Status of
Declining Aquatic Reptiles, Amphibians, and Fishes
in the Lower Santa Rosa Creek,
Cambria, California

Prepared For:

Greenspace: A Land Trust

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ABSTRACT

*The lower portion of Santa Rosa Creek, including its coastal lagoon, is representative of a unique and disappearing habitat in central and southern California. Also unique is a suite of aquatic vertebrates that are dependent on the creeks and lagoons. These vertebrates include the tidewater goby (*Eucyclogobius newberryi*), steelhead rainbow trout (*Oncorhynchus mykiss*), California red-legged frog (*Rana aurora draytonii*), western pond turtle (*Clemmys marmorata*), and two-striped garter snake (*Thamnophis hammondii*). In general, all five taxa require perennial fresh or brackish water in pools along arroyos or in lagoons. They also need suitable riparian and bank vegetation for shelter from predators, and as breeding, foraging, and basking sites. Lower Santa Rosa Creek, including its lagoon, supported moderate to large populations of all five taxa up until the mid-1980's. The excessive use of ground water for local urban and agricultural development has resulted in a decrease in instream flow and the loss of perennial standing water in the creