## Freshwater and Estuarine Fish

### Owens Tui Chub (*Gila bicolor snyderi*)

The Owens tui chub has been recorded throughout the Owens River basin in its tributaries, irrigation ditches, Owens Lake, and Owens River. Due to extensive hybridization throughout the basin, genetically pure and viable populations are now known from only two locations in Mono County, the headwater springs of Hot Creek, and approximately 8 miles of the Owens River below Long Valley Dam. Within the range of this species, there are no California Department of Fish and Game (DFG) hatcheries, and stocking no longer occurs; therefore, no additional information is necessary regarding the life history and potential limiting factors for this species.

### Goose Lake Tui Chub (*Gila bicolor thalassina*)

The Goose lake tui chub is found primarily in the Goose Lake basin on the border of Oregon and California but also occurs, at elevations of less than 1,441 meters, in Goose Lake tributary streams; Everly Reservoir in California; and Cottonwood, Dog, and Drews Reservoirs in Oregon. Within the range of this species, there are no DFG hatcheries, and stocking no longer occurs; therefore, no additional information is necessary regarding the life history and potential limiting factors for this species.

### Arroyo Chub (*Gila orcuttii*)

Arroyo chub are native to the Los Angeles, San Gabriel, San Luis Rey, Santa Ana, and Santa Margarita Rivers, as well as Malibu and San Juan Creeks (Wells and Diana 1975 in Moyle et al. 1995). Arroyo chub have been successfully introduced into the Santa Ynez, Santa Maria, Cuyama, and Mojave River systems and into other smaller coastal streams (Moyle 2002).

Arroyo chub are found in slow-moving or backwater sections of warm to cool (10°C to 24°C) streams with mud or sand substrates (Moyle et al. 1995). They primarily occupy streams with dense

aquatic vegetation and water depths greater than 40 cm (Wells and Diana 1975 in Moyle et al. 1995). Arroyo chubs are omnivores and are known to eat algae, insects, crustaceans, and nematodes (Moyle 2002).

Arroyo chub breed more or less continuously from February through August, with peak spawning activity in June and July (Tres 1992 in Moyle et al. 1995). Most spawning occurs in pools or in quiet edge water, at temperatures of 14°C to 22°C (Moyle et al. 1995). The eggs adhere to the bottom substrate and will hatch in 4 days at 24°C. (Moyle et al. 1995). After hatching, fry will cling to the bottom substrate until their yolk sack is fully absorbed and then will find refuge among emergent vegetation for the next 3–4 months (Tres 1992 in Moyle et al. 1995). The next 3–4 months are spent in quiet water, usually among vegetation or other flooded cover.

Female arroyo chub are larger than the males; they reach sexual maturity at age 1 to 2 and seldom live past the age of 4.

The decline of the arroyo chub has been attributed to habitat degradation and fragmentation resulting from urbanization within the Los Angeles metropolitan area, and to competition with introduced species (Moyle et al. 1995).

## **Hardhead (*Mylopharodon conocephalus*)**

Hardhead are distributed widely in low- to mid-elevation streams in the main Sacramento–San Joaquin River drainage, as well as in the Russian River drainage. Their range extends from the Kern River to the Pit River. In the San Joaquin River drainage, populations are scattered in the tributary streams yet are absent from the valley reaches of the San Joaquin River (Brown and Moyle 1987 in Moyle et al. 1995; Moyle and Nichols 1973; Saiki 1984). In the Sacramento River drainage, hardhead are present in most of the larger tributary streams, as well as in the Sacramento River.

Hardhead typically are found in undisturbed areas of small to large streams at elevations of 10–1,450 meters (Moyle and Nichols 1973; Reeves 1964). Hardhead primarily occupy clear pools >1 m deep with sand-gravel-boulder substrates and water velocities of less than 25 cm/sec (Knight 1985 in Moyle et al. 1995; Moyle and Baltz 1985; Moyle and Nichols 1973). In streams, adults tend to remain in the lower half of the water column (Knight 1985 in Moyle et al. 1995; Moyle 2002), while juveniles occupy shallow stream margins (Moyle and Baltz 1985). Optimal stream temperatures are 24°C to 28°C (Knight 1985 in Moyle et al. 1995; Moyle 2002). Hardhead also need relatively high dissolved oxygen (DO) levels, which may limit their distribution to clear, deep streams and the surface waters of lakes and reservoirs (Cech et al. 1990 in Moyle et al. 1995; Moyle 2002). Hardhead typically are found with Sacramento pikeminnow (*Ptychocheilus grandis*) and Sacramento suckers (*Catostomus occidentalis*) and are generally absent from streams containing nonnative fish species, especially centrarchids (Moyle and Daniels 1982 in Moyle et al. 1995; Moyle and Nichols 1973).

Hardhead become sexually mature in their third year (Moyle 2002). Spawning may begin as early as April and extend as late as August, depending on location (Moyle et al. 1995; Moyle 2002; Wang 1986 in Moyle et al. 1995). Spawning is presumed to occur in gravel riffles (Moyle 2002). The incubation period is unknown. Hardhead are bottom feeders, and their diets are size-dependent. Small fish (<20 centimeters standard length [cm SL]) feed on mayfly larvae, caddisfly larvae, and small snails (Reeves 1964 in Moyle et al. 1995), and larger fish feed on aquatic plants, crayfish and other large invertebrates (Moyle et al. 1995).

A primary factor affecting hardhead populations is the introduction of predator fish—in particular, the smallmouth bass (Brown and Moyle 1993 in Moyle et al. 1995; Gard 1994 in Moyle et al. 1995; Moyle et al. 1995). Another factor is habitat loss due to dams and diversions, which create unsuitable temperatures and flow regimes and eliminate upstream spawning grounds (Moyle et al. 1995).

## Owens Speckled Dace (*Rhinichthys osculus* ssp. 2)

The Owens speckled dace has been extirpated from the majority of its historic range. It currently persists at two Long Valley sites (Whitmore Hot Springs and Little Alkali Lake), one east fork Owens River site near Benton (a spring on Mathieu Ranch/Lower Marble Creek), and several sites in the northern Owens Valley (North McNally Ditch, north fork Bishop Creek, an irrigation ditch in north Bishop, Lower Horton Creek, and Lower Pine and Rock Creeks) (Moyle et al. 1995).

Owens speckled dace are known to occupy a variety of habitats, ranging from second- to third-order coldwater streams to hot-spring water systems, but are rarely found in water temperatures exceeding 29°C (Moyle et al. 1995). They also have been found in artificial habitats, such as irrigation ditches near Bishop. Speckled dace primarily occupy clear, well-oxygenated waters with abundant cover (e.g., rocks and aquatic and overhead vegetation) and areas of moving water resulting from stream current or waves (Moyle 2002). They are bottom browsers that feed on small aquatic insects typically found in riffle habitats.

They typically become sexually mature at 2 years and spawn in June, July, and early August. Spawning generally occurs in shallow gravel areas, including riffle edges within streams or lake shorelines. Embryos hatch in about 6 days at temperatures of 18°C–19°C and emerge after 7–8 days. Owens speckled dace typically live 3 years but may live 6 or more years (Moyle 2002).

Factors in the decline of Owens speckled dace populations include stream diversions, destruction of stream and riparian habitat by livestock, and predation by introduced fishes such as brown trout and green sunfish (Sada 1989 in Moyle et al. 1995). Other introduced fishes that may be competitors or predators of speckled dace are largemouth bass (*Micropterus salmoides*), mosquitofish (*Gambusia affinis*), channel cattish (*Ictalurus punctatus*), and Sacramento perch (*Archoplites interruptus*) (Moyle et al. 1995).

## Santa Ana Speckled Dace (*Rhinichthys osculus* ssp. 3)

The Santa Ana speckled dace was apparently once widespread in the upland (mountain, foothill) portions of the Santa Ana, San Gabriel, and Los Angeles river systems, Los Angeles and Orange counties, California. At least some local, widely scattered populations also formerly occurred on the Los Angeles Plain. The Santa Ana speckled dace is recently extirpated in the Los Angeles River drainage and is presently confined to the headwaters of the San Gabriel river and Santa Ana river, where it is in imminent danger of extirpation. This subspecies is also reported to be in the South Fork of the San Jacinto River, Riverside County, and this may be the second largest and best locality after the San Gabriel River. The Santa Ana speckled dace has been introduced into the Santa Clara and Cuyama rivers and River Springs on the east side of Adobe Valley, Mono County. The status of the introduced populations is not known, but the Santa Clara introduction apparently failed. This subspecies has been reported also from Pismo and Arroyo Grande creeks south of San Luis Obispo Creek (NatureServe 2009).

The Santa Ana speckled dace is found in shallow gravel and cobble riffles of permanent flowing streams with summer temperatures of 17-20 C, where overhanging riparian plants provide cover. In the West Fork of the San Gabriel River, this subspecies is most common where other native fishes also are common. The Santa Ana speckled dace probably lives up to three years (NatureServe 2009).

Unstable stream flows below Big Tujunga Dam and introduced red shiner have eliminated the Santa Ana speckled dace population in Big Tujunga Creek. The San Gabriel West Fork populations are low due to sediment releases from Cogswell Dam, and the area below the dam is managed as a catch-and-release and put-and-take trout fishery. The population supported by the San Gabriel River, East Fork is currently the most robust population in the watershed. The greatest number of individuals is found above the confluence of the stream with Cattle Canyon Creek. Above this confluence, the stream is unaffected by dams or recreation (O'Brien pers. comm.). Reduced flows in some areas restrict summer habitats to small stretches of stream and in dry years this may lead to extirpation of these populations. The Santa Ana speckled dace is also endangered by natural conditions such as drought, and the San Gabriel River populations are at risk of washing out if stabilizing vegetation is lost due to fires. Dams have fragmented populations and prevent them from intermixing even in wet winter conditions. Human recreational use in some areas is heavy enough to disrupt the spawning and feeding behavior of this subspecies (NatureServe 2009).

## Owens Sucker (*Catostomus fumeiventris*)

The Owens sucker is native to the Owens River watershed in eastern California, where the species is most abundant in Crowley Reservoir (Mono County; reservoir formed by dam on Owens River) and widely distributed in the Owens River, Bishop Creek, and other streams in the Owens Valley (NatureServe 2009). Its range also includes Convict Lake (Mono County) and Lake Sabrina (Inyo County) (NatureServe 2009). In the 1930s an Owens sucker population became established in the Santa Clara River in Los Angeles County via the Owens Aqueduct and is apparently present in lower Sespe Creek, in the outflow of Fillmore Trout Hatchery, and in Piru Creek and Reservoir (NatureServe 2009). Another introduced population occurs in June Lake in the Mono Lake Basin (NatureServe 2009).

The Owens Sucker spawns from early May-early July (water temperatures usually 7–13°C) in tributary streams of Owens River and Crowley Lake (NatureServe 2009). Habitat includes silty to rocky pools and runs of creeks (NatureServe 2009). In the lower Owens River and tributaries, this sucker is most abundant in sections with long runs and few riffles, over substrates of mostly fine material (some gravel and rubble) (NatureServe 2009). Adults occur in cool permanent streams with deep (1+ meters) pools and also do well in lakes and reservoirs, such as Convict Lake and Crowley Reservoir, where they seem to occur on the bottom at all depths (NatureServe 2009). Larvae are abundant in weedy edges and backwaters of streams. Spawning occurs in gravelly riffles in tributary streams; lacustrine populations spawn in springs and gravel patches along lake shores, as well as in tributary streams (e.g., Crowley Reservoir) (NatureServe 2009). Diet and feeding are probably similar to those of *C. tahoensis*, which feeds on algae, detritus, and small benthic invertebrates (NatureServe 2009).

The Owens sucker is abundant and widespread in its native range. In its established introduced populations, this species is likely relatively stable or slowly declining. This species is ecologically flexible and has adapted to and thrives in reservoir habitat. However, a large part of the population depends on reservoirs dominated by introduced game fishes and may suffer from competition or predation in the future (NatureServe 2009).

## Modoc Sucker (*Catostomus microps*)

The Modoc sucker occurs only in portions of Turner and Rush Creeks, which are two small drainage systems in Modoc County. These tributaries include Washington, Hulbert, and Johnson Creeks and two smaller, unnamed feeder streams.

Optimal habitat for Modoc suckers includes low- to moderate-flow streams that have large shallow pools, ample cover (e.g., riparian vegetation or undercut banks), soft sediments, and moderately clear water (Beacham et al. 2000; Moyle 2002). As stream habitat in lower reaches may dry up in the summer, Modoc suckers need adequate water flow and optimal temperatures to migrate upstream during April and May to spawn and find refuge. After spawning, eggs adhere to the bottom substrate. Sexual maturity usually occurs at age 3, although males may mature sooner, and they only live for 4 to 5 years. Adult suckers are bottom feeders that forage on bottom-dwelling invertebrates, such as chironomid larvae, crustaceans, and aquatic insects, along with algae, diatoms, and detritus (Beacham et al. 2000).

The decline of the Modoc sucker has occurred in response to habitat degradation and hybridization with the more common Sacramento sucker (*Catostomus occidentalis*). In addition, the introduction of brown trout has added competitive pressure for resources and space (Beacham et al. 2000).

## Santa Ana Sucker (*Catostomus santaanae*)

The Santa Ana sucker is native to the Los Angeles and Santa Ana basins in southern California, where it is restricted to three geographically separate populations in three different stream systems. One population resides in the lower and middle Santa Ana River; the second population is in the east, west, and north forks of the San Gabriel River; and the third is in the lower Big Tujunga Creek. The species also is reported to occur in the Santa Clara River (Moyle et al. 1995).

Santa Ana suckers primarily occupy shallow waters in rivers and streams. When flooding occurs, suckers move into quiet marginal refuges and move back into the main stem once waters are less turbulent. Substrates range from gravel to boulders, with plenty of algae growth (Moyle et al. 1995).

Santa Ana suckers can become sexually mature during their first year and are highly fecund, producing between 4,400 and 16,000 eggs at a time. Spawning peaks between late May and early June, and eggs hatch within 15 days of fertilization. The suckers live for between 2 to 4 years. Their diet consists of mostly detritus and algae, eating only a very small amount of insect larvae and fish eggs (Moyle et al. 1995; Moyle 2002).

The Santa Ana sucker is threatened primarily by the elimination or alteration of its stream habitats, reduction or alteration of stream flows, pollution, and introduction of nonnative species. The decline of this species indicates the poor state of the streams in the Los Angeles basin, which suffer from multiple and cumulative effects of many human-induced and natural changes (Moyle et al. 1995).

## Cui-Ui (*Chasmistes cujus*)

The cui-ui is a large sucker that does not occur in California but occupies spawns in the Truckee River in Nevada, downstream of DFG trout stocking locations and is therefore evaluated in this EIR/EIS. The known spawning locations of the cui-ui are so far downstream of the California-Nevada border that the analysis in Chapter 4 of this EIR/EIS concludes that there is no potential for trout

stocking to have any effect on the cui-ui whatsoever; therefore, no additional information is necessary regarding the life history and potential limiting factors for this species.

## **Unarmored Three-Spined Stickleback (*Gasterosteus aculeatus williamsoni*)**

Unarmored three-spined sticklebacks are found in some southern California streams. Populations in the Santa Clara River, San Antonio Creek (Santa Barbara County) and Sweetwater River (San Diego County) are morphologically similar and can be included under this name (Moyle 2002).

Unarmored threespine sticklebacks only occur in fresh water. They require clear, flowing, well-oxygenated water with associated pools and areas of dense vegetation or organic debris to provide adequate cover and food supply and water temperature less than 24°C. Juveniles congregate in backwaters among aquatic plants. Stickleback generally spawn in the spring (April through July) and the male guards eggs in a nest made from algae and aquatic plants (Moyle 2002).

Current population numbers are unknown. Major threats include stream dewatering, pollution, habitat alteration, and introduction of predators and competitors. These factors are all tied to increased urbanization of the Los Angeles region (Moyle 2002).

## **Sacramento Perch (*Archoplites interruptus*)**

The Sacramento perch is the only native centrarchid (fish related to sunfish and bluegill) west of the Rocky Mountains. It was originally widely distributed throughout the Sacramento-San Joaquin drainage, in the Pajaro and Salinas rivers, and in Clear Lake (Lake County), California. Persisting native populations exist in Clear Lake (small population) and Alameda Creek (in gravel pit ponds adjacent to the creek and in Calaveras Reservoir). However, the species has been introduced in other locations within the native range (often upstream of native habitats), and in several areas outside the native range in California, including the upper Klamath basin (California and Oregon), Pit River watershed, Walker River watershed, Mono Lake watershed, and Owens River watershed, and may also persist in Sonoma Reservoir. The Sacramento perch has also been introduced and currently is established in Nevada (several drainages) and Utah (Garrison Reservoir). Introduced populations in several other states apparently no longer exist (NatureServe 2009).

Formerly widely distributed and common in much of California, the Sacramento perch is now restricted to just a couple remaining native populations in California, which are small but persistent. While Sacramento perch native habitat is dominated by introduced species, which threaten Sacramento perch through competition and predation, this species is reasonably secure in several watersheds outside native range (NatureServe 2009)

The Sacramento perch was originally found in sloughs, sluggish rivers and lakes with beds of rooted and emergent vegetation, but is now found mostly in alkaline lakes, reservoirs and farm ponds. This species is tolerant of a wide range in water turbidity, temperature, and salinity and is often associated with submerged vegetation or other objects in the nearshore area of warmwater lakes/ponds. Young stay close to submerged vegetation or in shallow areas. Prior to spawning male establishes a small territory in shallow areas (20–75 cm) heavily vegetated with aquatic macrophytes or filamentous algae. Sacramento perch do not construct nests. The native population in Clear Lake may be able to reproduce successfully only when black crappie populations are low, as crappie presumably competes for breeding sites (NatureServe 2009).



Sacramento perch are opportunistic, diet mainly consisting of benthic insect larvae, snails, mid-water insects, zooplankton, and fishes. Young feed mainly on small crustaceans, but as they grow Sacramento perch consume more aquatic insect larvae and pupae. Large adults feed mainly on other fishes when available. Sacramento perch feed at any time during the day or night but activity apparently peaks at dawn and dusk (NatureServe 2009).

This species becomes sexually mature in 2nd or 3rd summer. In California, spawning occurs late March-early August, peak in May-June; timing of breeding depends on temperature. Spawning begins in mid-June in Pyramid Lake, or when water temperature reaches 68°F. Eggs hatch in about 50 hours at 21.7°C. The male remains with eggs until hatching and for about 2 more days following hatching (NatureServe 2009).

The Sacramento perch population in California declined rapidly due to such factors as habitat destruction, egg predation by non-native fishes, and interspecific competition with introduced centrarchids, especially black crappie; competition may be the most important cause of the decline (Moyle 2002). Most introduced populations are isolated and vulnerable to genetic bottlenecks and extirpation (NatureServe 2009).

## Salmonid Fish

### Coastal Cutthroat Trout (*Oncorhynchus clarkii clarkii*)

Coastal cutthroat trout are found in coastal drainages ranging from the Eel River in northern California to Prince William Sound in Alaska. Similar to rainbow/steelhead trout (*Oncorhynchus mykiss*), coastal cutthroat trout exhibit several life history strategies, ranging from fully anadromous to resident (Moyle 2002; Pauley et al. 1989). Resident forms are most common. Their ecological requirements are similar to those of rainbow/steelhead trout and include cool, clean water with plenty of cover and deep pools for holding in the summer (Moyle et al. 2008). They primarily occupy small, low-gradient coastal streams and estuarine habitats, and whenever they co-occur with rainbow/steelhead trout, they tend to use areas farther upstream in smaller tributaries than the dominant steelhead. Optimal stream temperatures are less than 18°C with high DO levels (Moyle et al. 2008).

In northern California, coastal cutthroat trout migrate upstream to spawn after the first significant rain, which may occur as early as August. Peak spawning occurs in December in larger streams and in January/February in smaller streams. Resident fish generally reach sexual maturity between the ages of 2 and 3 years, but anadromous fish rarely spawn before age 4 (Johnson et al. 1999). Cutthroat prefer to spawn in riffles and pool tailouts, in waters with velocities of 0.3–0.9 meters/second (m/sec) and gravel ranging from 0.16–10.2 cm in diameter (Moyle et al. 2008). Spawning has been recorded at temperatures of 6°C–17°C (Moyle 2002; Pauley et al. 1989). Coastal cutthroat trout are iteroparous and have a higher incidence of repeat spawning than steelhead. Eggs hatch after 6–7 weeks of incubation depending on temperature (Moyle et al. 2008). Fry emerge between March and June and initially occupy backwaters and stream margins (Johnson et al. 1999). Juveniles rear in the upper watershed until approximately 1 year in age and then migrate extensively throughout the watershed. Anadromous cutthroat trout generally migrate to the ocean when they are 2 to 3 years old but can be as old as 5. Lifespan is generally 4 to 7 years (Trotter 1991 in Moyle et al. 2008).

Juveniles feed primarily on zooplankton, macroinvertebrates, and microcrustaceans, while adults feed on benthic macroinvertebrates, terrestrial insects in drift, and small fish (Romero et al. 2005 in Moyle et al. 2008; Wilzbach 1985 in Moyle et al. 2008).

Major factors affecting the status of coastal cutthroat trout include habitat degradation, dams and diversions, overexploitation, interactions with hatchery salmonids, and hybridization with steelhead (Moyle et al. 2008).

## **Lahontan Cutthroat Trout (*Oncorhynchus clarkii henshawi*)**

Lahontan cutthroat trout are native to the greater Lahontan basin in eastern California, southern Oregon, and northern Nevada (Trotter 2008 in Moyle et al. 2008). In the Carson, Walker, and Truckee basins, only a few scattered streams contain Lahontan cutthroat trout (Trotter 2008 in Moyle et al. 2008). Lahontan cutthroat trout also have been planted and established in a few creeks outside their historic range, including west-slope drainages near the Truckee basin (Moyle et al. 2008).

Lahontan cutthroat trout occur in a wide variety of coldwater river and lake habitats, including alkaline (e.g., Pyramid and Walker Lakes) and alpine oligotrophic lakes (e.g., Lake Tahoe and Independence Lake) (Moyle et al. 2008). Lahontan cutthroat trout primarily occupy streams with well-vegetated and stable stream banks and pools with close proximity to cover, as well as riffle-run complexes for spawning and cover (U.S. Fish and Wildlife Service 1995a). Lake residents are adapted to a wide variety of lake habitats with optimal average mid-summer epilimnion temperatures of less than 22°C and a mid-epilimnion pH of 6.5 to 8.5 (Moyle et al. 2008). They can tolerate alkalinity and total dissolved solid (TDS) levels as high as 3,000 milligrams per liter (mg/L) and 10,000 mg/L, respectively (Koch et al. 1979 in U.S. Fish and Wildlife Service 1995a).

Whether Lahontan cutthroat trout reside in rivers or lakes, they spawn in river habitats from April to July, depending on stream flow, water temperature, and elevation (U.S. Fish and Wildlife Service 1995a). Spawning migrations are observed at water temperatures between 5°C and 16°C (U.S. Fish and Wildlife Service 1995a). Preferred water depths for redds average 13 cm, and velocities average 56 centimeters/second (cm/sec) (Schmetterling 2000; Moyle et al. 2008), while gravel substrate ranges from 6 to 50 mm (Coffin 1981 in Moyle et al. 2008). Water must be saturated with oxygen and have minimal siltation to prevent eggs from suffocating. Eggs hatch after 4 to 6 weeks, depending on water temperature, and fry emerge from the gravel after 13 to 23 days (U.S. Fish and Wildlife Service 1995a). Fry can spend up to 2 years in their natal stream before migrating to lake environments, but most migrate at the end of their first summer (Trotter 2008 in Moyle et al. 2008). Females reach reproductive maturity at age 3 to 4 years, while males mature at 2 to 3 years. Consecutive year spawning is unusual, and only 50% of surviving females spawn again as compared with 25% of males (U.S. Fish and Wildlife Service 1995a). Lahontan cutthroat trout generally live 4 to 9 years; stream-dwelling fish have shorter life spans than lake-dwellers (Moyle et al. 2008). Both larval and adult phases feed primarily on terrestrial and aquatic invertebrates but also on oligochaetes and zooplankton (U.S. Fish and Wildlife Service 1995a). Large Lahontan cutthroat trout also feed on juvenile fish of other species (Moyle et al. 2008).

Factors affecting Lahontan cutthroat trout abundance and habitat are the introduction of nonnative trout, overexploitation, logging, dams and diversions, grazing, mining, loss of genetic diversity, and disease (Moyle et al. 2008).

## **Paiute Cutthroat Trout (*Oncorhynchus clarkii seleniris*)**

The historical distribution of the Paiute cutthroat trout is limited to 9.1 miles of habitat in Silver King Creek from Llewellyn Falls downstream to Silver King Canyon as well as the accessible reaches of three small named tributaries: Tamarack Creek, Tamarack Lake Creek, and the lower reaches of Coyote Valley Creek downstream of barrier falls (USFWS 2004, Ryan and Nicola 1976, Behnke and Zarn 1976, Behnke 1992, Moyle 2002).

Currently, Paiute cutthroat trout are found only where they have been introduced outside their historic range. They occupy approximately 20.6 miles of habitat in five widely- distributed drainages. The present distribution in the Silver King Creek Watershed consists of populations in Upper Silver King Creek above Llewellyn Falls (2.7 miles total), Fly Valley Creek (1.1 miles), Four Mile Canyon Creek (1.9 miles), and Bull Canyon Creek (0.6 miles), as well as below the falls including Coyote Valley Creek (3.0 miles) and Corral Valley Creek (2.2 miles). There are four self-sustaining, pure populations outside the native drainage in the North Fork of Cottonwood Creek (3.4 miles), Cabin Creek (1.5 miles) (Inyo National Forest, Mono County), Stairway Creek (2 miles) (Sierra National Forest, Madera County), and Sharktooth Creek (2 miles) (Sierra National Forest, Fresno County) (U.S. Fish and Wildlife Service 2004a). Within the range of this species, there are no California Department of Fish and Game (DFG) hatcheries, and stocking no longer occurs; therefore, no additional information is necessary regarding the life history and potential limiting factors for this species.

## **Volcano Creek (California) Golden Trout (*Oncorhynchus mykiss aguabonita*)**

California golden trout (formerly known as Volcano Trout) are native to Golden Trout Creek (of which Volcano Creek is a small tributary) and the south fork of the Kern River in the upper Kern River basin (Moyle 2002). Within the range of this species, there are no DFG hatcheries, and stocking no longer occurs; therefore, no additional information is necessary regarding the life history and potential limiting factors for this species.

## **Eagle Lake Rainbow Trout (*Oncorhynchus mykiss aquilarum*)**

The Eagle Lake rainbow trout is endemic to Eagle Lake, Lassen County, California, and its main tributaries, Pine creek and Papoose Creek. Introduced in numerous sites in northern and central California, and in other states and Canada, but these populations are maintained from hatchery stock (likely there is no natural reproduction of genetically pure stock) (NatureServe 2009).

Eagle Lake is an alkaline lake, 24 kilometer (km) long and 3–4 km wide, consisting of 3 basins, the deepest of which is nearly 30 meters (m); in summer, most trout are in the deeper cooler waters of the deepest basin. Stream spawner. Formerly spawned in the shaded, gravelly upper reaches of Pine Creek, where the young spent 1–2 years before moving down into the lake. Zooplankton and benthic invertebrates, especially leeches and amphipods, dominate the diet of Eagle Lake rainbow trout in their first year in the lake. By August, young-of-the-year tui chubs are the principal food for most individuals (NatureServe 2009).

The Eagle Lake rainbow trout now depends on hatcheries for its existence because Pine Creek became inaccessible to spawning in most years after roads, railroads, grazing and logging changed its basic hydrology. Since 1959, annual hatchery production has occurred, and little or no natural

reproduction has taken place. This likely has altered the genetic makeup of the population, and this could increase the difficulty of reestablishing a natural population. Efforts to restore the Pine Creek watershed are underway (NatureServe 2009).

## **Kern River Rainbow Trout (*Oncorhynchus mykiss gilberti*)**

Little information is available on the Kern River rainbow trout's life history or habitat requirements, but it is probably similar to other rainbow trout in these regards (Moyle et al. 1995).

The Kern River rainbow trout is endemic to the Kern River and its tributaries. It once existed in the Kern River as far downstream as Keyesville (below Lake Isabella Dam), and on the South Fork of the Kern River, upstream as far as Onyx. Remnant populations live in the Kern River from Durrwood Creek Junction Meadow, in Rattlesnake and Osa creeks and possibly upper Peppermint Creek and Salmon Creek. Much of the remaining habitat for the Kern River rainbow trout is in Sequoia National Forest and Sequoia National Park (Moyle et al. 1995).

Efforts are being made to identify streams still retaining Kern River rainbow trout and extensive collections of fish for genetic analysis were made 1991–1993. A management plan for the upper Kern River basin (above Isabella Reservoir) was completed in 1995 (Moyle et al. 1995). Problems addressed in the plan include grazing in riparian areas and heavy recreational use of the basin. Population surveys to monitor trout populations and identify habitats in need of protection are scheduled on a five year interval. To reestablish populations of Kern River rainbow trout, anglers are now allowed to keep only two fish with a maximum length of 10 inches in most of the upper basin, DFG ultimately plans to replace nonnative rainbow trout stocked in tributary streams with catchable size Kern River rainbow trout if hatchery production of the native trout is successful. According to the management plan, if native hatchery production is unsuccessful, stocking of nonnative rainbow trout will stop (Moyle et al. 1995).

Threats to remaining populations of Kern River rainbow trout are introgression with nonnative rainbow trout, habitat losses from poor management and events such as floods, droughts and fires. Some of its current habitat suffered from the landslides that filled in pools and silted spawning areas as a result of the Flat Fire of 1976. Introduced Beaver have significantly altered the river in Kern Canyon in Sequoia National Park, flooding meadows and increasing meandering in the channel (Moyle et al. 1995).

## **Goose Lake Redband Trout (*Oncorhynchus mykiss* ssp. 1)**

The Goose Lake redband trout is native to the Goose Lake basin in California and Oregon and its tributaries; upper Pit River and headwater tributaries; and the south fork Pit River drainage (California Department of Fish and Game 2007). Within the range of this species, there are no DFG hatcheries, and present stocking only occurs in the south fork Pit River drainage. Berg (1987) reported that Joseph, Parker, and East Creeks, tributaries of the upper Pit River in California, contained trout genetically similar to Goose Lake redband.

The Goose Lake redband trout has two ecological types: a relatively large lake-dwelling form (up to 45–50 cm tail length) and a smaller stream-dwelling form (generally <25 cm tail length) (Moyle et al. 2008; Moyle et al. 1995). According to Moyle et al. (1995), the lake-dwelling form lives in Goose Lake and spawns in the tributaries and headwaters of Lassen and Willow Creeks, none of which are

within trout stocking locations. Therefore, no additional information is necessary regarding the life history and potential limiting factors for this lake-dwelling form.

The stream-dwelling form presumably has similar ecological requirements (e.g., cool, clean, fast-flowing water with plenty of cover; a high proportion of riffles with some deep pools for holding in the summer; and an abundant and diverse invertebrate supply) and life histories (e.g., spawn timing and sexual maturity) as other nonanadromous rainbow trout found in small, high-elevation streams. Redband trout can survive extended durations of warm temperatures (15°C–20°C), short durations at high temperatures (29°C), and high alkalinity and turbidity that would be lethal to other trouts (Moyle et al. 1995; Hendricks 1995).

Goose lake redband trout presumably reach sexual maturity in their third year and live to 4 or 5 years old (Moyle et al. 1995). Spawning generally occurs from March through June but may occur at almost any time of the year except during high summer temperatures (Marshall 2008). Egg incubation through fry emergence can range from 5 to 7 weeks at temperatures ranging from 10°C–15°C (Moyle 2002). Newly emerged fry and juveniles generally prefer low-velocity, shallow stream margins and shift to runs and pools as they become larger (Moyle 2002; U.S. Forest Service 1998). Goose Lake redband trout live up to 5 years and eat insects, insect larvae, and nymphs (California Department of Fish and Game 2007a).

Factors affecting Goose Lake redband trout abundance and habitat are stream channelization, habitat degradation/fragmentation, grazing, water diversions, and introduced species (Moyle 2008; U.S. Forest Service 2007).

## **McCloud River Redband Trout (*Oncorhynchus mykiss* ssp. 2)**

McCloud River redband trout occur only in Trout, Swamp, Edson, Sheepheaven, Blue Heron, Tate, Bull, Moosehead, Dry, and Raccoon Creeks and the main stem McCloud River above Middle Falls (U.S. Forest Service 1998). They became established in Swamp Creek and Trout Creek after being transplanted in the 1970s from Sheepheaven Creek (Moyle et al. 1995).

McCloud River redband trout are thought to be a “relict subspecies of non-anadromous rainbow trout adapted to harsh, fragmented environments” (U.S. Forest Service 1998). They have similar ecological requirements (e.g., cool, clean, fast-flowing water with plenty of cover; a high proportion of riffles with some deep pools for holding in the summer; and an abundant and diverse invertebrate supply) and life histories (e.g., spawn timing and sexual maturity) to other nonanadromous rainbow trout found in small, high-elevation, spring-fed streams.

In their home waters, water temperatures in summer typically reach 15°C but can exceed 22°C in drought years (Hoopaugh 1974 in Moyle et al. 2008; Moyle 2002). Sexual maturity generally occurs at age 2 or 3 but can range from 1 to 5 (Moyle 2002). Redband trout spawning occurs between May and June in gravel riffles (Moyle et al. 2008; Hoopaugh 1974 in U.S. Forest Service 1998). Egg incubation through fry emergence can range from 5 to 7 weeks at temperatures ranging from 10°C–15°C (Moyle 2002). Newly emerged fry and juveniles generally prefer low-velocity, shallow stream margins and shift to runs and pools as they become larger (Moyle 2002; U.S. Forest Service 1998). Redband trout generally live less than 4 years but may reach 6–7 years in the McCloud River (Moyle 2002). Similar to most rainbow trout, fry and juveniles in the McCloud River feed mostly on drifting benthic invertebrates; however, adults generally feed on bottom invertebrates, and this behavior is thought to result from turbidity associated with suspended glacial material (Tippetts and Moyle 1978 in Moyle 2002).

Factors affecting McCloud River redband trout include genetic threats (e.g., hybridization and the founder effect) from the introduction of nonnative trout, logging, grazing, habitat loss/degradation/fragmentation, stream channelization, water diversions, fire, forest succession, natural and manmade barriers, volcanic activity, and harvest (U.S. Forest Service 1998; Moyle et al. 2008). Drought also has become a major concern for the long-term survival of McCloud River redband trout in small creeks that are susceptible to drying up, such as Sheepheaven Creek (Moyle et al. 2008; U.S. Forest Service 1998).

### **Warner Valley Redband Trout (*Oncorhynchus mykiss* ssp. 3)**

The Warner Valley redband trout is found in southern Oregon and a small part of northern California within the Warner Valley basin. Within the range of this species, there are no DFG hatcheries, and stocking no longer occurs; therefore, no additional information is necessary regarding the life history and potential limiting factors for this species.

### **Little Kern Golden Trout (*Oncorhynchus mykiss whitei*)**

The Little Kern Golden Trout is native to the Little Kern River and its tributaries. Within the range of this species, there are no DFG hatcheries, and stocking no longer occurs; therefore, no additional information is necessary regarding the life history and potential limiting factors for this species.

### **Klamath Mountain Province DPS Steelhead (*Oncorhynchus mykiss irideus*)**

The Klamath Mountain Province (KMP) steelhead DPS includes all naturally spawned populations found in coastal rivers and creeks throughout the Klamath River and Trinity River basins and streams from north of the mouth of the Klamath River to the Elk River near Port Orford, Oregon, including the Smith River in California and the Rogue River in Oregon (Moyle et al. 2008). This DPS consists of two run types: the summer-run<sup>1</sup> and winter-run, which are designated according to the state of sexual maturity at the time of river entry (i.e., the summer run enters the river in a sexually immature state and requires several months before ripening to spawning condition; while winter run enters the river sexually mature and spawns shortly after reaching the spawning grounds) but may overlap in their migration and spawning periods. Both summer- and winter-run populations have declined; however, the summer run has declined more substantially, with only a few populations large enough to persist for more than 10–25 years under existing conditions (Moyle et al. 2008).

In California, KMP summer steelhead typically enter fresh water in a sexually immature condition between April and June; however, in the Trinity River, they enter between May and October (Moyle et al. 2008). Over-summering habitat for adult summer steelhead needs to support fish during

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<sup>1</sup> According to Busby et al. (1994), there is uncertainty regarding run-type designation for steelhead in the Klamath and Trinity Rivers. Some biologists contend that fall-run steelhead should be designated as a separate run (Heubach 1992) or should be considered winter steelhead, while other biologists believe that spring- and fall-run steelhead in the Klamath Mountain Province (KMP) are actually summer-run steelhead based on lack of segregation at spawning (Everest 1973 in Busby et al. 1994; Roelofs 1983 in Busby et al. 1994). The National Marine Fisheries Service uses the latter for designating run types in the KMP (Busby et al. 1994).

periods of unfavorable conditions (low flows and higher water temperatures); important factors include deep pools (>1m), low substrate embeddedness (<35%), presence of riparian habitat shading, and instream cover associated with increased velocity through the occupied pools (Baigun 2003; Nakamoto 1994). Summer steelhead spawning begins in late December and peaks in January, except in the Trinity River, where peak spawning occurs in February. KMP summer steelhead spawn in upstream regions where winter steelhead generally do not spawn, including intermittent streams whence the juveniles emigrate to perennial reaches soon after hatching (Everest 1973; Roelofs 1983). Water velocity and depth measured at redds are 23–155 cm/sec and 10–150 cm, respectively, and gravel size is typically 0.64–13 cm.

KMP winter steelhead are sexually mature when they enter fresh water between September and March, and they spawn shortly thereafter (Busby et al. 1996). In the Trinity River, the spawning peak occurs in March, and fry emerge starting in April and migrate downstream beginning in May (Moffett and Smith 1950). Fry generally are found along stream margins while larger juveniles “become very territorial and exhibit aggressive behavior to establish territories (Shapovalov and Taft 1954) in or below riffles, where food production is greatest” (Moyle et al. 2008). An approximately equal proportion of young-of-the-year (34%), age 1+ (37%), and age 2+ (27%) steelhead have been observed migrating downstream in the Trinity River (U.S. Fish and Wildlife Service 2001), while results of scale analysis indicates that most steelhead (86%) in the Klamath River basin migrate as 2-year-olds (Hopelain 1998). Juvenile habitat requirements of KMP steelhead are similar to those of Northern California steelhead.

KMP steelhead also express a “half-pounder” life history strategy where subadults spend 2–4 months in the Klamath estuary or nearshore marine environments before returning to overwinter within the river. After overwintering in the lower and mid-Klamath regions, they return to the ocean the following spring and spend 1 to 3 years there before returning to spawn (Moyle et al. 2008). Half-pounders occur more often in spawning fish of mid-Klamath region tributaries (86%–100%) when compared with the Trinity River (32%–80%) (Israel 2004).

Because of their over-summering behavior and extended residence time in fresh water, KMP summer steelhead are particularly susceptible to human activities and factors contributing to their decline include poaching, placer mining, logging, harvest, and disturbance from swimmers and rafters. There is no hatchery production of summer steelhead. Factors affecting KMP winter-run steelhead include dams, diversions, logging, agriculture, hatcheries, and harvest. (Moyle et al. 2008.)

## **Northern California DPS Steelhead (*Oncorhynchus mykiss irideus*)**

The Northern California steelhead DPS includes all naturally spawned populations of steelhead in California coastal river basins from Redwood Creek (inclusive) southward to the Russian River (exclusive) and those associated with two artificial propagation programs: the Yager Creek Hatchery and the north fork Gualala River Hatchery (neither is a DFG hatchery). The Northern California steelhead consists primarily of winter-run steelhead, but summer-run steelhead also occur in some tributaries, including Redwood Creek and the Mad, Van Duzen, middle fork Eel, and Mattole Rivers, and possibly also the north fork Eel, upper main-stem Eel, and south fork Eel Rivers (Moyle et al. 2008). Little quantitative abundance information exists, but Busby et al. (1996) concluded that population abundances were low relative to historical estimates.

Adult Northern California winter-run steelhead enter estuaries and rivers as sexually mature adults between September and March (Busby et al. 1996) and spawn primarily between December and

early April but occasionally into May (Busby et al. 1996). Adult steelhead require high flows with water at least 18 cm deep for passage (Bjornn and Reiser 1991). Steelhead generally spawn in pool tails, and redds usually are built in water depths of 0.1 to 1.5 meters where velocities are between 0.2 and 1.6 meters/second and in substrate between 0.6 to 12.7 cm in diameter (Moyle et al. 2008). Steelhead embryos incubate for 18 to 80 days depending on water temperatures (optimal in the range of 5°C to 13°C; McEwan and Jackson 1996), and emergence from the gravel occurs after 2 to 6 weeks (Moyle 2002; McEwan and Jackson 1996). Newly emerged fry generally school together along shallow-margin habitat, while larger juveniles maintain territories in faster and deeper locations in pool and run habitats favoring areas with cool, clear, fast-flowing water, ample cover (riparian vegetation and undercut banks), and abundant food (Moyle 2002). Juveniles typically rear in streams for 2 years and migrate to the ocean or estuary during high spring flows with movement peaking during late April or May. Young-of-year steelhead will emigrate to estuaries as late as June or July (Moyle et al. 2008).

Adult Northern California summer-run steelhead migrate into the upper middle fork Eel River as sexually immature adults from mid-April through June, and potentially into July (Jones and Ekman 1980 in Moyle et al. 2008; Puckett 1975 in Moyle et al. 2008). Spawn timing has not been well-documented but is assumed to occur in similar months to winter-run steelhead. Basic habitat requirements are believed similar to those of other steelhead, with the exception that over-summering habitat needs to support fish survival under unfavorable low flow and higher water temperature conditions. Cold tributary confluences and deep pools provide over-summering habitat for Northern California summer-run steelhead. (Moyle et al. 2008.)

In small estuaries where Northern California steelhead occur, a summer lagoon typically forms as a result of sandbar formation at river mouths, which prevents juvenile movement into the ocean, and steelhead may hold in these estuaries for 1 or more years. Northern California steelhead can spend up to 4 years in the ocean, and spawning adults typically return to the same stream into which they were reared, where they may spawn 2–4 times in their lifetime (Moyle et al. 2008).

Factors contributing to the decline of Northern California steelhead include agricultural and forestry operations, artificial barriers (dams; erosion and flood-control structures; pits from gravel mining; road crossings, including bridges; culverts; and low-water fords), gravel extraction, suction dredging, illegal harvest, unscreened or substandard fish screens on diversions, water over-allocation and pollution, urbanization, potential genetic modification in hatchery stocks, incidental mortality from catch-and-release hooking, climatic variation leading to drought, flooding, and variable ocean conditions, and predation (National Marine Fisheries Service 2008d).

## **Central Valley DPS Steelhead (*Oncorhynchus mykiss irideus*)**

The Central Valley steelhead DPS includes all naturally spawned anadromous steelhead below natural and manmade impassable barriers in the Sacramento and San Joaquin Rivers and their tributaries, excluding steelhead from San Francisco and San Pablo Bays and their tributaries but including two artificial propagation programs: the Coleman National Fish Hatchery, and the DFG Feather River Hatchery. Estimates of historical and recent mean run abundance are 1–2 million and approximately 3,600, respectively (National Marine Fisheries Service 2008c).

The habitat requirements of Central Valley steelhead are similar to those of central California coast steelhead. Water quality is a critical factor during the freshwater residence time with cool, clear, and well oxygenated water needed for maximum survival (Moyle 2002). Juvenile steelhead (ages 1+ and



2+) occupy deeper water than fry and show a stronger preference for pool habitats with ample cover, as well as for rapids and cascade habitats (Dambacher 1991). Juveniles generally occupy habitat with large structures such as boulders, undercut banks, and large woody debris that provide feeding opportunities, segregation of territories, refuge from high water velocities, and cover from fish and bird predators (Moyle et al. 2008).

Central Valley steelhead exhibit flexible reproductive strategies that allow for persistence in spite of variable flow conditions (McEwan 2001). Peak adult migration historically occurred from late September to late October, with some creeks, such as Mill Creek, showing a small mid-February run (Hallock 1989 in Moyle et al. 2008). Optimal spawning temperatures are 4°C to 11°C (McEwan and Jackson 1996). Emergent fry migrate into shallow water (<36 cm) areas such as the stream edge or low gradient riffles, often in open areas with coarse substrates (Everest and Chapman 1972, Everest et al. 1986, and Fontaine 1988, all in Moyle et al. 2008). In the late summer and fall, juveniles move into higher-velocity, deeper, mid-channel areas (Everest and Chapman 1972, Fontaine 1988, and Hartman 1965, all in Moyle et al. 2008). Age data from a sample of 100 fish taken in 1954 indicated that steelhead spent 1 (29%), 2 (70%), or 3 (1%) years in freshwater before migrating out of the basin to the ocean (Hallock et al. 1961). Juvenile Central Valley steelhead generally migrate from late December through the beginning of May, with a peak in mid-March (Moyle et al. 2008).

Central Valley steelhead are opportunistic predators of aquatic and terrestrial insects, small fish, frogs, and mice, but their primary diet consists of benthic aquatic insect larvae, particularly caddisflies (*Trichoptera*), midges (*Chironomidae*), and mayflies (*Ephemeroptera*) (Merz 2002). Depending on season and steelhead size, they also may eat salmon eggs, juvenile salmon, sculpins, and suckers (Merz 2002).

The primary limiting factor for Central Valley steelhead is the inaccessibility of more than 95% of its historic spawning and rearing habitat due to major dams (National Marine Fisheries Service 2008c). Other limiting factors include small passage barriers, water development and land use activities, levees and bank protection, dredging and sediment disposal, mining, contaminants, fisheries management practices, hatcheries, inadequately screened water diversions, and predation by nonnative species (McEwan 2001; Moyle et al. 2008; National Marine Fisheries Service 2008c).

## **Central California Coast DPS Steelhead (*Oncorhynchus mykiss irideus*)**

The central California coast steelhead DPS includes all naturally spawned populations below natural and manmade impassable barriers in California streams from the Russian River (inclusive) south to Aptos Creek (inclusive); the drainages of San Francisco, San Pablo, and Suisun Bays eastward to Chipps Island at the confluence of the Sacramento and San Joaquin Rivers; tributary streams to Suisun Marsh, including Suisun Creek, Green Valley Creek, and an unnamed tributary to Cordelia Slough (commonly referred to as Red Top Creek), excluding the Sacramento–San Joaquin River basin and those fish associated with two artificial propagation programs: the Don Clausen Fish Hatchery and Kingfisher Flat Hatchery/Scott Creek (Monterey Bay Salmon and Trout Project) steelhead hatchery programs (neither is a DFG hatchery). There are few quantitative abundance data, but estimated runs in the Russian River declined from 65,000 in the 1960s to 1,750–7,000 in the 1990s, indicating a potential loss of at least 89% (Busby et al. 1996; National Marine Fisheries Service 2007a).

Central California coast steelhead require freshwater spawning and rearing sites similar to those described for Northern California steelhead. Like other salmonids, central California coast steelhead require cool water for health, growth, and reproduction, though they tolerate warmer water conditions as well. Generally, central California coast steelhead juveniles are absent from waters that exceed 25°C–26°C for even short periods (Moyle et al. 2008). For adult steelhead, lethal temperatures are 23°C–24°C (Moyle 2002). Estuaries provide critical nursery areas for juvenile steelhead. Estuaries along the central California coast vary in size but tend to undergo sandbar formation and become seasonal freshwater lagoons during summer low flow conditions. Although estuaries provide nursery habitat, fish cannot remain there for their entire life, and sandbars must be breached by high stream flows on a recurring basis so that adult spawners can migrate upstream to spawn and juveniles can migrate to the sea (Moyle et al. 2008).

The majority of central California coast steelhead enter rivers as sexually mature adults between late December and April (Moyle et al. 2008) and spawn soon after reaching spawning grounds. Peaks in adult migration were observed in Wadell Creek in early January and mid-March (Shapovalov and Taft 1954). Depending on water temperature (Shapovalov and Taft 1954), incubation time ranges from 25 to 35 days. Alevins spend 2 to 3 weeks in the gravel before emerging as fry, which start to move into the water column and occupy deeper water as they grow.

Juvenile downstream migration may occur throughout the year, but the primary migration season occurs in spring and summer, with a secondary migration in the late fall or early winter (Shapovalov and Taft 1954). Hayes et al. (2008) has described three life history expressions: Some juvenile steelhead migrate to the estuary after spending only a few months in the upper watershed, some migrate after spending 1 to 2 years rearing in the upper watershed, and some rear for at least a year in the upper watershed before migrating downstream. The first two types also will rear in the estuary for 1 to 10 months before ocean entry, whereas the third type immediately enters the ocean upon migration without rearing in the estuary.

Central California coast steelhead are threatened by the same factors that affect Northern California steelhead (National Marine Fisheries Service 2008b).

## **South/Central California Coast DPS Steelhead (*Oncorhynchus mykiss irideus*)**

The south-central California coast steelhead DPS includes all naturally spawned populations in coastal river basins from the Pajaro River southward to, but not including, the Santa Maria River dividing Santa Barbara and San Luis Obispo Counties (National Marine Fisheries Service 2007b). Estimated historical runs of 27,000 adults declined to less than 500 fish by 1996 with all four of the largest watersheds (Big Sur, Little Sur, Arroyo Seco, and Carmel Rivers) experiencing declines of 90% or more (National Marine Fisheries Service 2008e). In the Carmel River, counts at San Clemente Dam subsequently increased to a peak of 800 in 1997 but declined again after 2001 with less than an estimated 200 adults returning in 2009 (Williams 2009). Current population trends in other individual watersheds are generally unknown but may be similar to the Carmel River.

South-central California coast steelhead have ecological requirements similar to those of Northern California steelhead described above with the exception that steelhead in more southern areas are exposed to warmer water temperatures than their northern counterparts and may have adapted greater tolerance levels for warmer summer temperatures. During the summer, warm air

temperatures can heat up south-central coastal streams to temperatures close to steelhead thermal tolerance limits or above; therefore, oversummering thermal refuge habitat is important.

South-central California coast steelhead and central California coast steelhead encounter similar physical habitat features that influence their juvenile life history, including small, steep coastal watersheds, which result in outmigration by relatively young and small juveniles; and rearing within seasonally closed estuaries, which influences patterns of smoltification, marine survival, and migration (Moyle et al. 2008).

Adults return to spawn between January and May (Boughton et al. 2006; Moyle et al. 2008). Due to warmer stream water temperatures, incubation is shorter than in more northern populations. Optimal mean monthly rearing temperatures are between 6°C and 10°C (Moyle et al. 2008; National Marine Fisheries Service 2007c). High flow events, which do not occur every year, are required to breach estuarine lagoon barriers. When barriers are not breached, migratory access between the ocean and fresh water is impossible. In these cases, migrating adults are thought to spend another year in the ocean before returning to try again and that older juveniles prevented from entering the ocean may experience high mortality (Moyle et al. 2008). However, some juveniles are able to over-summer in the estuary of their natal creek where temperatures may at times be near their thermal tolerance (~25°C) (Myrick and Cech 2004) but food is abundant; these conditions allow fish to grow fast enough during their first year of lagoon rearing to migrate to the ocean (Bond 2006). Most of these “lagoon anadromous” fish enter the ocean at a larger size than their freshwater rearing counterparts; larger size upon ocean entry enhances survival, as evidenced by a large proportion of lagoon reared fish returning to the steelhead spawning population (Bond 2006).

The National Marine Fisheries Service (NMFS) (2007) identified several factors affecting south-central California coast steelhead, including alteration of natural stream flow patterns; physical impediments to fish passage; alteration of floodplains and channels; sedimentation and urban and rural waste discharges; spread and propagation of alien species resulting in predation, competition, and disease transmission; and loss of estuarine habitat.

## **Southern California DPS Steelhead (*Oncorhynchus mykiss irideus*)**

The southern California steelhead DPS includes all naturally spawned populations below natural and human-made impassable barriers in streams from the Santa Maria River near San Luis Obispo, California (inclusive), south to the U.S. border with Mexico. Runs have declined from 55,000 fish in historical time to fewer than 500 fish now, and the DPS has been extirpated from more than half of the 46 watersheds that historically supported steelhead runs (National Marine Fisheries Service 2008f).

Southern California steelhead depend on winter rains to provide upstream passage through seasonally opened estuaries and flowing main-stem rivers. Southern California steelhead typically spawn between January and May, with a peak in February through mid-April (Santa Ynez River Technical Advisory Committee 2000 in Moyle et al. 2008). Rivers within the range of southern steelhead are presumably warmer than streams farther north, and these warmer temperatures likely decrease incubation time with emergence occurring in as little as 3 weeks (Barnhart 1986). Southern California steelhead probably out-migrate relatively early because of the inhospitable conditions created by low flows and warm temperatures in their natal streams. These conditions can result in a greater dependence on coastal lagoons compared with more northern steelhead populations (Moyle et al. 2008).

Southern California steelhead have habitat requirements similar to those of other salmonids (e.g., cool, clear, well-oxygenated water, and ample food) but may have a broader physiological tolerance because of their highly variable environment (Moyle et al. 2008). Optimal water temperatures for juvenile steelhead are reported as 10°C–17°C, but southern steelhead have been found in waters as warm as 28°C (Carpanzano 1996 in Moyle et al. 2008; Moyle et al. 2008; Santa Ynez River Technical Advisory Committee 2000 in Moyle et al. 2008; Spina 2007). Southern steelhead primarily spawn and rear in higher-elevation headwaters, but access to these waters is limited by artificial barriers (Moyle et al. 2008).

Southern California steelhead typically outmigrate to lagoonal estuaries between January and June, with a peak from late March through mid-May (Santa Ynez River Technical Advisory Committee 2000 in Moyle et al. 2008). Because of the unpredictability of the environmental conditions in the southern rivers, it is likely that during wet years, a high percentage of the southern steelhead returning to spawn have spent only 1 year in the ocean (Moyle et al. 2008).

The NMFS (2007) identified varied threats to southern California steelhead, including urbanization, dams and other barriers, stream habitat loss, estuarine habitat loss, species interactions, hatcheries, drought, climate change, and wildfire.

## **Southern Oregon/Northern California Coast ESU Coho Salmon (*Oncorhynchus kisutch*)**

The southern Oregon/northern California coast Coho salmon ESU includes all naturally spawned populations in coastal streams from Cape Blanco in Curry County, Oregon, and Punta Gorda in Humboldt County, California, and three artificial propagation programs: Cole River Hatchery in the Rogue River basin and the DFG Trinity River Hatchery and Iron Gate Hatchery in the Klamath-Trinity River basin (National Marine Fisheries Service 2008h). The estimated historical and recent mean run abundance are 150,000 and 5,170, respectively (National Marine Fisheries Service 2008h). The Klamath and Trinity River populations are largely maintained by hatchery production: Fish of hatchery origin account for 80% of fish returning to Iron Gate Hatchery and 89% to 97% of fish returning to Trinity River Hatchery (Moyle et al. 2008).

Coho salmon in California typically return to their natal streams to spawn after 2 years in the ocean, but some return to spawn after the first year, and these are referred to as grilse or jacks (Laufle et al. 1986; California Department of Fish and Game 2002). Adult migration timing varies between tributaries but generally begins after stream flows increase in fall and early winter and generally occurs from September through January (California Department of Fish and Game 2002). In small coastal streams, flows must be high enough to breach any sandbars that have formed, so migration typically begins mid-November through mid-January (Baker and Reynolds 1986 in California Department of Fish and Game 2002; California Department of Fish and Game 2002). In the Klamath River, southern Oregon/northern California coast Coho salmon adults migrate between September and late December, with a peak in late September to early October. In the Eel River, migration begins 4–6 weeks later, with a peak in upper reaches occurring in November–December (Baker and Reynolds 1986 in California Department of Fish and Game 2002).

Spawning in small coastal streams occurs mainly from November to January but may occur as late as March, depending on flow and access conditions (Shapovalov and Taft 1954; California Department of Fish and Game 2002). In both the Klamath and Eel Rivers, spawning primarily occurs in

November and December (Baker and Reynolds 1986 in California Department of Fish and Game 2002; U.S. Fish and Wildlife Service 1979).

Coho salmon migrate and spawn mainly in smaller streams than Chinook salmon, including those that flow directly into the ocean or in tributaries of large rivers. Females choose redd sites with coarse, mixed-size gravel (up to 15 cm average diameter, up to 5% fines), often at pool tailouts (Moyle et al. 2008). Spawning typically occurs in water 10–54 cm deep, with flow velocities of 0.2–0.8 meters/second. Incubation lasts 8 to 12 weeks, depending on temperature and local adaptations, and fry emerge between March and July, with peak emergence occurring from March to May (Shapovalov and Taft 1954; California Department of Fish and Game 2002). Juveniles initially rear in shallow stream margins. As they grow, parr shift into deeper water until July and August, when they are in the deepest pools (California Department of Fish and Game 1994 in California Department of Fish and Game 2002) with in-stream cover (undercut banks, logs, and other woody debris). During winter, juveniles seek refuge from high, turbid flows in areas with lowered velocities and less turbidity, such as in side channels, masses of large woody debris, and small tributaries (Moyle et al. 2008). Rearing areas generally used by juvenile Coho salmon are low-gradient coastal streams, wetlands, lakes, sloughs, side channels, estuaries, low-gradient tributaries to large rivers, beaver ponds, and large slackwaters (Pacific Fishery Management Council 1999). Juveniles optimally rear at temperatures around 12°C to 14°C but have been found at temperatures as high as 29°C (Bisson et al. 1988; Moyle 2002). Juveniles typically migrate to the ocean at age 1+ but may defer another year. Juvenile migration typically begins in late March and early April but may begin prior to March (California Department of Fish and Game unpublished data in California Department of Fish and Game 2002). Peak juvenile migration occurs from April to late May/early June (Weitkamp et al. 1995; California Department of Fish and Game 2002) and can persist into July in some years (Shapovalov and Taft 1954; Sandercock 1991). Bell (2001) has found a small percentage of Coho salmon that remain more than 1 year in Prairie Creek before going to the ocean and suggests that this can occur when fish are spawned late and are too small at time of smolting (California Department of Fish and Game 2002).

Factors contributing to the decline of southern Oregon/northern California coast Coho salmon include poor land-use practices (especially those related to logging and agriculture), dams and diversions, in-stream structures, gravel mining, suction dredging, substandard or unscreened diversions, overharvest and poaching, water over-allocation and pollution, nonnative species, and urbanization (Brown et al. 1994; Moyle et al. 2008; National Marine Fisheries Service 2008h).

## **Central California Coast ESU Coho Salmon (*Oncorhynchus kisutch*)**

The central California coast Coho salmon ESU (CCC Coho ESU) includes all populations from Punta Gorda in northern California south to and including the San Lorenzo River in central California, as well as populations in tributaries to San Francisco Bay, excluding the Sacramento–San Joaquin River system (National Marine Fisheries Service 2008g). From the late 1980s to 2001, adult Coho abundance declined for streams within this ESU; however, some streams of the Mendocino County coast showed an upward trend in 2000 and 2001, and some streams in Marin County also had relatively large adult returns in 2001 (California Department of Fish and Game 2002). More recently, declines of coastal Coho thought to be the result of unusual ocean conditions have been observed in 2007 (Varanassi and Bartoo 2007).

In most respects, the life history and ecological requirements of central California coast Coho are similar to southern Oregon/northern California coast Coho salmon in California typically return to

their natal streams to spawn after two years in the ocean, but, some return to spawn after the first year, and these are referred to as grilse or jacks (Laufle et al. 1986; California Department of Fish and Game 2002). Adult migration timing varies between tributaries but generally begins after stream flows increase in fall and early winter and generally occurs from September through January (California Department of Fish and Game 2002). In small coastal streams, flows must be high enough to breach any sandbars that have formed so migration typically begins mid-November through mid-January (Baker and Reynolds 1986 in California Department of Fish and Game 2002). Generally, Coho salmon spawn in smaller streams than do Chinook salmon and spawning primarily occurs from November to January but can extend into March under drought conditions (Shapovalov and Taft 1954; California Department of Fish and Game 2002). Fry emerge from gravels between March and July, with peak emergence occurring from March to May, depending on when the eggs were fertilized and the water temperature during development (Shapovalov and Taft 1954; California Department of Fish and Game 2002). Similar to other salmonids, fry seek out shallow water at stream margins larger fish move progressively into deeper water. Juvenile rearing areas include low gradient coastal streams, wetlands, lakes, sloughs, side channels, estuaries, low gradient tributaries to large rivers, beaver ponds and large slackwaters (Pacific Fishery Management Council 1999). Yearling smolts migrate downstream from as early as February to as late as July (DFG unpublished data in California Department of Fish and Game 2002; Shapovalov and Taft 1954; Sandercock 1991 in California Department of Fish and Game 2002) with peak migration from April to late May/early June (Weitkamp et al. 1995). A small percentage of Coho may rear for more than a year in freshwater (Bell 2001 in California Department of Fish and Game 2002; Bell and Duffy 2007). Central California coast Coho populations are declining in response to the same factors as southern Oregon/northern California coast Coho, along with other factors, such as habitat loss and degradation, the conversion of forest to agricultural lands (especially vineyards), hatchery domestication effects, catch-and-release incidental mortality, climatic variation, and predation (Moyle et al. 2008; National Marine Fisheries Service 2008; California Department of Fish and Game 2002).

## **Klamath–Trinity Rivers Spring-Run ESU Chinook Salmon (*Oncorhynchus tshawytscha*)**

The Klamath–Trinity Rivers (KTR) spring-run Chinook salmon ESU includes naturally reproducing populations of salmon in the Klamath and Trinity Rivers. Adult KTR Chinook salmon enter the Klamath estuary from March to July, with a peak between May and early June (Moyle et al. 2008; Myers et al. 1998). Once they reach the upper portions of the watershed, they remain in cold-water areas for 2 to 4 months before spawning. Optimal adult holding habitat is characterized by pools or runs over 1 m deep with summer temperatures less than 20°C, shade, little human disturbance, and ample cover (e.g., bedrock ledges, boulders, or large woody debris) (West 1991).

Spawning starts in mid-September in the Salmon River and in early October in the Trinity River basin. For KTR spring-run Chinook, a majority of spawning habitat is found on low-gradient gravel riffles and at pool tailouts (Moyle et al. 2008). With optimal conditions, embryos hatch after 40–60 days and remain in the gravel for another 4–6 weeks until emerging from early winter until late May (Leidy and Leidy 1984). Juvenile downstream migration occurs primarily from February through mid-June (Leidy and Leidy 1984) with entry into the Klamath estuary when river water temperatures are at or above optimal holding temperatures (Moyle et al. 2008).

The KTR spring-run Chinook have been largely extirpated from their historic range because their life history makes them extremely vulnerable to the combined effects of dams, mining, habitat degradation, and harvest (Moyle et al. 2008).

## **California Coastal ESU Chinook Salmon (*Oncorhynchus tshawytscha*)**

The California coastal Chinook salmon ESU includes all naturally spawned populations from rivers and streams south of the Klamath River (exclusive) to the Russian River (inclusive), as well as those associated with five artificial propagation programs, at the Humboldt Fish Action Council (Freshwater Creek), Yager Creek, Redwood Creek, Hollow Tree, and Mattole Salmon Group hatcheries (National Marine Fisheries Service 2008i) (DFG formerly participated in this program at its Van Arsdale and Mad River hatcheries, but these programs have been discontinued).

California coastal Chinook are fall-run salmon, and adults return to their natal rivers between September and early November after sandbars at estuarine river mouths have been breached by storm or peak flow events (Moyle et al. 2008). California coastal Chinook salmon may spawn immediately or may rest in holding pools for a considerable time if flows allow river entry but do not initially permit access to spawning habitat farther upstream. Chinook use the largest substrate of any California salmonid for spawning, which includes a mixture of small cobble and large gravel. For California coastal Chinook, a majority of spawning habitat is in the upper main stems of rivers and lower reaches of coastal creeks. Preferred spawning habitat is at depths of 30–100 cm and water velocities of 40 to 60 cm/sec (Moyle et al. 2008). Under optimal conditions, incubation lasts 40–60 days, and fry emerge 4–6 weeks later in late winter or spring. Fry first use shallow nearshore waters, but as they grow larger, they move into the tails of pools or other moderately fast-flowing habitats where food is abundant and there is some protection from predators. Most California coastal Chinook salmon begin migrating downstream within a week to months of emergence at sizes ranging from 30 to 50 millimeters fork length (mm FL). California coastal Chinook and may reside in estuaries, lagoons, and bays for several months, feeding and growing considerably, before continuing into the ocean (Moyle et al. 2008).

California coastal Chinook are threatened by the same factors affecting Northern California steelhead, and they are also affected by non-federal timber harvest (National Marine Fisheries Service 2008i).

## **Sacramento River Winter-Run ESU Chinook Salmon (*Oncorhynchus tshawytscha*)**

The Sacramento River winter-run Chinook salmon ESU includes all naturally spawned populations in the Sacramento River and its tributaries, as well as two artificial propagation programs: winter-run Chinook from the Livingston Stone National Fish Hatchery and winter-run Chinook in a captive brood stock program maintained at Livingston Stone National Fish Hatchery and the University of California, Davis, Bodega Marine Laboratory.

Winter-run Chinook occur in areas that have a continuous supply of cold water, such as the spring-fed streams of the basalt and porous lava region of northeastern California (Moyle et al. 2008). They occur only in the Sacramento River basin because they require water temperatures cold enough in summer to enable successful incubation but warm enough in winter to support juvenile rearing

(Moyle et al. 2008; Stillwater Sciences 2006). Winter-run Chinook historically migrated high into the watersheds of the McCloud, Pit, and upper Sacramento Rivers to spawn. This habitat was lost to them with the construction of Shasta Dam in the 1940s (Moyle et al. 2008).

Winter-run Chinook life history timing differs considerably from the other three Central Valley Chinook salmon races. Their spawning migration extends from January to May with a peak in mid-March. They enter fresh water as sexually immature adults and migrate upriver to the reaches below Keswick Dam, where they hold for several months until spawning in April through early August (Moyle et al. 2008; Williams 2006). Optimal temperatures for holding range from 10°C to 16°C, and optimal water velocities range from 0.47 to 1.25 meters/second (U.S. Fish and Wildlife Service 2003a). Incubation, which is the most temperature-sensitive life history stage, occurs in the hottest part of the year (Moyle et al. 2008). To ensure moderate redd temperatures, winter-run Chinook spawn at depths of 1 to 7 meters (Moyle 2002). Fry emerge from the gravel from July through mid-October (Moyle et al. 2008; Williams 2006; Yoshiyama et al. 1998). After emergence, juveniles are restricted in their rearing habitat to those reaches that maintain cool summer temperatures. According to Williams (2006), most fry migrate past Red Bluff Diversion Dam in summer or early fall, but many rear in the river below Red Bluff for several months before they reach the Delta in early winter. Juvenile entry into the Delta occurs from January to April. Little is known about current juvenile usage of the San Francisco estuary, but a recent study by the U.S. Army Corps of Engineers (USACE) indicates that residence time is limited and outmigration through this region is swift (Moyle et al. 2008).

The biggest single cause of winter Chinook salmon decline was the loss of access to spawning areas caused by construction of the Shasta and Keswick dams in the 1940s. Other, ongoing factors include having only one existing population with a low population size, climate variability (e.g., drought), unscreened or inadequately screened water diversions, predation, pollution (e.g., from the Iron Mountain Mine), adverse flow and water quality conditions leading to high water temperatures, fisheries management, passage barriers (e.g., Red Bluff Diversion Dam), and degraded spawning habitat (Moyle et al. 2008; National Marine Fisheries Service 2008k).

## **Central Valley Spring-Run ESU Chinook Salmon (*Oncorhynchus tshawytscha*)**

The Central Valley spring-run Chinook salmon ESU includes all naturally spawned populations in the Sacramento River and its tributaries in California, including the Feather River, and one artificial propagation program: the DFG Feather River Hatchery spring-run Chinook salmon program. There are only three remaining independent populations, Mill, Deer, and Butte Creeks, which are in close geographic proximity to each other. Estimates of historic abundance indicate about 700,000 spawners, which has declined to a current level of and 500 to 4,500 spawners (National Marine Fisheries Service 2008j).

Returning Central Valley spring-run Chinook migrate upstream as sexually immature fish in spring, hold through the summer in deep pools, spawn in early fall, and migrate downstream as juveniles after either a few months or a year in fresh water (Moyle et al. 2008). Spawning migration extends from February to early July with peaks in mid-April in Butte Creek and in mid-May in Deer and Mill Creeks (Williams 2006). Central Valley spring-run Chinook attain maturity at ages of 2 to 4 years. They generally migrate higher into watersheds than other runs in order to find deep pools where cooler temperatures allow over-summering (Moyle et al. 2008). Spawning often occurs in the tail



waters of their final holding pool (Moyle 2002). Preferred spawning habitat seems to be at depths of 25–100 cm and at water velocities of 30–80 cm/sec (Williams 2006). Incubation lasts 40–60 days and is extremely sensitive to temperature, with high egg mortality at temperatures above 14 to 16°C. Fry emerge in another 4-6 weeks (Williams 2006). Migration can begin within hours of emergence, after a few months of natal rearing, or after over-summering in the natal stream (Hill and Webber 1999; Moyle et al. 2008; Stillwater Sciences 2006). As Central Valley spring-run Chinook travel downstream, they may rear in the lower reaches of non-natal tributaries and along main-stem margin habitats, particularly for smaller fish that need to grow larger before ocean entry (Moyle et al. 2008). Juveniles feed mainly on zooplankton, benthic invertebrates, terrestrial drift, and larvae of other fishes, especially suckers (Moyle 2002; Moyle et al. 2008).

According to the NMFS (2008), there are three primary limiting factors to Central Valley spring-run Chinook:

1. loss of most historic spawning habitat due to impassable dams,
2. degradation of remaining habitat, and
3. genetic threats from the Feather River Hatchery spring-run Chinook salmon program.

Other limiting factors include water diversions, unscreened or inadequately screened water diversions, excessively high water temperatures, predation by nonnative species, urbanization and rural development, logging, grazing, agriculture, mining, estuarine alteration, fisheries management, and “natural” factors (Moyle et al. 2008; National Marine Fisheries Service 2008j).

## **Central Valley Fall-/Late Fall–Run ESU Chinook Salmon (*Oncorhynchus tshawytscha*)**

The Central Valley fall-/late fall–run Chinook salmon ESU includes all populations in the Sacramento and San Joaquin River basins and their tributaries. Fall-run Chinook are the most abundant run in the Central Valley and are the principal run raised in hatcheries (Moyle 2002; Williams 2006). However, the fall-run Chinook population has declined during the last several years from an average of 450,000 (1992–2005), to less than 200,000 fish in 2006 and to about 90,000 spawners in 2007. The population includes both wild and hatchery-origin fish, and the proportion of hatchery fish can be as high as 90% depending on location, year, and surveyor bias (Barnett-Johnson et al. 2007 in Moyle et al. 2008).

Fall-run Chinook habitat requirements are generally similar to those of California coastal Chinook, but juveniles make more extensive use of off-channel habitats where they grow faster because of warmer water temperatures and abundant food (Moyle et al. 2008; Sommer et al. 2001).

Fall-run Chinook migrate to spawning grounds as sexually mature adults and usually spawn 1 to 2 months after entry. Peak spawning time is from October to November, but spawning can continue through January. Fry typically emerge from December through March and rear in natal streams for 1 to 7 months, usually moving downstream into the main rivers within a few weeks after emergence. Both fry and smolts can be found in the San Francisco estuary. Fish spend 2 to 5 years at sea before returning to spawn (Moyle et al. 2008).

Limiting factors affecting the fall-run/late fall–run Chinook salmon include hatcheries, harvest, and reduced spawning and rearing habitat due to agriculture and water management actions (West Coast Chinook Salmon Biological Review Team 1999).

# Amphibians

## California Tiger Salamander (*Ambystoma californiense*)

The U.S. Fish and Wildlife Service (USFWS) recognizes three DPSs of California tiger salamander (Central Valley DPS, Santa Barbara County DPS, and Sonoma County DPS) while DFG recognizes one which encompasses the entire range of the species. The range of the Santa Barbara County DPS and Sonoma County DPS is restricted to their respective counties. The Central Valley DPS encompasses four populations, including the Bay Area (central and southern Alameda, Santa Clara, western Stanislaus, and western Merced Counties, and the majority of San Benito County), Central Valley (Yolo, Sacramento, Solano, eastern Contra Costa, northeast Alameda, San Joaquin, Stanislaus, Merced, and northwestern Madera Counties), southern San Joaquin Valley (portions of Madera, central Fresno, and northern Tulare and Kings Counties), and central Coast Ranges (southern Santa Cruz, Monterey, northern San Luis Obispo, and portions of western San Benito, Fresno, and Kern Counties).

California tiger salamanders primarily inhabit grasslands of the Central Valley and oak savannah plant communities of the Sierra Nevada and Coast Range and usually occur at elevations below 1,500 feet but have been documented at elevations of up to 4,500 feet (Stebbins 1985; Barry and Shaffer 1994; Jennings and Hayes 1994). They require aquatic breeding sites and terrestrial aestivation or refuge sites and inhabit the grassy understories of open woodlands and valley and foothill grasslands, usually within one mile of water (Jennings and Hayes 1994). Following metamorphosis, California tiger salamanders are terrestrial animals that spend most of their time underground in subterranean refuge sites during the non-breeding season (Zeiner et al. 1988). Refuge sites are primarily burrows of small mammals (e.g., California ground squirrel [*Spermophilus beechyii*] and pocket gopher [*Thomomys bottae*]), but California tiger salamanders are also known to use logs, piles of lumber, and shrink-swell cracks in the ground for cover as well (Holland et al. 1990).

California tiger salamanders can live for 10 years or more (Trenham et al. 2000) and adults typically reach sexual maturity at 4 to 5 years old but some may be breed for the first time as early as 2–3 years of age (Bolster 2004). Adults emerge from underground for brief periods during the year to breed. Emergence and adult breeding migration (i.e., movement from upland areas to breeding ponds that is typically nocturnal and less than 0.5 miles) is associated with rain events. Adults generally do not migrate to breeding ponds if weather conditions are unfavorable (e.g., drought, atypical timing of rainfall) and only a fraction of the adult population breeds annually (Trenham et al. 2000; Trenham and Shaffer 2005; Bolster 2004). Breeding usually takes place during warm rains between November and February (Barry and Shaffer 1994; Shaffer and Fisher 1991).

California tiger salamanders breed primarily in vernal pools and other ephemeral ponds that fill during winter and often dry out by summer (Loredo et al. 1996); they also use permanent human-made ponds (e.g., stock ponds), reservoirs, and small lakes that do not support predatory fish or bullfrogs (Stebbins 1972; Zeiner et al. 1988). Large vernal pool complexes likely provide the best habitat since they include a mixture of core breeding sites and nearby refugia (Jennings and Hayes 1994; Shaffer et al. 1993). However, many current populations use artificial ponds created and maintained by ranchers that would not exist without grazing and farming activities (Bolster 2004). For instance, a relatively high percentage of breeding sites (43%) in the Bay Area population were found to be in artificial water bodies (i.e., stock, farm, or berm ponds) used for cattle grazing and/or

small farm irrigation water source (U.S. Fish and Wildlife Service 2003). Also, streams are rarely used for reproduction (Kucera 1997).

Eggs are laid singly or in clumps on submerged or emergent vegetation, on submerged debris, or on objects at the bottom of the pond if no vegetation or debris are present (Barry and Shaffer 1994; Jennings and Hayes 1994; Shaffer and Fisher 1991; Stebbins 1972). Larvae hatch in approximately 2 weeks and occupy aquatic habitats through metamorphosis, which requires a minimum of 10 weeks but generally takes 3 to 6 months to complete (Petranka 1998).

Adults return to their underground refugia after breeding (usually within one to two weeks, but some remain in breeding pools for several weeks), and juveniles that have gone through metamorphosis will disperse into upland habitats (Holland et al. 1990; Storer 1925). Estimates of movement indicate that 95% of adults disperse to within approximately 820 feet (250 m) to 1,500 feet (450 m) (Trenham 2001; Semlitsch 1998; Trenham and Shaffer 2005) and 95% of subadults to within approximately 2,100 ft (640 m) of breeding ponds (Trenham and Shaffer 2005). Juveniles have also been observed to exhibit unseasonable migration movements, such as a late summer migration into a seasonal lake which was stimulated by a significant atypical late summer rain event (Holland et al. 1990). Nearly all juvenile salamanders observed during this unusual migration subsequently died of dehydration from hot weather.

California tiger salamander diets vary depending on life history stage and body size. Small aquatic larvae feed on algae, small crustaceans, and mosquito larvae (U.S. Fish and Wildlife Service 2000a), while larger larvae feed on zooplankton, amphipods, mollusks, and smaller tadpoles of Pacific treefrogs (*Pseudacris regilla*), California red-legged frogs (*Rana aurora draytoni*), western toads (*Bufo boreas*), and spadefoot toads (*Spea* spp.) (U.S. Fish and Wildlife Service 2000a; Zeiner et al. 1988). As adults, California tiger salamanders eat earthworms, snails, insects, fish, and small mammals (Stebbins 1972).

California tiger salamander populations have experienced dramatic declines throughout the historical range of the species, particularly in the Central Valley. These declines have been attributed to habitat loss and fragmentation; agricultural and urban development (Stebbins 1985); and the introduction of bullfrogs, Louisiana red swamp crayfish, and nonnative fishes (e.g., mosquitofish, bass, and sunfish) (59 FR 18353; Jennings and Hayes 1994; Shaffer et al. 1993; Fisher and Shaffer 1996; U.S. Fish and Wildlife Service 2000a). Additional threats include hybridization with a non-native “waterdog” (an eastern tiger salamander, *Ambystoma tigrinum* ssp.), diseases, contaminants (e.g., road runoff oil and methoprene—an insect hormone that inhibits molting), and other factors (e.g., illegal grading, plowing, filling of ponds, and rodent control practices) (Riley et al. 2003; Shaffer et al. 1993; Shaffer and Trenham 2002; Worthylake and Hovingh 1989; Kiesecker and Blaustein 1997; Lefcort et al. 1997; Jancovich et al. 2001; 65 FR 57241; Bolster 2004). Besides predation, fish may carry viruses that may affect salamanders (Carey et al. 2003).

## Northwestern Salamander (*Ambystoma gracile*)

Northwestern salamander occurs along the Pacific coast from the Gualala River (Sonoma County), California north to extreme southeastern Alaska. They occur in wetlands at elevations from sea level up to 3,100 meters (CaliforniaHerps.com 2009).

The breeding season is variable; beginning as early as January in the south, extending into late July in the north or at higher elevations. Females lay masses of up to 100-200 eggs, which hatch in 2-4 weeks. The larval period lasts 1-2 years (NatureServe 2009).

Transformed adults are most likely to be seen on rainy nights during migrations over land to and from breeding sites, or when breeding in ponds, lakes, and streams. At other times of the year they stay in rotten logs or moist places underground such as animal burrows. They are often found under surface objects near breeding pools or streams in the breeding season, and under driftwood on stream banks after storm waters recede. When molested, they may emit a ticking sound and assume a defensive posture, elevating the tail and secreting a sticky white poison from glands on the head, back, and tail, which can kill or sicken small animals.

Adults migrate to breeding waters and breed between January and April (and as late as August in high elevations in Washington). Egg masses are roughly the size of a small grapefruit are laid in wetlands adjacent to lakes, ponds, and slow-moving streams. Attached to underwater shrub branches, grass, or aquatic plants, the eggs hatch in 6–8 weeks. Aquatic larvae usually transform after one year at around 85 cm. (CaliforniaHerps.com 2009), but may last 1–2 years (NatureServe 2009). Larvae are pond-adapted, brown or olive green with dark pigment along the base of the dorsal fin, long feathery gills. (CaliforniaHerps.com 2009). Montane populations of adults often retain juvenile traits (known as paedomorphism), some obligatorily so. Incidence of paedomorphosis is positively correlated with increasing elevation, stability of the aquatic habitat, lack of fishes, and slower larval growth rates. Metamorphic and paedomorphic individuals may coexist in the same population. Larvae feed on zooplankton as well as many other aquatic invertebrates. Diet of terrestrial adults is not well documented, but they apparently feed on a wide variety of terrestrial invertebrates (NatureServe 2009).

Adults and larvae are mildly poisonous which may explain their general ability to survive in lakes and streams with populations of introduced fishes and bullfrogs (CaliforniaHerps.com 2009). However, some populations have been reduced due to predation by introduced trout. In Washington, a lake population increased after removal of non-native fishes. (NatureServe 2009).

## Long-Toed Salamander (*Ambystoma macrodactylum*)

Except where otherwise cited, the following information comes from the NatureServe database and the California Department of Fish and Game's California Wildlife Habitat Relationship System.

Long-toed salamander occurs from Alaska south through British Columbia, Alberta, Washington, Montana, Idaho, Oregon, and northern California. In California the species is found in the Cascades and Sierra Nevada mountains south to Tuolumne County and in an isolated subspecies (*A. m. croceum*) population in Santa Cruz and Monterey Counties (Stebbins 2003). A separate discussion of the Santa Cruz long-toed salamander is provided in the section following this one.

Long-toed salamander adults spend most of the year underground in mammal burrows, rock fissures, and occasionally human-made structures. Adults are active above ground at night during the periods prior to and after breeding. In California, preferred habitats include ponderosa pine forests, montane hardwood-conifer forest, mixed conifer forest, montane riparian woodland, red fir forest, and wet meadows.

Long-toed salamanders breed primarily in temporary ponds formed by winter and spring rains and snowmelt. High elevation populations require permanent ponds because of slow development rates of larvae. Breeding occurs in late May or June in the Sierra Nevada. Adults will typically migrate to breeding sites on rainy nights. In high montane areas, salamanders emerge and migrate to breeding ponds as soon as springtime temperatures are warm enough to reduce snow cover and open ponds. Eggs are usually laid in loose clusters of 8 to 10 eggs on the underside of logs and slabs of bark in

water between 11 and 30 inches deep. Larvae metamorphose prior to the drying of breeding ponds, but at high elevations larvae may overwinter in permanent ponds.

Long-toed salamanders are considered vulnerable in California. The few existing populations are very restricted, and exist in ecologically fragile locations. Threats include the predation by introduced trout populations, destruction of wetland habitats, timber harvests, grazing, and fire management activities.

## **Santa Cruz Long-Toed Salamander (*Ambystoma macrodactylum croceum*)**

Except where otherwise cited, the following information comes from the NatureServe database.

Santa Cruz long-toed salamander is endemic to California and is known from a few localities within southern Santa Cruz County and northern Monterey County (California Natural Diversity Database 2009).

Santa Cruz long-toed salamanders are nocturnal amphibians that occur in wet meadows near sea level, inhabiting both aquatic and upland habitats. The salamander spends most of its life underground in small mammal burrows or in spaces among root systems of woody plants. The salamander is also found among the root systems of plants in upland chaparral and woodland areas of coast live oak (*Quercus agrifolia*) and Monterey pine (*Pinus radiata*) and in strips of riparian vegetation, such as arroyo willows (*Salix lasiolepis*), cattails (*Typha* spp.), and bulrush (*Scirpus* spp.) (U.S. Fish and Wildlife Service 1999d).

Adults migrate from upland habitats to seasonal breeding ponds and marshes on wet foggy nights in September or October. Breeding ponds are shallow with abundant emergent vegetation and must hold water for at least 90 days. They typically are dry by late summer. Recorded migration distances range from less than 125 meters feet to more than 1.6 kilometers (U.S. Fish and Wildlife Service 1999d). Mating reaches its peak in January and February, when heavy rain have filled breeding ponds and marshes. Adults will return to upland habitat in March. Eggs hatch a week after being laid and larvae metamorphose in 90 to 140 days, depending on temperature, leaving for cover in upland areas. They become sexually mature in 3 to 4 years, before which they do not return to breeding ponds.

Santa Cruz long-toed salamanders have declined due to habitat destruction and degradation of water quality from agriculture and development, loss of food resources due to the spread of exotic plants, and predation by introduced fishes, bullfrogs, and parasites (U.S. Fish and Wildlife Service 1999d).

## **California Giant Salamander (*Dicamptodon ensatus*)**

The California giant salamander is endemic to California. This species is found in two, possibly three, isolated regions. One region is from near Point Arena in Mendocino County east into the coast ranges into Lake and Glenn counties and south to the San Francisco Bay. The second region is south of the San Francisco Bay from San Mateo County to southern Santa Cruz County. This species does not occur in the East Bay. A third possible region is Big Sur, Monterey County where there was an unconfirmed sighting (CaliforniaHerps.com 2009).

Adults inhabit humid forests under rocks and logs near mountain streams or rocky shores of mountain lakes or ponds. This species breeds in both spring and fall months. (CaliforniaHerps.com 2009). Breeding typically occurs in water-filled nest chambers under logs and rocks or in rock crevices. Females lay clutches of 135–200 eggs in the spring, usually in headwaters of mountain streams. Females guard their eggs until they hatch. The larvae metamorphose usually in 18-24 months. However, there are times when they may be paedomorphic (NatureServe 2009). Little is known about the natural history of California giant salamander. Presumably, the diet consists of anything small enough for a salamander to overpower and eat, including invertebrates and small vertebrates such as salamanders, small rodents, and lizards. Aquatic larvae probably have a diet which consists of small aquatic invertebrates and small fish hatchlings (CaliforniaHerps.com 2009).

The greatest threats to this species are stream siltation and urban development. Although the range is small and close to urban areas, the species probably is only moderately threatened since it occurs in numerous protected areas (NatureServe 2009).

## **Pacific Giant Salamander (*Dicamptodon tenebrosus*)**

In California, the Pacific giant salamander ranges from Mendocino County near Point Arena, north along the coast and into the north coast mountain ranges as far east as Shasta Reservoir, Shasta County, and McCloud, Siskiyou County, and north to the Oregon border. From there it ranges northwest of the Cascade Mountains (and east of the crest in a few locations) into extreme southwestern British Columbia. The Pacific giant salamander is absent from the Olympic Peninsula in Washington. (CaliforniaHerps.com 2009.)

This species occurs in wet forests in or near clear, cold streams and rivers, mountain lakes, and ponds. Elevation ranges from sea level to near 2,135 m, but mostly below 945 m. Adults are found under objects near streams, under rocks in streams, and sometimes crawling in daytime. Larvae frequent clear cold streams, creeks, and lakes and can be found under rocks and leaf litter in slowly moving water near the banks or out exposed in the water at night. Pacific giant salamanders breed in both spring and fall. Females lay clutches of 100–200 eggs in spring. Females attend to the eggs until they hatch. (NatureServe 2009). Larvae transform in 18 months to 3 years, depending on environmental conditions and the size and permanence of the stream. (CaliforniaHerps.com 2009).

The diet consists of anything small enough for a salamander to overpower and eat, including invertebrates and small vertebrates such as salamanders, small rodents, and lizards. Aquatic larvae feed on small aquatic invertebrates and small fish hatchlings. (CaliforniaHerps.com 2009).

Pacific giant salamanders are common in many areas and still well distributed throughout the historical range from southwestern British Columbia to northwestern California. Logging and road construction may result in unfavorable increases in water temperature and siltation. Larvae may be reduced in numbers where there has been clear-cut logging or siltation from roads. However, opening of forest canopies over streams may lead temporarily to higher primary productivity that in turn increases the body sizes of larva. Abundance is much greater in old growth and mature forests than in young forests. (NatureServe 2009).

## **Southern Torrent Salamander (*Rhyacotriton variegatus*)**

In California, southern torrent salamanders occur throughout humid coastal drainages from near Point Arena in southern Mendocino County, to the Oregon border in the coniferous belt, and north

into Oregon along the coast and inland into the Cascade Mountains. A single record exists from the Sacramento River drainage near Dunsmuir, Siskiyou County (CaliforniaHerps.com 2009).

This species occurs in coastal coniferous forests in small, cold (usually 5.8°C–12.0°C), clear, high-gradient mountain streams and spring seepages, especially in gravel-dominated riffles with low sedimentation. Larvae often occur under stones in shaded streams. Adults also inhabit these streams or streambanks in saturated moss-covered talus, or under rocks in the splash zone. The salamander typically occurs in older forest sites with large conifers, abundant moss, and > 80% canopy closure; required microclimatic and microhabitat conditions generally exist only in older forests. Adults are very sensitive to desiccation. Young, managed forests may be occupied as long as the required microhabitats are present. Southern torrent salamanders are opportunistic feeders. Larvae feed on aquatic invertebrates such as flatworms, annelids, snails, arachnids, crustaceans, and insects. Adults eat aquatic/semi-aquatic invertebrates, including beetles, stoneflies, snails, flies, amphipods, etc. (NatureServe 2009).

Little is known about the seasonal reproductive habits of the southern torrent salamander. Females lay single, loosely laid, pigmentless eggs which are abandoned after they are laid. The eggs hatch after 210 days (CaliforniaHerps.com 2009).

This species occurs in coastal coniferous forests in small, cold (usually 5.8-12.0 C), clear, high-gradient mountain streams and spring seepages, especially in gravel-dominated riffles with low sedimentation. Larvae often occur under stones in shaded streams. Adults also inhabit these streams or streambanks in saturated moss-covered talus, or under rocks in splash zone. Typically occurs in older forest sites with large conifers, abundant moss, and > 80% canopy closure; required microclimatic and microhabitat conditions generally exist only in older forests. Adults are very sensitive to desiccation. Young, managed forests may be occupied as long as the required microhabitats are present. Southern torrent salamanders are opportunistic feeders. Larvae feed on aquatic invertebrates such as flatworms, annelids, snails, arachnids, crustaceans, and insects. Adults eat aquatic/semi-aquatic invertebrates, including beetles, stoneflies, snails, flies, amphipods, etc.

The southern torrent salamander still occurs throughout most of historic range. The small range of this species in northern California and Oregon makes this species vulnerable to localized extirpations and reduction in abundance. Threats include impacts from past logging practices since this species is sensitive to increased water temperatures and sedimentation. Threats from logging have decreased and current logging practices are not regarded as a threat to the species. (NatureServe 2009).

## **Rough-Skinned Newt (*Taricha granulosa*)**

Except where otherwise cited, the following information comes from the NatureServe database and AmphibiaWeb 2009.

Rough-skinned newts occur from along the Pacific Coast from southeast Alaska south to Santa Cruz County, California and extend inland mostly to the west slopes of the Cascades and along the west slope of the Sierra Nevada foothills to Butte County, California (Stebbins 2003).

Rough-skinned newts migrate seasonally between terrestrial and aquatic habitats. Terrestrial habitat consists of coniferous forests, redwood forests, oak-woodland, farmlands, and grassland. In these habitats, adults will spend much of their time underground in burrows and also beneath logs, bark, or boards to avoid high temperatures and drier conditions.. Aquatic habitats include lakes,

ponds, roadside ditches, and slow-moving portions of streams. Aquatic habitats with thick vegetation surrounding them are preferred. Adults and larvae feed on various invertebrates.

In California, rough-skinned newts migrate to aquatic habitat for breeding during or shortly after fall rains. They are often seen moving in large numbers with males typically migrating earlier than females. Breeding occurs primarily from December to July. Eggs are laid singly on aquatic plants or submerged twigs. Eggs hatch in 20-26 days. Larvae metamorphose in late summer or overwinter and metamorphose the following summer. Juveniles will exit aquatic habitat and quickly seek subterranean retreats. Juveniles will typically remain terrestrial until mature, which for other species of *Taricha* is typically 3 to 4 years.

Rough-skinned newt populations are considered secure in California. Potential treats include timber harvests and impacts to aquatic habitats.

## **Red-Bellied Newt (*Taricha rivularis*)**

Except where otherwise cited, the following information comes from the NatureServe database and AmphibiaWeb 2009.

Red-bellied newts are endemic to California, occurring along the coastal region from Sonoma County north to Humboldt County (Stebbins 2003).

Red-bellied newts migrate seasonally between terrestrial and aquatic habitats. Terrestrial habitats are typically coastal woodlands and redwood forests. When inactive, they seek cover under rocks, logs, forest debris, rodent burrows, and subterranean crevices. Aquatic habitats include streams and rivers, and apparently don't use ponds or other standing water habitats for breeding. Adults and larvae feed on various invertebrates.

Red-bellied newts migrate to breeding habitat (rivers and creeks) during fall rains. Migration to breeding habitat is spread out over several months, until the middle of February. Breeding occurs from February through May. Adults enter streams only after the winter floodwaters have receded, returning to the same stream segment in which they were born. Males enter the water a considerable amount of time before females, whose aquatic phase is restricted to a short period during mating and oviposition. Breeding sites are typically mountain streams with clean and rocky substrates. Females lay eggs in flattened clusters to the undersides of cobble and boulders in swift flowing water. Incubation is temperature dependent and ranges from 16 to 34 days. Larvae metamorphose between 4 to 6 months after hatching. Juveniles will typically remain in underground shelters until they reach sexual maturity, which is approximately 5 years or longer.

The red-bellied new population is considered secure in California. Potential threats to this species include changes in land use that remove terrestrial habitat and result in increased sediment load to streams and rivers.

## **Sierra Newt (*Taricha torosa sierrae*)**

Except where otherwise cited, the following information comes from the NatureServe database and AmphibiaWeb 2009.

Sierra newt is endemic to California occurring from the Cascades and Sierra Nevada ranges from Shasta County south to Kern County.



Sierra newts migrate seasonally between terrestrial and aquatic habitats. Terrestrial habitats include mixed forests and woodlands, savannas, shrublands, and grasslands. In these habitats adults spend most of their time under woody debris or in animal burrows. Aquatic habitats include temporary pools and other bodies of water with minimal current. Adults and larvae feed on various invertebrates.

Sierra Newts will migrate to breeding streams in January through February. Breeding activity occurs from early march through early May and is dependent on elevation and local site conditions, and seasonal rainfall. Males arrive at breeding sites before females and stay longer after breeding. Females will attach eggs in spherical masses to the sides and bottoms of stones, submerged rootwads and other woody debris, and emergent vegetation in fairly fast-flowing stream water. Incubation lasts from 14-52 days, depending on local water temperatures, population, and other factors.. The larval period lasts for a few months with metamorphosis occurring in late summer or early fall. Juveniles leave aquatic habitats and spend the next 5 to 8 years in terrestrial habitats before returning to aquatic breeding sites..

Sierra newt populations are considered to be apparently secure. Potential threats included predation from introduced bullfrogs, stocked trout, and from collecting.

## **Coast Range Newt (*Taricha torosa torosa*)**

The Sierra Nevada subspecies of the California Newt (*T. t. sierrae*) (Hedgecock and Ayala 1974), is sometimes commonly called the Sierra newt. This subspecies inhabits variable types of aquatic and terrestrial habitats (Petranka, 1998) on the western low elevation slopes of the Sierra Nevada (Meyers 1942). This subspecies is found at elevations between sea level and 2000 m (Petranka 1998), from Shasta County (Forman 1951) southward TO Kern county (Tan 1993). The Coast Range subspecies of the California Newt (*T. t. torosa*) is commonly called the Coast Range Newt. This second subspecies historically inhabited the California Coast Range from central Mendocino County south to Boulder Creek, San Diego County (Tan 1993; Jennings and Hayes 1994). A recent study found the Coast Range newt to occur as far inland as San Joaquin County (Buchholz and Ely 2000). This subspecies is found between sea level and approximately 1830 m in elevation (Jennings and Hayes 1994). Current populations are highly fragmented in southern California, and were possibly fragmented historically as well (Jennings and Hayes 1994). The northern and southern populations of the Coast Range Newt differ genetically (Hedgecock and Ayala 1974; Tan 1993), to the same extent that *T. t. sierrae* and *T. t. torosa* differ (Hedgecock and Ayala 1974).

Coast range newt populations are considered to be apparently secure in California. Population declines appear to be due to the introduction of exotic predators such as green sunfish, mosquito fish, and crayfish, as well as habitat degradation (Stebbins 2003).

## **Western Tailed Frog (*Ascaphus truei*)**

Tailed frogs are the oldest of all western amphibians, having lived in this region for at least 70 million years. All life history stages (egg, tadpole, and adult) are associated with swift mountain streams having exceptionally cold water, with temperatures of less than 16°C. Other habitat requirements include cover where the tadpoles can escape predators and, in some streams, thermal refugia such as cold upwelling areas. Adults, though primarily aquatic, are occasionally found in cool, moist terrestrial settings. Tadpoles primarily feed upon diatoms that they scrape off of rocks in the streams; adult prey includes a wide variety of invertebrates (Adams and Pearl 2009).

The tailed frog has an exceptionally delayed maturity. One study found that metamorphosis required 4 years and the time to reproductive maturity was 8 to 9 years (Daugherty and Sheldon 1982 cited in Adams and Pearl 2009). The tailed frog thus requires considerable time to recover from disturbances that produce population declines. Most such declines have been noted in the aftermath of timber harvest, which is commonly associated with increased sedimentation and increased maximum annual water temperatures; the tailed frog is sensitive to both types of disturbance. Apart from local declines noted in association with timber harvest, tailed frog populations across the western U.S. remain fairly stable (Adams and Pearl 2009).

## **Western Spadefoot (*Spea [=Scaphiopus] hammondi*)**

The western spadefoot occurs throughout the Central Valley and adjacent foothills from near Redding in Shasta County south to northwestern Baja California. It is known from elevations ranging from sea level up to 1,370 meters (Jennings and Hayes 1994).

Western spadefoots can be found in dry grassland habitat close to ephemeral pools such as vernal pool complexes, typically near extensive areas of friable (but not usually sandy) soil (Storer 1925; Stebbins 1951; Barry 2000). Although spadefoot populations primarily occur in grassland settings, they are occasionally found in valley-foothill woodlands (Zeiner et al. 1988). Western spadefoots can also be found in creeks, drainages, and ponds (Jones & Stokes file information; Westphal pers. comm.).

Western spadefoots require seasonal wetlands for reproduction and metamorphosis. It is frequently assumed that spadefoots require loose soils for subsurface dormancy (Jennings and Hayes 1994); however, there is some evidence that spadefoots may also use rodent burrows (Stebbins 1951; Barry 2000). Also, most sites that support western spadefoots are moderately to heavily grazed (Morey pers. comm.).

Adult western spadefoots spend most of the year in self-excavated underground retreats or, possibly, mammal burrows (Stebbins 1951). They emerge from underground retreats during heavy rains in autumn and winter and spawn in seasonal wetlands in late winter or early spring (Storer 1925; Stebbins 1951). Spawning cues are believed to include the onset of heavy, warmer winter rains of subtropical origin; the filling of vernal pools with rainwater; and the increase of ambient temperatures (Feaver 1971; Jennings and Hayes 1994; Morey 1998; Barry 2000). During dry years, spawning pools may not fill, and western spadefoots may not reproduce. Eggs hatch in less than a week and larvae metamorphose in 30–80 days; the period to metamorphosis apparently depends on the duration of pool depth that is sufficient to support larvae, and possibly on pool temperatures (Feaver 1971; Morey 1998).

Because spadefoots occur primarily in seasonal wetlands and have a short breeding cycle (approximately 30 days), aquatic predators are few, especially for adult spadefoots. California tiger salamanders (*Ambystoma californiense*), garter snakes (*Thamnophis* sp.), Great Blue Herons (*Ardea alba*), and raccoons (*Procyon lotor*) are probably the most important predators of larval and postmetamorphic western spadefoots (Childs 1953; Feaver 1971). Because adult spadefoots spend most of the year below ground, they are able to avoid most predators. Introduced predators such as mosquitofish, other fish species, and bullfrogs (*Rana catesbeiana*) are found in more permanent water habitats than those that typically provide suitable habitat for western spadefoots.

According to Jennings and Hayes (1994), more than 80% of the habitat once occupied by western spadefoot south of Santa Barbara and Kern Counties has been lost to urban and agricultural

development. More than 30% of western spadefoot habitat north of that region has been lost, primarily to agricultural development. Although the decline in southern California is clearly documented, the decline in northern California is much less clear. Previously undocumented populations may yet be discovered that could fill distribution gaps in the species' known range; a recent example is the 1992 discovery of a Glenn County population (Fisher cited in Barry 2000).

## Western Toad (*Bufo boreas*)

The following information is summarized from the NatureServe 2009 website except where noted. The western toad's range extends along the Pacific Coast from southern Alaska to Baja California, and eastward through the Rocky Mountains (Stebbins 2003). The species is absent from most of the desert Southwest (Stebbins 2003). Elevations range is from sea level to at least 3,640 m.

Western toads are mostly terrestrial and can be found in a wide variety of habitats ranging from desert springs to mountain wetlands, and into various uplands habitats around ponds, lakes, reservoirs, and slow-moving rivers and streams. This species digs its own burrow in loose soil or uses burrows of small mammals, or shelters under logs or rocks. Adults feed on flying insects, spiders, crayfish and earthworms. Larvae eat suspended plant material and detritus. Western Toads are preyed upon by garter snakes, coyotes, raccoons, and some birds such as crows and herons. Breeding season varies depending on ice and snow melt, and can occur from late January through July. The eggs and larvae develop in shallow areas of ponds, lakes, or reservoirs, or in pools of slow-moving streams. Females deposit an average of about 12,000 eggs/clutch, in two strands. Larvae metamorphose in the first months of summer. Adult females may skip one or more years between successive breeding events. Metamorphosed individuals feed on various small terrestrial invertebrates while larvae filter suspended plant material or feed on bottom detritus.

Their decline may be related at least in part to habitat destruction and degradation, water retention projects, predation by and competition with native and non-native species, and fishery management activities (<http://aknhp.uaa.alaska.edu>)

Fisher and Schaffer (1996) combined field sampling with historical analyses of museum records to quantify amphibian declines in California's Central Valley. Western toad was one of the species most affected by decline. They concluded that introduced predators are the primary threat. Introduced predators (frogs and fish) occur at lower elevations than native species, and their data indicate that for some native species there has been a significant restriction to higher elevation sites from a formerly broader elevation. Western toad has declined the most in the Sacramento Valley, followed by the San Joaquin Valley, with still viable populations in the coast range.

Die-offs in the Southern Rockies have been associated with chytrid fungus infections.

Eggs are highly susceptible to the pathogenic fungus *Saprolegnia ferax*, which may be introduced during fish stocking (Kiesecker and Blaustein 1997; Kiesecker et al. 2001). Kiesecker et al. (2001) observed catastrophic embryo mortality from *S. ferax* infection in shallow water that was protected from UV-B but not in water protected from UV-B.

## Arroyo Toad (*Bufo [=Anaxyrus] californicus*)

The Arroyo toad is now thought to be restricted to the Transverse and Peninsular Ranges in elevations from sea level to 2,440 meters. Most populations of this species occur on public lands, including Los Padres, San Bernardino, Angeles, and Cleveland National Forest. In San Diego County,

arroyo toads have been found in the Santa Margarita, Guejito, Sweetwater, Vallecito, San Luis Rey, Santa Ysabel, Witch, Cottonwood, Temescal, Agua Caliente, Santa Maria, Lusardi, Pine Valley, Noble, Kitchen, Long Potrero, Upper San Diego, San Juan, San Vicente, and Morena drainages. (U.S. Fish and Wildlife Service 1999a). This species has also been recorded from Kitchen Creek, La Posta Creek, Potrero Creek, Pine Valley Creek, Peterson Creek, Sweetwater River, and Cedar Creek on national forest service lands (California Department of Fish and Game 2007b).

Arroyo toads are extreme habitat specialists (Jennings and Hayes 1994). Habitat features used by this species include those listed below.

- Open streamside sand or gravel flats—Canopy closure is rare along streams inhabited by arroyo toads because the channel is usually wide and because episodic flooding prevents the establishment of a riparian strip of tall trees, especially those bordering breeding pools.
- Margins of old flood channels on low terraces, particularly on sand and in association with dense clumps of willows (*Salix* spp.)—Arroyo toads make extensive use of canopy margins of willow clumps on sand and gravel flats during late spring and summer.
- Canopy margins of live oaks (*Quercus agrifolia*) or scrub oaks (*Q. berberidifolia*, *Q. dumosa*) on terraces adjacent to the floodplain—Arroyo toads have been observed within 6 feet of the dripline of the oak canopies, most often where the branches were within 6–8 feet of the ground.
- Adjacent upland coastal sage scrub and chaparral habitats, used for wintering/hibernation (Sweet 1992).
- In general, arroyo toad breeding areas are restricted to riparian environments in the middle reaches of large (third order and higher) coastal streams throughout their aboveground activity season. Aquatic arroyo toad habitats are created and maintained by the hydraulic processes that result from the geographic position of the habitat within the drainage and the size of the upstream watershed (Campbell et al. 1996).

Arroyo toads usually breed in pools where the average water depth is 30 cm or less at the time of egg deposition and there is a sand or gravel substrate with a minimum of embedded silt. Depending on weather conditions, nightly emergence and surface activity may occur from late February to early July at the start of breeding season when males begin to call. The peak of male calling begins in early to mid-April and extends through late May. The late breeding season and long periods of dependence of surface water by arroyo toad larvae (tadpoles) and juveniles restricts them from areas where riverbeds dry out by early summer. Arroyo toad breeding season for the San Diego area typically is from mid-March through early July, and depending on weather conditions, as early as February. Embryos usually hatch in 4 to 6 days and the larval period for arroyo toads lasts about 65 to 85 days. After metamorphosis, from June to August, the juveniles remain on bordering sandbars until the pool no longer persists. Sexual maturity is reached in 1 to 2 years (U.S. Fish and Wildlife Service 2000b).

Adult toads eat a variety of insects and arthropods including ants, beetles, spiders, larvae, and caterpillars, while juveniles eat mostly ants (Sweet 1992).

Since the arroyo toad is an extreme breeding habitat specialist, it is highly sensitive to alterations of stream and riparian habitat. These processes, both natural (droughts, fires, and floods) and human-induced (human-made flooding; habitat depletion and alteration; construction and operation of dams, bridges, and culverts; and urban and agricultural development) have depleted and restricted critical upland (winter/hibernation) and breeding habitats. Introduced exotic predators, especially

bullfrogs (*Rana catesbeiana*) and nonnative fish, also have caused population declines by acting as predators and competitors in an already limited and degraded environment (Sweet 1992, 1993; U.S. Fish and Wildlife Service 1999b).

## Yosemite Toad (*Bufo [=Anaxyrus] canorus*)

Yosemite toads are endemic to the Sierra Nevada in California, from Ebbetts Pass in Alpine County to the Spanish Mountain area in Fresno County. Yosemite toads occur at elevations from 6,400 to 11,300 feet (1,950 to 3,450 meters), with the majority of sites between 8,500 and 10,000 feet (2,590 to 3,050 meters) (Karlstrom 1962 in Davidson and Fellers 2005).

Yosemite toads require habitats that include montane open meadows, willow groves, and forest structure. They are often found in high elevation areas within 100 meters of a permanent water source (Karlstrom 1962 in Davidson and Fellers 2005). Adult toads take refuge in rodent burrows, under surface objects such as logs and boulders, and in dense willow stands. The critical thermal maximum for adults has been documented as between 38°C to 40°C, although temperature is assumed to play a minor factor in occupancy since toads have been reported in temperatures between 2°C to 30°C with no signs of stress (Karlstrom 1962 in Davidson and Fellers 2005).

Breeding takes place from mid-May to mid-August (Kagarise-Sherman 1980 in Davidson and Fellers 2005; Fellers unpublished data in Davidson and Fellers 2005). Male toads usually arrive at breeding habitats first followed by females a few days later (Kagarise-Sherman 1980 in Davidson and Fellers 2005; Sherman and Morton 1984). Males tend to spend 1 to 2 weeks at breeding ponds, and females only stay 1 to 3 days (Kagarise-Sherman 1980 in Davidson and Fellers 2005). Breeding sites include meadow edges with shallow waters (Karlstrom 1962 in Davidson and Fellers 2005) and occasionally shallow portions of lakes (Fellers pers. obs. in Davidson and Fellers 2005). After breeding, both sexes disperse and return to forage in meadow environments for 2–3 months before they find refuge for the winter months (Kagarise-Sherman 1980 in Davidson and Fellers 2005). Ideal locations for egg deposition include shallow pools, as well as slow-moving shallow streams that are adjacent to meadows and contain emergent vegetation with loose silt substrate. Females can lay an estimated 1,500 to 2,000 eggs (Karlstrom 1962 in Davidson and Fellers 2005), which will hatch 10 to 12 days later (Kagarise-Sherman 1980 in Davidson and Fellers 2005). After hatching, tadpoles forage for algae scraped from plants, rocks, and various other submerged objects. Tadpoles begin to metamorphose 52 to 63 days after spawning (Kagarise-Sherman 1980 in Davidson and Fellers 2005).

The causes of declines in Yosemite toads are unclear but may include disease, airborne contaminants, and livestock grazing (Davidson and Fellers 2005). Other potential factors include the 1980s California drought, fish predation, and increased predation by ravens (*Corvus corax*) (Kagarise-Sherman and Morton 1993 in Davidson and Fellers 2005). In the case of fish predation, recent laboratory studies have found that Yosemite toad tadpoles were unpalatable to Brook trout and did not suffer any ill effects from being sampled and released by trout (Grasso 2005), which indicates that predation may not be a contributing factor as previously thought. However, no other life stages were studied for their potential susceptibility to trout predation nor were field studies conducted so the possibility for predation remains uncertain.

## Woodhouse's Toad (*Bufo woodhousii*)

The following information is summarized from the CaliforniaHerps.com and AmphibiaWeb 2009 websites except where noted.

In California Woodhouse's toad is found in the southeast—along the Colorado River, in the Imperial Valley, and north to the Palm Springs area. Out of the state, it occurs in isolated populations in southern Washington, extreme east Oregon and part of western Idaho, southern Nevada, eastern Montana, North Dakota, south to Texas. The species occurs throughout much of the United States and north-central Mexico from below sea level to 2600 m.

This toad inhabits a wide variety of habitats including irrigation ditches, temporary pools, backyards, grassland, sagebrush flats, woods, desert streams, farms, river floodplains. It prefers sandy areas. Woodhouse's toad is nocturnal, remaining underground in the daytime, but occasionally may be seen moving about in daylight or resting at the edge of breeding pools in the breeding season. Its diet probably consists of a wide variety of invertebrates. Typical of most frogs, the prey is located by vision, then a large sticky tongue is used to catch the prey and bring it into the mouth to eat.

Standing water is apparently preferred for breeding—either pools in river channels following spring run-off, artificial ponds and reservoirs, or rain-formed pools and cattle tanks in open desert flats (Stebbins 1951). Mating and egg-laying occurs from February to August, usually during or after rains. Fertilization is external. Eggs are laid in strings and attached to vegetation in shallow water. This species hybridizes with red-spotted toad (*B. punctatus*).

Widespread declines have not been noted for Woodhouse's toads. Woodhouse's toads remain at historical localities in southern Nevada. The expansion of Woodhouse's toads into areas formerly occupied by Arizona toads in central Arizona stands in contrast to the declines noted for other anurans in the past decade. However, some local declines are suspected and require continued monitoring: Woodhouse's toads appear absent from the Santa Cruz River floodplain in the vicinity of Tucson, Arizona and from the vicinity of Austin, Texas.

## California Treefrog (*Hyla [=Pseudacris] cadaverina*)

This species occurs from southwestern California, south into northern Baja California Norte, Mexico. It is found from near sea level to about 2,290m (Stebbins 2003).

This species is found in rocky canyons near streams and washes with permanent pools. It requires some shade as it retreats to shaded rock crevices during the day. It ranges from desert and coastal stream-courses to the pine belt in the mountains (Stebbins 2003). It breeds from March to May in the quiet water of rocky streams where eggs are attached to twigs or are loose on the bottom (Stebbins 1972).

Adults feed on insects, spiders, and centipedes. Larvae probably eat algae, organic debris, and plant tissue. Species is inactive in cold temperatures and hot, dry weather. Primarily nocturnal except during the breeding season when it may be heard calling day and night. (Stebbins 1972).

## Pacific Treefrog (*Hyla* [=*Pseudacris*] *regilla*)

The following information is summarized from the Californiaherp 2009 website except where noted.

There has been a recent proposal for a new taxonomic rearrangement for *Pseudacris regilla* as it is currently recognized. The proposal is to break the one species up into 3 species, all of which occur in California. The three species include the northern Pacific treefrog (*Pseudacris regilla*) ranging along the north coast from approximately Humboldt County north into parts of Oregon and Washington; Sierran treefrog (*P. sierra*) ranging approximately from Humboldt County south to Santa Barbara, and east into the Sierras, and the north-central and northeast part of the state, including Shasta County, and into Nevada, Eastern Oregon, Idaho and Montana; and the Baja California treefrog (*P. hypochondriaca*) ranging approximately from Santa Barbara south throughout Baja California, east to Bakersfield, Beatty, and southern Inyo County.

Pacific treefrogs are found in a wide variety of habitats including grassland, chaparral, woodland, forests, farmland, and urban areas. They occur from sea level to high into the mountains (to nearly 3,540 meters). They are usually found among low vegetation near water. Treefrogs breed from mid-May to early August in northern California and January-June in southern California. Breeding locations include slow streams, permanent and seasonal ponds, reservoirs, ditches, lakes, marshes, shallow vegetated wetlands, wet meadows, even potholes and roadside ditches. Females lay small, loose, irregular clusters of 10–70 eggs, and attach them to sticks, stems, or grass in quiet shallow water. The eggs hatch in two to three weeks. Tadpoles metamorphose from June to late August. In summer, there are often large congregations of new metamorphs along the banks of breeding pools. Larvae are preyed upon by carnivorous aquatic insects, bullfrogs, garter snakes, and many birds and mammals. Stebbins 2003

Introduced mosquitofish (*Gambusia affinis*) prey heavily on larvae and may negatively affect treefrog populations. However, this is not a pervasive threat. In lakes in the Sierra Nevada, treefrog distribution and abundance were negatively related to non-native trout presence (Matthews et al. 2001).

## Northern Leopard Frog (*Rana* [=*Lithobates*] *pipiens*)

Historically, Northern leopard frogs in California lived in scattered locations below 6,500 feet (1981 meters) elevation in Siskiyou and Modoc counties, in the northern Owens Valley, and possibly near Lake Tahoe. The northern leopard frog is now absent from much of this range, except for a few small populations in northeastern California (Stebbins and Cohen 1995; Smith and Keinath 2007).

Northern leopard frogs require suitable habitats for breeding, overwintering, and upland foraging areas after leaving the breeding ponds, and habitat corridors to connect them. Adults breed in aquatic sites but occupy meadows, peat bogs, and occasionally perennial field crops, such as grass, alfalfa, and clover, during post-breeding summer months (Dole 1965; Merrell 1970; Hinshaw 1992, Klemens 1993, Noble and Aronson 1942, and Wright 1914, all in Rorabaugh 2008). Juvenile frogs disperse to habitats as varied as upland forests, meadows, and temporary bodies of water (Dole 1971, 1972a, and 1972b; Smith 1961 in Rorabaugh 2008). Northern leopard frogs can breed in streams or rivers with slow-moving water, in wetlands linked with lakes or tidal areas, in permanent or temporary pools, in beaver ponds, and also in artificial habitats such as borrow pits and cattle ponds (Degenhardt et al. 1996, Klemens 1993, Orr et al. 1998, Roberts 1981, Wagner 1997, and Zenisek 1963, all in Rorabaugh 2008; Werner and Glennemeier 1999). Hibernation begins

in October/November and continues through February/March (DeGraaf and Rudis 1983 in Rorabaugh 2008) and typically occurs in deep, well-oxygenated waters that do not freeze solid (Cory 1952 and Wagner 1997, both in Rorabaugh 2008). But it also may occur in mud substrates, where the frogs bury themselves (Cunjak 1986, DeGraaf and Rudis 1983, and Harding 1997, all in Rorabaugh 2008).

Following emergence from hibernation, frogs begin migrating to breeding areas (Dole 1968), and breeding usually takes place during a relatively short period between April and June. Female northern leopard frogs reach sexual maturity at 2 to 3 years of age, and males did at 1 to 2 years of age (Gilbert et al. 1994). Egg masses are attached to emergent vegetation in waters 10–65 cm deep and will hatch in 2 to 17 days at temperatures of 11.4°C to 27°C (Pope et al. 2000; Nussbaum et al. 1983; Volpe 1957). Duration of larval stage varies depending on latitude and weather (Hinshaw 1992 and Merrell 1977, both in Rorabaugh 2008). In Michigan, survival and growth have been documented to occur much better in open-canopy versus closed-canopy ponds (Rorabaugh 2008). Tadpoles spend most of their time in the quiet backwater where there is little to no flow (Roberts 1981 in Rorabaugh 2008) and prey upon algae, other forms of plant material, and occasionally detritus (Hendricks 1973 in Rorabaugh 2008; Seale 1982). Metamorphosis typically occurs approximately 3–6 months following spawning (Hinshaw 1992 and Merrell 1977, both in Rorabaugh 2008) and within 2 to 3 days, juvenile frogs begin to disperse to surrounding permanent bodies of water up to 800 meters away from their breeding habitats (Cochran 1982 and Merrell 1977, both in Rorabaugh 2008; Dole 1971).

Juvenile northern leopard frogs eat arthropods, snails, slugs, earthworms, leeches, and other invertebrates (Hedeen 1970 in Rorabaugh 2008; Knowlton 1944 in Rorabaugh 2008; Linzey 1967). Larger frogs will eat various vertebrates, such as other frogs (Harding 1997 in Rorabaugh 2008; Russell and Bauer 1993 in Rorabaugh 2008), small birds and snakes (Breckenridge 1944 in Rorabaugh 2008; DeGraaf and Rudis 1983 in Rorabaugh 2008), fish (Leonard et al. 1993 in Rorabaugh 2008), and bats (Creel 1963 in Rorabaugh 2008).

Declines in northern leopard frogs have been attributed to the introduction of nonnative predators (e.g., American bullfrog and exotic trout species), diseases (chytridiomycosis), UV radiation, agriculture, and grazing. Also, intense wildfires resulting from past fire suppression have destroyed habitat (Dahms and Geils 1997 in Rorabaugh 2008).

## **Lowland Leopard Frog (*Rana [=Lithobates] yavapaiensis*)**

The following information is summarized from the Californiaherp website 2009 except where noted.

Historically the lowland leopard frog was distributed discontinuously from extreme west New Mexico, north to Clark County, Nevada & Utah, south to Sonora, Mexico, and west to Imperial County, California. It occurs from sea level to 1700 m. Jennings and Fuller (2004) determined that lowland leopard frogs are apparently native to the lower Colorado River and natural overflow lakes and tributary streams in the Imperial Valley. This frog was known to be present at isolated locations such as Carrizo Wash, Harper's Well Wash, and Kane Springs west of the Salton Sea before 1940. Observations indicate that lowland leopard frogs expanded their range in the Imperial Valley and along the Colorado River with the development of large-scale, irrigated agriculture in former desert areas during the early part of the 20th century.



In California, this frog historically ranged from San Felipe Creek, Imperial County east to the lower Colorado River Valley. Isolated populations may remain in the Imperial Valley and the San Felipe Creek drainage, but it is likely that the lowland leopard frog has been extirpated in California.

In California, the lowland leopard frog apparently inhabited slackwater aquatic habitats dominated by bulrushes, cattails, and riparian grasses near or under an overstory of Fremont's cottonwoods and willows. Lowland leopard frogs were also seen in canals, roadside ditches, and ponds in the Imperial Valley during the first quarter of this century, but the context of its occurrence in those areas is not well understood because that era was a period of extensive habitat alteration. Lowland leopard frogs may have simply been transitory in those areas.

No frogs have been recorded in California since 1965, but there have been no extensive surveys. The spread of introduced Rio Grande leopard frog (*Rana berlandieri*), predatory crayfish, fish, bullfrogs (*Rana catesbiana*), habitat alteration by agriculture, grazing, development, and building of reservoirs have all been mentioned as possible contributors to the decline of the lowland leopard frog.

## **Northern Red-Legged Frog (*Rana aurora aurora*)**

Northern red-legged frogs occur along the California coast north from Elk Creek (Mendocino County) into British Columbia. They occur in wetlands at elevations of up to 1,200 meters, west of the Cascade crest.

In summer, northern red-legged frog's habitat includes stream banks and moist riparian areas (Hayes et al. 2001 in Pearl 2008; Pearl pers. obs. in Pearl 2008) and also may include microhabitats near standing water (Twedt 1993 in Pearl 2008). Northern red-legged frogs travel long distances to reach their breeding grounds from their summer habitat sites (Hayes et al. 2001 in Pearl 2008; Nussbaum et al. 1983). Most commonly, males reach the breeding grounds before female frogs starting in October and continuing through December (Storm and Pimentel 1954 in Pearl 2008; Twedt 1993 in Pearl 2008; Storm 1960). Males generally become sexually mature at age 2 while females reach sexual maturity at age 3; however, each can reach maturity a year earlier (Hayes and Hayes 2003 in Pearl 2008; Licht 1974 in Pearl 2008). Breeding takes place between January and March (Storm 1960; Pearl pers. obs. in Pearl 2008). Adult northern red-legged frogs generally deposit their eggs in shallow wetland areas where there is plenty of vegetation and slow-moving currents (Licht 1971; Storm 1960) but also have been known to deposit eggs in waters up to 5 meters deep (Calef 1973). Egg masses are attached to herbaceous vegetation and will begin to hatch in 30 to 45 days in March and April, with metamorphosis occurring 11 to 14 weeks later in June and July (Brown 1975 in Pearl 2008; Calef 1973; Licht 1974 in Pearl 2008; Storm 1960 in Pearl 2008).

Larvae take refuge in densely vegetated areas (Nussbaum et al. 1983) and eat epiphytic algae (Dickman 1968). After metamorphosis, the young frogs typically occupy the edges of the breeding ponds for a few days to a week (Licht 1986a in Pearl 2008; Twedt 1993 in Pearl 2008) and then disperse into riparian areas (Pearl and Hayes pers. obs. in Pearl 2008) to feed upon a variety of small insects, arachnids, and mollusks (Fitch 1936; Licht 1986b in Pearl 2008). Larger adults are able to take larger food items, such as small frogs and salamanders (Licht 1986b in Pearl 2008; Rabinowe et al. 2002 in Pearl 2008).

Nonnative species (American bullfrog, in particular, and nonnative fish) are primary threats to the Northern red-legged frog (Kiesecker and Blaustein 1997, 1998; Nussbaum et al. 1983; St. John 1987 in Pearl 2008). Other factors contributing to the decline of the species include water quality degradation and altered hydrological regimes associated with agricultural and urban land uses (De

Solla et al. 2002 in Pearl 2008; Nussbaum et al. 1983; Platin 1994 in Pearl 2008; Richter and Azous 1995 in Pearl 2008).

## California Red-Legged Frog (*Rana draytonii*)

The California red-legged frog is closely related to the northern red-legged frog (*Rana aurora*). California red-legged frogs are currently common in the San Francisco Bay Area and along the central coast and occur at isolated locations in the Sierra Nevada, on the northern coast, in the Santa Monica Mountains, and in San Fransquito Canyon in Newhall (Hogan pers. comm. in Jones & Stokes 2006).

California red-legged frogs occur from sea level to about 5,000 feet (1,524 meters) above sea level (U.S. Fish and Wildlife Service 2002). Both adults and tadpoles occur in streams, deep pools, backwaters within streams, creeks, ponds, marshes, sag ponds, dune ponds, and lagoons. Optimal habitat includes deep (>2 feet [0.6 meters]) still or slow-moving water with dense, shrubby riparian or emergent vegetation (Hayes and Jennings 1988). During summer and after breeding, adult California red-legged frogs will disperse to seek out summer habitat shelter, which may include boulders, rocks, logs, industrial debris, agricultural drains, watering troughs, abandoned sheds, hayricks, small mammal burrows, incised streambed channels, or areas with moist leaf litter (61 FR 25813; Jennings and Hayes 1994; U.S. Fish and Wildlife Service 2002).

California red-legged frogs breed from November through April (Storer 1925; U.S. Fish and Wildlife Service 2002). Males and females will first breed at the ages of 2 years and 3 years, respectively. Females lay egg masses of about 2,000 to 5,000 eggs, which hatch in 6 to 14 days, depending on water temperatures (U.S. Fish and Wildlife Service 2002). Larvae metamorphose in 3.5 to 7 months, typically between July and September (Storer 1925; U.S. Fish and Wildlife Service 2002; Wright and Wright 1949). California red-legged frogs will disperse 0.25 mile to 2.0 mile (0.4–3.2 km) away from their aquatic breeding habitats to find refuge in cool, moist soils and vegetated areas of the riparian zone (Bulger 1998; U.S. Fish and Wildlife Service 2005).

California red-legged frogs consume a wide variety of prey. Adult frogs typically feed on aquatic and terrestrial insects, crustaceans, and snails (Hayes and Tennant 1985; Stebbins 1985), as well as worms, fish, tadpoles, smaller frogs (e.g., *Hyla regilla*), and occasionally mice (*Peromyscus* spp.) (U.S. Fish and Wildlife Service 2002). The tadpoles are mostly herbivorous and feed primarily on algae (Jennings et al. 1992). Juveniles forage during both day and night, whereas subadults and adults are nocturnal feeders (Hayes and Tennant 1985).

Factors contributing to the decline of California red-legged frogs include degradation, fragmentation, and loss of habitat through agriculture, mining, recreation, timber harvesting, nonnative plant invasions, impoundments, water diversions, degraded water quality, introduced nonnative predators, and poorly managed infrastructure maintenance activities such as road construction and repair. Populations isolated due to habitat fragmentation are now more vulnerable to extinction through random environmental events, such as drought or floods, as well as human-caused impacts, such as grazing or contaminant spills (Soulé 1998).

## Foothill Yellow-Legged Frog (*Rana boylei*)

Historically, foothill yellow-legged frogs occurred from west of the crest of the Cascade mountains in Oregon south to the Transverse Ranges in Los Angeles County, and in the Sierra Nevada foothills south to Kern County (Stebbins 2003; Zweifel 1955). Currently, the foothill yellow-legged frog is still common along the north coast of California, and there have been reports of healthy, reproducing populations throughout suitable habitat in Alameda, western Stanislaus, Santa Clara, San Benito, and western Fresno Counties (Fellers 1994). The known elevation range of the species extends from near sea level to about 6,700 feet (2,040 meters) (Stebbins 2003).

Unlike other frogs that occupy lakes, ponds, and marshes, the foothill yellow-legged frog resides exclusively in rivers and streams (Nussbaum et al. 1983; Seltenrich 2002). Foothill yellow-legged frogs require shallow, flowing water in small to moderate-sized streams with at least some cobble-sized substrate (Hayes and Jennings 1988; Jennings 1988). This habitat is believed to favor oviposition (Fitch 1936; Storer 1925; Zweifel 1955) and to provide refuge (Hayes and Jennings 1988; Jennings 1988). This species has been found in streams without cobble (Fitch 1936; Zweifel 1955), but it is not clear whether these habitats are regularly used (Hayes and Jennings 1988; Jennings and Hayes 1994). Foothill yellow-legged frogs are usually absent from habitats where introduced aquatic predators, such as various fishes and bullfrogs, are present (Hayes and Jennings 1986, 1988; Kupferberg 1996).

Foothill yellow-legged frogs in California generally breed between March and early June (Grinnell et al. 1930; Jennings and Hayes 1994; Storer 1925; Wright and Wright 1949), depositing their egg masses on the downstream side of cobbles and boulders over which a relatively thin, gentle flow of water exists (Fitch 1936; Storer 1925; Zweifel 1955). The timing of oviposition typically follows the period of high-flow discharge from winter rainfall and snowmelt (Jennings and Hayes 1994; Kupferberg 1996). The embryos have a critical thermal maximum temperature of 26°C (Zweifel 1955). After oviposition, a minimum of approximately 15 weeks is required to reach metamorphosis, which typically occurs between July and September (Jennings 1988; Storer 1925). Larvae attain adult size in 2 years (Storer 1925). In a study on the Eel River, foothill yellow-legged frogs chose sites to lay eggs and timed egg laying to avoid fluctuations in river stage and current velocity associated with changes in river discharge (Kupferberg 1996). This suggests that suitable reproductive sites for foothill yellow-legged frogs require stable flow and current velocities.

Foothill yellow-legged frogs are highly aquatic, spending most or all of their life in or near streams, though frogs have been documented underground and beneath surface objects more than 50 meters from water (Nussbaum et al. 1983). Adult foothill yellow-legged frogs have high site fidelity and typically occupy small home ranges. Normal home ranges are probably less than 10 meters in the longest dimension, with occasional long-distance movements of 50 meters during periods with high water conditions (Morey 2005). During the breeding season, from March through June, adults and subadults may move several hundred meters or more to congregate at breeding sites (Seltenrich 2002).

Factors contributing to the decline of foothill yellow-legged frogs include habitat loss and degradation (specifically riverine and riparian impacts from nonselective logging practices), introduction of exotic predators (centrarchid fishes and bullfrogs), and toxic chemicals (including airborne pesticides). In addition, poorly timed water releases from upstream reservoirs can scour egg masses from their substrates and also may affect frogs in streambed hibernation sites. (Jennings and Hayes 1994.)

## **Southern and Northern DPS Mountain Yellow-Legged Frog (*Rana muscosa*, including *Rana sierrae*)**

For several years, the USFWS has recognized two DPSs of mountain yellow-legged frog: the southern DPS, also known as the Sierra Madre yellow-legged frog, and the northern DPS, segregated by some authorities as the distinct species *Rana sierrae*. Populations in the southern DPS have declined from about 166 documented localities in southern California (Jennings and Hayes 1994; 67 FR 44382) to only seven known locations in portions of the San Gabriel, San Bernardino, and San Jacinto Mountains (Backlin et al. 2002 in 67 FR 44382). Conversely, the northern DPS ranges from southern Plumas County to southern Tulare County and extends into Nevada in the vicinity of Lake Tahoe and northward to the slopes of Mount Rose (U.S. Fish and Wildlife Service 2003b). The native habitat for the northern DPS is almost entirely outside the range of introduced fish (Knapp 1996).

Frogs in the southern DPS occupy mostly stream habitats that run through narrow canyon environments (Grinnell and Camp 1917 in Vredenburg et al. 2008) and chaparral belts (Zweifel 1955). Frogs in the northern DPS occupy meadows, streams, and lakes (Wright and Wright 1933), usually within 1 m of the water's edge. Both adults and tadpoles are found most frequently in shallow water areas (Bradford 1984). Frogs in the northern DPS have been known to overwinter in various places, including the bottoms of lakes, rocky stream environments (Vredenburg et al. 2005), and rock crevices (Matthews and Pope 1999), but the latter behavior may be a response to the presence of fish.

Spawning occurs from April at lower elevations to June–July at higher elevations (Stebbins 1951 in Vredenburg et al. 2008; Wright and Wright 1933; Zweifel 1955). Zweifel (1955) has reported that first reproduction is most likely at around 3 years of age. In the northern DPS, egg masses are deposited in areas where they are completely submerged either under banks or attached to submerged objects, such as boulders, logs, or vegetation (Stebbins 1951 in Vredenburg et al. 2008; Wright and Wright 1949; Zweifel 1955). Since the tadpoles overwinter, breeding sites are permanent lakes and ponds where bottom waters do not freeze; such waters are over 1.7 meters deep and usually more than 2.5 meters deep (Bradford 1983 in Vredenburg et al. 2005). Southern DPS populations are primarily stream dwelling, so they may not need deep, permanent waters, but their breeding requirements are currently unknown.

Incubation requires 18–21 days at temperatures of 5°C to 13.5°C (Zweifel 1955). When tadpoles emerge, they take cover in mud, under rocks, under banks, or in submerged vegetation (Stebbins 1951 in Vredenburg et al. 2008). The duration of the larval stage ranges from one (Storer 1925) to several seasons, depending upon elevation and water temperature. However, throughout most of their range in the Sierra Nevada, three size classes are typically observed, and it appears that metamorphosis generally occurs when tadpoles are 2.5 years old (Wright and Wright 1933; Zweifel 1955).

The diet of southern DPS frogs consists of invertebrates such as beetles, ants, bees, wasps, flies, true-bugs, and dragonflies (Long 1970 in Vredenburg et al. 2008). Northern DPS frogs probably have a similar diet and also have been documented to occasionally eat Yosemite toad tadpoles (Mullally 1953) and Pacific treefrog tadpoles (Pope 1999 in Vredenburg et al. 2008). Tadpoles, unlike adults, are thought to be mostly herbivorous and detritivorous.

Several factors have been implicated in northern DPS population declines, including predation and competition with introduced trout (Drost and Fellers 1996; Jennings and Hayes 1994; Knapp 1996;

Knapp and Matthews 2000), diseases including chytrid fungus, *Batrachochytrium dendrobatidis* (Berger et al. 1998; Rachowicz et al. 2006), air pollution from pesticide drift (Davidson and Knapp 2007), livestock grazing (U.S. Fish and Wildlife Service 2003b), UV-B radiation, and long term changes in weather patterns, especially concerning the severity and duration of droughts.

## Cascades Frog (*Rana cascadae*)

The Cascades frog occurs throughout the Cascade Range from the northern Sierra Nevada Mountains in California into northern Washington. In California, Cascades frog populations were historically distributed from the Shasta-Trinity area to the Modoc plateau as two separate populations: one centered around the Lassen area and the other around the Klamath area. Currently, populations appear to be moderately to extremely abundant in fishless areas from the upper McCloud River system to the Trinity Alps but are extremely rare in the southernmost part of its range.

The Cascades frog occupies open wetlands and moist meadows near permanent or temporary pools at high elevations (Bosakowski 1999; Brown 1997, Bury and Major 1997, O'Hara 1981, Olson 1992, Olson 2001, and Sype 1975, all in Pearl and Adams 2008). At lower elevations, adult frogs will occupy streams instead of less common lentic environments (Dunlap 1955; Pearl pers. obs. in Pearl and Adams 2008). They also have been known to use artificially created wetlands as habitat and breeding sites (Quinn et al. 2001 in Pearl and Adams 2008). When conditions are moist and humid, Cascades frogs may briefly leave their aquatic habitat to forage in upland areas (Nussbaum et al. 1983). Juvenile habitat is similar to that of adults, but juveniles are more abundant in shallow, densely vegetated areas (Pearl pers. obs. in Pearl and Adams 2008). Breeding habitats include small bodies of temporary or perennial lentic waters (Bury and Major 1997 in Pearl and Adams 2008; Briggs 1987; Nussbaum et al. 1983). Optimum breeding sites have silt/mud substrates, a lack of predatory fish, and low UV-B transmission (Adams et al. 2001).

Breeding occurs from March to mid-August in large communal settings and generally takes place within less than a week. Egg masses typically are deposited in aggregations in shallow waters along low gradient shorelines (Briggs 1987; Sype 1975 in Pearl and Adams 2008). Hatch time and metamorphosis are highly dependent on water temperature (Sype 1975 in Pearl and Adams 2008). After hatching, larvae form loose aggregations (O'Hara and Blaustein 1985) near their oviposition sites, massing together in warm shallow waters with vegetative cover (O'Hara 1981 in Pearl and Adams 2008; Wollmuth et al. 1987 in Pearl and Adams 2008). Larvae are primarily benthic feeders, but specific forage preferences are not well-known (Nussbaum et al. 1983). Metamorphosis is generally achieved about 2 months after hatching (Briggs 1987; Nussbaum et al. 1983) depending on larval density, food availability, and water temperature (Blaustein et al. 1984). Their diet is poorly known, but adult Cascades frogs are thought to consume a variety of invertebrate prey and will occasionally consume conspecifics (Rombough et al. 2003 in Pearl and Adams 2008).

The causes of Cascades frog population decline are not fully known, but introduced trout, UV-B radiation, disease, and loss of open meadow habitat due to fire suppression have been suggested (Adams et al. 2001; Blaustein et al. 1994; Fellers and Drost 1993; Fite et al. 1998; Hayes and Jennings 1986; Kiesecker and Blaustein 1995). Fertilizers also may pose a threat, as juveniles do not appear capable of sensing and avoiding toxic levels in laboratory studies (Hatch et al. 2001 in Pearl and Adams 2008).

## Oregon Spotted Frog (*Rana pretiosa*)

Precise historic data is lacking, but this species has been documented in British Columbia, Washington, Oregon, and California. It is considered extirpated (locally extinct) from California (U.S. Fish and Wildlife Service 2008b) but likely occurred historically within the Pit River system (northeastern California) (Hayes and Pearl 2008).

## Reptiles

### Western Pond Turtle (*Clemmys marmorata*)

The Western pond turtle includes two recognized subspecies: the northwestern pond turtle (*Clemmys marmorata marmorata*) and the southwestern pond turtle (*Clemmys marmorata pallida*). Historically, the western pond turtle had a relatively continuous distribution in most Pacific slope drainages from Klickitat County in Washington (Slater 1962) to Arroyo Santo Domingo, Baja California Norte, Mexico. In California, western pond turtles were historically found in most Pacific slope drainages between the Oregon and the Mexican borders (Jones & Stokes 2004). The area of the Central Valley of California between the American River drainage and the Transverse Ranges is considered a zone of intergradation between the two subspecies (Seeliger 1945; U.S. Fish and Wildlife Service 1999c). The western pond turtle still occurs in 90% of its historic range in the Central Valley and west of the Sierra Nevada, but in greatly reduced numbers (Jennings and Hayes 1994).

Western pond turtles occur in a variety of aquatic habitats, from sea level to elevations of 6,500 feet. They inhabit rivers, streams, lakes, ponds, wetlands, reservoirs, and brackish estuarine waters (Holland 1994; Jennings and Hayes 1994). Western pond turtles' habitats feature extensive cover (such as logs, algae, and vegetation) and basking sites (such as boulders or other substrates). They use their aquatic habitat primarily for foraging, thermoregulation, and avoidance of predators. Both adult and juvenile turtles favor aquatic habitats with access to areas of deep, slow water with underwater refugia. Hatchlings, on the other hand, tend to seek out areas where the water is shallow, warm, and free of predators and has aquatic vegetation (Holland 1994; Jones & Stokes 2004; Reese 1996). Western pond turtles will overwinter in both aquatic and terrestrial refugia. Aquatic refugia consist of rocks, logs, mud, submerged vegetation, and undercut areas along banks. Terrestrial refugia consist of burrows in leaf litter or soil (Davis 1998; Holland 1994; Jones & Stokes 2004).

Western pond turtles first breed at 10 to 14 years of age (U.S. Fish and Wildlife Service 1999c; Stebbins 2003). Breeding occurs around May through July, and females usually breed and lay eggs every other year. Clutch sizes range from one to 13 eggs, depending on the size of the female (Holland 1985, 1991). Gravid females will deposit their eggs in sunny, upland habitats, including grazed pastures and agricultural fields (Crump 2001). Nesting sites average 28 meters away from aquatic habitats (Rathbun et al. 2002), but there have been reports of females nesting up to 402 meters away (Jennings and Hayes 1994). The eggs incubate 80 to 100 days, with the normal hatch success being approximately 70%. Nest predation rates are high, and complete failure of nests is not uncommon.

Western pond turtles are omnivores and scavengers. They eat mainly insects (e.g., the larvae of caddisflies, dragonflies, and nymphs) but also small fish, frogs, and some plants (Pacific Biodiversity Institute 2001).

Numerous factors threaten the population integrity of the Western pond turtle throughout its widespread range. The major threats to this species include loss, degradation, and fragmentation of habitat; disease; introduced predators and competitors; and combinations of other natural and anthropogenic conditions (Holland 1991; U.S. Fish and Wildlife Service 1999c). Because of the longevity of the Western pond turtle, the magnitude of these threats are still unforeseen, and while populations may still exist, it is most likely that they are non-reproducing and that there is little recruitment (Holland 1991; Jennings and Hayes 1994; U.S. Fish and Wildlife Service 1999c).

## **Common Garter Snake (*Thamnophis sirtalis*)**

The common garter snake has the largest distribution of any garter snake. This species ranges from east coast to the west coast of the U.S. and north into Canada, farther north than any species of snake in North America. In California, this species ranges from Del Norte and Humboldt counties south through the Central Valley and along the coast from Monterey Bay to Santa Barbara County. (Stebbins 2003).

Common garter snakes inhabit a wide variety of habitats including forests, mixed woodlands, grasslands, chaparral, and agricultural lands. The species often occurs near aquatic habitat including ponds, marshes, and streams where it freely enters and retreats to when alarmed. Prey include fish, adult and larval salamanders, frogs, and toads, and smaller birds and their eggs and invertebrates. Common garter snakes are one of the few predators that can prey on Pacific newts (*Taricha* sp.) without suffering lethal poisoning. (Stebbins 2003)

Garter snakes in general have been negatively impacted by competition with introduced bullfrogs and non-native fish. Higher elevation populations may especially become vulnerable. (NatureServe 2009; CaliforniaHerps.com 2009).

## **Mountain Garter Snake (*Thamnophis elegans elegans*)**

Except where otherwise cited, the following information comes from the NatureServe and CaliforniaHerps.com databases (2009).

Mountain garter snake occurs throughout the Sierra Nevada Mountains, the Cascades, and the Klamath Ranges.

Mountain garter snake is a medium-sized snake that is found in streamside habitats, springs, mountain lakes, grasslands, meadows, brush, woodlands, and coniferous forests. They are active in daylight and are chiefly terrestrial, though are found near water. They seek refuge in vegetation or ground cover. They will hibernate during the cold winter weather. Mountain garter snakes eat a range prey, including amphibians, fish, mice, lizards, and various invertebrates.

Mountain garter snakes mate in spring and young are born live between July and September. They bear anywhere from 4 to 19 young.

Mountain garter snake populations are considered secure but garter snakes in general have been negatively impacted by competition with introduced bullfrogs and non-native fish. Higher elevation populations may especially become vulnerable.

## Sierra (Western Aquatic) Garter Snake (*Thamnophis couchii*)

Except where otherwise cited, the following information comes from the NatureServe and CaliforniaHerps.com databases (2009).

Sierra garter snake occurs in the western Sierra Nevada Mountains from the Pit and Sacramento Rivers south to the western end of the Tehachapi Mountains, and also in the Owens Valley. They occur up to 7,500 feet above mean sea level (California Department of Fish and Game 2005).

Sierra garter snakes are associated with permanent or semi-permanent bodies of water, from slow-moving low-elevation seasonal creeks to high-elevation mountain streams, ponds, and lakes in a variety of habitats including montane riparian, montane hardwood-conifer, montane chaparral, and Sierran mixed conifer (California Department of Fish and Game 2005). Low-elevation snakes may be active 10 months per year and at higher elevations they may be active for less than 4 months. They seek cover at night in mammal burrows, crevices, and surface objects. During the day they are often found basking in streamside vegetation. They will retreat to water when disturbed. They feed on amphibians and fish.

Courtship and mating normally occur in spring, later at higher elevations. Young are born alive between July and September, usually in secluded sites such as under the loose bark of rotting logs or in dense vegetation near pond or stream margins (California Department of Fish and Game 2005).

Sierra garter snakes are considered secure in California. No major threats are known but they may be vulnerable to non-native fishes (NatureServe 2009).

## Two-Striped Garter Snake (*Thamnophis hammondi*)

The range of the two-striped garter snake extends through the South Coast and Peninsular Ranges west of the San Joaquin Valley from the vicinity of Salinas (Monterey County) south into northern Baja California, Mexico. Its known elevation range extends from sea level to 2,440 m above sea level. (Jennings and Hayes 1994).

The two-striped garter snake is highly aquatic and is often found in or near perennial or flowing intermittent streams with rocky beds and dense streamside vegetation. Associated with chaparral, oak woodland, and pine woodland habitat types, the species can also occur around stock ponds, lakes, reservoirs, meadows, and other aquatic habitats as long as sufficient cover is available. The diet consists of tadpoles, small frogs and toads, fish, worms, and eggs. Two-striped garter snakes have a mild toxin in their saliva that can be deadly to their prey. However, the venom of two-striped garter snakes is not considered dangerous to humans. Breeding occurs in late March and April. Females bear between 1 and 25 live young in late July and August. (CaliforniaHerps.com 2009).

Two-striped garter snakes have disappeared from approximately 40% of its former range. Much of the decline can be attributed to habitat loss from urbanization, cement lining of stream channels in southern California for flood control, and construction of large reservoirs. Introduction of predatory bullfrogs, fishes, and feral pigs have also contributed to the decline of this species. (Jennings and Hayes 1994.)



## Giant Garter Snake (*Thamnophis gigas*)

Historically, giant garter snakes were found in the Sacramento and San Joaquin Valleys from Butte County south to Buena Vista Lake in Kern County. Today, populations are found only in the Sacramento Valley and isolated portions of the San Joaquin Valley as far south as Fresno County. Giant garter snakes are still presumed to occur in 11 counties: Butte, Colusa, Fresno, Glenn, Merced, Sacramento, San Joaquin, Solano, Stanislaus, Sutter, and Yolo. USFWS recognizes only 13 separate populations of the species, with each population representing a cluster of discrete locality records. (U.S. Fish and Wildlife Service 1999c).

Giant garter snake inhabits wetlands, irrigation and drainage canals, rice fields, marshes, sloughs, ponds, low-gradient streams, and adjacent uplands in the Central Valley. The species requires adequate water during its active season (early spring through fall); emergent, herbaceous wetland vegetation for foraging habitat and escape cover; open areas for basking; and upland habitat, high above the high-water line, with rodent burrows for hibernating during winter. Riparian woodlands do not provide suitable habitat because potential basking areas are often shaded. Giant garter snakes do not inhabit large rivers or wetlands with sand, gravel, or rock substrates. The species tends to stay within 200 feet of wetland habitat. It hibernates from early October to late March in burrows located in adjacent uplands, especially grasslands, high above the high-water line. The breeding season begins soon after the species emerges from hibernating burrows, from March to May, and resumes briefly during September. (U.S. Fish and Wildlife Service 1999c).

The USFWS determined in a 2006 status review that the abundance and distribution of giant garter snakes had not changed significantly since the time of listing (U.S. Fish and Wildlife Service 2006). This report indicates that the most serious threat to the species' is loss and fragmentation of habitat from urban and agricultural development and loss of habitat associated with changes in rice production.

## San Francisco Garter Snake (*Thamnophis sirtalis tetrataenia*)

Except where otherwise cited, the following information comes from the NatureServe database.

San Francisco garter snakes occur in scattered wetland areas on the San Francisco Peninsula from approximately the San Francisco County line south along the eastern and western bases of the Santa Cruz Mountains, at least to the Upper Crystal Springs Reservoir and along the coast south to Año Nuevo Point, San Mateo County, and Waddell Creek, Santa Cruz County (U.S. Fish and Wildlife Service 2009).

San Francisco garter snakes are found near freshwater marshes, ponds, and slow-moving streams. Upland areas near pond/marsh habitat are important in fall and winter. Adults sometimes estivate in rodent burrows during summer months when aquatic habitat dries and will hibernate in rodent burrows during the winter. Marshes provide important feeding and breeding habitat. They are often found basking on floating algae or rush mats or on grassy hillsides near drainages and ponds. They seek cover in bankside vegetation such as cattails, bulrushes, and spikerushes, and in rodent burrows. They typically feed on small amphibians, especially California red-legged frog, and fish.

Mating occurs over a brief period of time between March and April. Females give live birth from June through September, with litter averaging 16 newborn (U.S. Fish and Wildlife Service 2009).

San Francisco garter snake is a state and federally endangered species and is fully protected under CFGC 5050. Urbanization has destroyed most of the prime habitat for this species, leaving highly fragmented populations. Collecting for commercial trade has been a problem, though this threat has been reduced by better enforcement.

## **South Coast Garter Snake (*Thamnophis sirtalis* ssp.)**

The south coast garter snake is a California endemic that is only known from a few localities along the southern California coast from the Santa Clara River valley (Ventura County) south to San Pasqual (San Diego County). Its known elevation range extends from sea level to 832 m above sea level. (Jennings and Hayes 1994).

The south coast garter snake is restricted to upland habitats near permanent water that have healthy strips of riparian vegetation, which provide both prey and refuge sites, as well as meadow-like habitats adjacent to marshlands (Jennings and Hayes 1994).

Little is known about the life history of the south coast garter snake, though the little that is known is interpreted in the context of similarities to other *T. sirtalis* subspecies. The south coast garter snake gives birth to 12–20 live young during the late summer and early fall months. This species is active during the spring through fall. It is unknown if this subspecies overwinters in aggregations. Individuals may be active during the winter months on exceptionally warm days. Prey includes fish, amphibian larvae and adults, and insects. Predators include king snakes, hawks, herons, raccoons, coyotes, and introduced fishes. (Jennings and Hayes 1994).

Of the 24 historic localities identified in Jennings and Hayes 1994, 18 (75%) no longer supported snakes. Causes to this decline can be attributed to extensive urbanization and flood control projects. Introduced aquatic predatory species threaten the six remaining localities where the snake still exists. (Jennings and Hayes 1994).

## **Birds**

### **Bald Eagle (*Haliaeetus leucocephalus*)**

Bald Eagle breeds mainly in Lake, Lassen, Modoc, Butte, Plumas, Shasta, Siskiyou, and Trinity Counties. Nearly half of the state's wintering population is in the Klamath Basin. It is not found in the high Sierra Nevada, and is more common at lower elevations. It is fairly common as local winter migrant at a few favored inland locations in southern California, with the largest numbers occurring at Big Bear Lake, Lake Mathews, Cachuma Lake, Nacimiento Reservoir, San Antonio Reservoir, and along the Colorado River (Garrett and Dunn 1981; Buehler 2000.)

Bald Eagles typically breed in forested areas (usually over 2 kilometers) from large bodies of open water or free-flowing rivers with abundant fish and adjacent snags or other perches. They prefer to perch high in large, stoutly limbed trees; on snags or broken-topped trees; or on rocks near water. Bald Eagles roost communally in winter in dense, sheltered, remote conifer stands. Nests are massive structures of sticks located in large old-growth or dominant live trees with open branches, especially ponderosa pine (Baicich 1997; California Department of Fish and Game 2000). The nests are most frequently situated in stands with less than 40% canopy. Nests are usually placed below the top of the crown with some foliage shading them (Call 1978:9–10).

The statewide Bald Eagle nesting population has increased steadily since the mid-1970s, when the population totaled less than 30 breeding pairs. By the end of the 1990s there were 188 known breeding pairs nesting in 28 counties. The wintering population has also increased dramatically during this timeframe (DFG 2000). However, the species remains an uncommon resident and winter visitor throughout the state.

Early declines of Bald Eagle populations resulted from persecution, shooting, egg collection, and habitat loss and disturbance. After 1945, population declines were exacerbated by the widespread use of DDT and other pesticides that led to eggshell thinning and reproductive failure. By 1960, the southern California breeding population was extirpated, and by 1970, the species no longer bred in central California (Detrich 1985). Certain areas within the Bald Eagle's range continue to have problems with contamination, including the Great Lakes, Maine, the Columbia River, and southern California.

Power line construction and human disturbances can threaten eagle populations in some areas. Because of their large wingspan, Bald Eagles are particularly susceptible to electrocution on power lines. Bald Eagles are also sensitive to human disturbance during the breeding season; human disturbance can cause abandonment or relocation of nest sites (Buehler 2000). The most disturbing human activity appears to be boating, although hiking and car traffic are also significant disturbances (Buehler 2000).

Loss of perching habitat and communal roosting sites can also be a factor in some populations (U.S. Forest Service 2000).

## **Osprey (*Pandion haliaetus*)**

Except where otherwise cited, the following information comes from the NatureServe database and the California Wildlife Habitat Relationship System (California Department of Fish and Game 2005).

Ospreys occur throughout North America as permanent residents, non-breeding residents, and migrants depending on latitude and proximity to coastal areas. In California osprey are known to breed in northern California from the Cascades Range south to Lake Tahoe, and along the coast south to Marin County.

Osprey is a large diurnal raptor that is associated strictly with large, fish-bearing waters, primarily in ponderosa pine and mixed conifer habitats. They use large trees, snags, and dead-topped trees in open forest habitats for cover and nesting. They require open, clear waters for foraging. The swoop from flight, hover, or perch to catch fish near the water surface on rivers, lakes, reservoirs, bays, estuaries, and surf zones. The prey mostly on fish, but are known to take a few mammals, birds, reptiles, amphibians, and invertebrates.

Osprey will arrive on nesting grounds in mid-March to early April. They typically breed from March to September. Osprey will nest on platforms of sticks at the top of large snags, dead-topped trees, on cliffs, or on human made structures. They need tall open-branched trees nearby nests for landing before approaching the nest. These "pilot trees" are also used by young for flight practice. Nest are usually within 400 meters of fish-producing water, but may nest up to 1.6 km from water. Clutch size usually consists of 3 eggs, but do range anywhere from 1 to 4 eggs. Incubation lasts 4 to 6 weeks and young first fly at 44 to 59 days. Osprey will usually breed for the first time at 3 years of age. Osprey will begin their winter migration south to Central and South America in October.

Osprey populations globally are considered secure but in California the species is ranked vulnerable. Past declines have been attributed to pesticides, though populations appear to be increasing in California since the early 1970s.

## **Willow Flycatcher (*Empidonax traillii*)**

Except where otherwise cited, the following information comes from the NatureServe database and the California Wildlife Habitat Relationship System (California Department of Fish and Game 2005).

Willow flycatchers occur throughout North America as breeding residents and migrants. In California, they occur in the Sierra Nevada and Cascade Ranges. Willow flycatchers have also been observed breeding along the Santa Ynez River in Santa Barbara County and along the Santa Clara River in Ventura County.

Willow flycatchers are summer residents in wet meadow and montane riparian habitat from 600 to 2,500 meters above mean sea level in the Sierra Nevada and Cascades, and in riparian habitats in portions of coastal California. During migration they use a variety of riparian habitats. In these habitats, willow flycatchers nest and roost in dense willow thickets. They need low, exposed branches for singing posts and hunting perches. They primarily eat flying insects but occasionally eat berries and seeds.

Willow flycatchers typically arrive from Central and South America to breeding grounds in May and June. Willow flycatchers are monogamous and typically build their open, cup nests in upright forks of willows or other shrubs. Nest sites are typically near slow moving streams, standing water, or seeps. Peak egg laying occurs in June and clutch sizes average 3 to 4 eggs. Eggs incubate for 12 to 13 days. Both sexes care for young, which fledge 13 to 14 days after hatching. Willow flycatchers will begin departing in August with transients observed through mid-September.

Willow flycatcher populations are globally secure but considered critically impaired in California and so have been listed as a state endangered species under the California Endangered Species Act. Declines have been attributed to nest parasitism by brown headed cowbirds (*Molothrus ater*) and loss of riparian habitat from livestock grazing, invasive vegetation, agriculture, development, and water diversions.

## **Southwestern Willow Flycatcher (*Empidonax traillii extimus*)**

The Southwestern Willow Flycatcher (*Empidonax traillii extimus*) is one of five recognized subspecies of Willow Flycatcher (*Empidonax traillii*). The Willow Flycatcher is the most widely distributed North American *Empidonax* flycatcher (Sedgwick 2000). All subspecies occupy different breeding ranges, and are differentiated by subtle differences in morphology and color. The other recognized subspecies are *E. t. traillii*, *E. t. brewsteri*, *E. t. adastus*, and *E. t. campestris*. In southern California, Willow Flycatcher is a common to fairly common to transient, and rare breeder (Garrett and Dunn 1981). The Willow Flycatcher is difficult to identify by sight and is a typical representative of a difficult group of small flycatchers in this genus. It is a small, greenish, relatively flat-headed flycatcher. Willow Flycatchers are fairly vocal in migration and are best identified by their distinctive calls (Sibley 2003).

Southwestern Willow Flycatcher's historical breeding range included southern California, Arizona, New Mexico, western Texas, southwestern Colorado, southern Utah, southern Nevada, and northern portions of Sonora and Baja California (Unitt 1987). This subspecies is currently known to nest at

only about 75 riparian sites in the southwestern United States. The current breeding range includes southern California, extreme southern Nevada, Arizona, New Mexico, and western Texas (Hubbard 1987; Unitt 1987; Browning 1993; McKernan and Braden 1998; Sedgwick 2000). This subspecies may also breed in southwestern Colorado, but recent documented nesting records are lacking (U.S. Fish and Wildlife Service 1995b). Few nesting records of this subspecies have been recorded from northwestern Baja California (Unitt 1987).

Willow Flycatcher is a riparian obligate during the breeding season. This species primarily occurs in densely vegetated riparian habitats, preferring streamside associations of cottonwood, willow, alder, and other riparian vegetation (Unitt 1987). The Willow Flycatcher also occurs in woodland edges, meadows, and brushy fields; however, nesting birds are typically restricted to willow thickets in riparian areas (Sogge et al. 1997a, 1997b).

There is considerable variation in patch size, patch shape and configuration, and plant species composition among Southwestern Willow Flycatcher breeding sites (Sogge and Marshall 2000). However, three factors are consistently characteristic of Southwestern Willow Flycatcher breeding habitat: patches of dense riparian vegetation with complex understory structure, presence of standing or slow-moving water, and gaps or open foraging areas (Sogge and Marshall 2000; Jones & Stokes 2001). Sogge et al. (1997b) defined suitable habitat as riparian areas greater than 10 meters wide with dense vegetation, occasional openings, and open water. Tibbits et al. (1994) described suitable habitat as including dense riparian vegetation and surface water or soils that are saturated during the mid-summer breeding season. Tibbits et al. (1994) noted that Southwestern Willow Flycatchers typically do not breed in riparian habitat along high-gradient streams. Also, cottonwood-willow gallery forests that lack understory structure are not suitable breeding habitat for Southwestern Willow Flycatchers (Sogge and Marshall 2000).

Insufficient data exist to estimate the minimum patch size or the total amount of habitat within an area required to support nesting Southwestern Willow Flycatchers (Jones & Stokes 2001). However, linear riparian habitat less than 10 meters wide usually does not function as breeding habitat. The available information indicates that habitat patches as small as 0.5 hectare can support one or two nesting pairs (U.S. Fish and Wildlife Service 1995b). Sogge et al. (1993) found territorial flycatchers in tamarisk-dominated habitat patches ranging from 0.5 to 1.2 hectares. Two habitat patches of 0.5 and 0.9 hectare each supported two territories (Muiznicks et al. 1994).

## Other Species

### Brown Trout (*Salmo trutta*)

Brown trout are native to Europe, North Africa, and Asia, but were introduced in California beginning in 1893 (Moyle 2002). Brown trout have been planted at many locations throughout the state and are abundant along more than 5,000 kilometers of streams and in numerous lakes in particular within Sierra Nevada watersheds (Moyle 2002; Staley 1966 in Moyle 2002).

Brown trout prefer “medium to large, slightly alkaline, clear streams with both swift riffles and large, deep pools” (Moyle 2002). Preferred temperatures are between 12°C and 20°C, but brown trout can survive temperatures up to 29°C for short periods (Moyle 2002). Different life stages select different habitats; fry occupy shallow stream margins, juveniles occupy deeper water (50–75 cm)

with higher velocities, and adults occupy deep water (0.7–3.5 meters) of varying velocity (Moyle 2002).

Small brown trout feed on drift organisms, larger trout (25–40 cm long) eat more benthic invertebrates and begin eating other fish and crayfish, and trout over 40 cm long mostly consume other fish and occasionally amphibians (Moyle 2002).

Brown trout usually become sexually mature in their second or third year and spawn in November and December when temperatures drop below 6°C and 10°C (Moyle 2002). Spawning habitat is usually within riffles at pool tailouts having gravel with a diameter of 0.7 to 4.0 cm. The optimal water depth for redds is 24.4 to 45.7 cm, and the optimal water velocity is 40 to 70 cm/sec (Waters 1976 in Raleigh et al. 1986). Hatching usually occurs in 7 to 8 weeks, and fry emergence occurs 3 to 6 weeks later (Moyle 2002).

Brown trout display highly competitive and predatory interactions with other fish species, particularly native trout, and brown trout “generally win, all things being equal” (Sorenson et al. 1995 in Moyle 2002).

## **Brook Trout (*Salvelinus fontinalis*)**

Brook trout are native to the northern half of the United States and to eastern Canada and were introduced into California in 1871 (Moyle 2002). They now occur in mountain streams and lakes from the San Bernardino Mountains north to the Oregon border, with the highest abundance in Sierra Nevada watersheds (Moyle 2002). They are present in more than 1,000 lakes and along 2,200 kilometers of streams in California (McAfee 1966 in Moyle 2002).

Brook trout primarily occupy cold, clear lakes and streams. Their thermal optimum is 14°C to 19°C, but they can tolerate temperatures up to 26°C, with reduced growth occurring at above 19°C (Moyle 2002). Brook trout primarily eat drifting organisms (terrestrial and aquatic insects and zooplankton) but also eat some benthic organisms (e.g., sculpins) and occasionally fish (Moyle 2002).

Males achieve sexual maturity at 1 to 3 years of age, and females achieve it at 2 to 4 years; total lifespan is 4 to 5 years (Moyle 2002). Spawning usually occurs between mid-September and early January at temperatures between 4°C and 11°C (Moyle 2002). Spawning sites are generally in water deeper than 40 cm, with pea- to walnut-sized gravel and nearby cover. The eggs hatch within 100 to 144 days (at water temperatures of 2°C to 5°C) and emerge as fry after another 3 to 4 weeks (Moyle 2002). Fry occupy shallow stream margins or shorelines and backwater pools.

Brook trout released into native trout waters typically displace native trout through competitive interactions (Moyle 2002). Those released into formerly fishless lakes have been found to result in changes to lake ecosystems (Schindler et al. 2001 in Moyle 2002) and amphibian populations (Knapp et al. 2001).

## **Rainbow Trout of Hatchery Origin (*Oncorhynchus mykiss*)**

Rainbow trout are native to watersheds throughout North America, including numerous watersheds within California. Due to their adaptability to a wide range of habitats and flexible life history strategies, they have also been extensively raised in hatcheries and have been released into a variety of watersheds throughout California, including locations occupied by wild rainbow trout and in

formerly fishless streams and lakes. The prevalent mixing of hatchery and natural populations has made it difficult to distinguish native populations.

*Oncorhynchus mykiss* generally exhibit two basic life history patterns: resident inland trout and anadromous steelhead (steelhead are discussed above under individual steelhead DPSs). Resident forms often spend their entire lives occupying a relatively small area within their stream or lake, not ranging for more than a few hundred meters, but some do carry out migrations within fresh water for spawning or in response to seasonally shifting environmental conditions and food supplies (Moyle 2002). Rainbow trout prefer cold (15°C to 18°C), well-oxygenated water bodies, and mortality typically results if temperatures exceed 24°C to 27°C (Moyle 2002).

Most rainbow trout become sexually mature in their second to third year, but this may occur as late as their fifth year (Moyle 2002). Spawn timing depends on location and ranges from December to August, with most populations spawning between February and June (Moyle 2002). Spawning sites generally consist of gravel substrate within riffles or pool tails. Embryos hatch in 3 to 4 weeks, and fry emergence occurs within another 2 to 3 weeks. Generally, rainbow trout can live to age 6 or 7 in cooler, productive streams and to age 3 to 4 in warmer, low-gradient streams; however, some have lived to as old as 11 years (Moyle 2002). Small fish prefer shallow areas, and as they become larger, they shift to moderately deeper areas and eventually to deeper pools. Rainbow trout eat zooplankton, invertebrates, insects, drifting organisms, and, as they grow larger, sometimes other fish and amphibians.

Butler and Borgeson (1965) found that 50% of hatchery rainbow trout reared and released for “put-and-take” fisheries in streams and lakes were caught within 2 weeks of planting. For those released in streams, the remaining uncaught fish likely die of starvation or stress within a few weeks. Although few stream-released hatchery fish survive, hybridization with native trout has nonetheless occurred and likely has contributed to the loss of many populations of rainbow, redband, golden, and cutthroat trout. Catchable-sized hatchery rainbow trout released into lake environments are more likely to survive due to lower energy costs associated with the absence of stream currents, and they are less vulnerable to angling and predation (Moyle 2002).

## **Kokanee (*Oncorhynchus nerka*)**

Kokanee are a landlocked form of sockeye salmon. Sockeye salmon are native to rivers and lakes from the Columbia River north to the Yukon River in Alaska (Moyle 2002). Kokanee were first introduced into California in 1941 and now are found in many coldwater reservoirs and some lakes in the Sierra Nevada region and other locations throughout the state.

Kokanee are most common in well-oxygenated, cold (10°C to 15°C) open waters of large lakes and reservoirs. Their diet consists mainly of zooplankton and occasionally includes small fish and insects. Age at sexual maturity varies based on a number of factors, with life cycles ranging from 2 to 7 years, but most mature in 4 years. Spawning typically occurs between early August and early February but may extend through early April. Kokanee spawn in either gravel riffles within lake tributaries or in gravel beds close to the lakeshore. Fry emerge in April through June, and those in streams migrate to lake habitat immediately (Moyle 2002).

It is likely that the introduction of Kokanee has led to changes in ecosystem processes in natural lakes. Their impact on native fishes is unknown but potentially negative (Moyle 2002).

## Other Wildlife

Phytoplankton are tiny photosynthetic, free-floating plants that are found near the surface in all water bodies. They represent many different species, and phytoplankton communities differ between types of aquatic habitats, such as lakes, rivers, and estuarine environments, and may consist of different types of microscopic and submicroscopic organisms, such as diatoms, algae, cyanobacteria, and photosynthetic flagellates. These, along with periphyton (algae attached to rocks or other substrates) are the primary producers in aquatic ecosystems and form the base of the food web in most lakes and in larger streams (in smaller streams the food web is often anchored in adjacent terrestrial habitats). Phytoplankton provide a source of food for zooplankton, which in turn, are a source of food for fish and amphibians.

Zooplankton include a wide variety of microscopic, free-floating animals including protozoans, rotifers, and crustaceans (chiefly copepods and cladocerans). Copepods and cladocerans are often important in high mountain lake ecosystems. Zooplankton are the first consumer level in the food web that generally feed on phytoplankton, but some may also prey upon smaller species of zooplankton. Zooplankton provide a source of food for fish, amphibians, and turtles.

Macroinvertebrates are animals that have no backbone and are visible without magnification, such as aquatic insects, crayfish, amphipods, mussels, aquatic snails, and aquatic worms. These organisms primarily eat phytoplankton, periphyton, and zooplankton and also may consume detritus (decaying plants and animals). They provide a food source for fish and amphibians, which in turn, are a source of food for larger mammals (e.g., birds, bats, and raccoons) and water snakes.

Aquatic environments provide habitat and food resources to a wide variety of birds, including groups such as ducks, wading birds (e.g., herons and egrets), raptors (e.g., osprey and eagles), pelicans, and cormorants. Some aquatic birds divide their time between aquatic and terrestrial environments, while others spend most of their lives in water, returning to land only to breed. See Table E-1, above, for a list of special-status bird species potentially in areas of DFG program influence.

Aquatic environments also provide habitat and food resources to a wide variety of mammals, including bats, raccoons, otters, beavers, and many others. Many mammals spend most of their time in terrestrial environments and access aquatic environments occasionally for food and water, while others (e.g., otters and beavers) spend much of their lives in or near water and heavily rely on aquatic environments for food sources. Also, many species of insect-eating bats do not directly access aquatic environments for food sources but use the space above streams, ponds, and lakes to feeding on the flying adult stages of insects that have an aquatic larval stage. See Table E-1 for a list of special-status mammal species potentially in areas of DFG program influence.



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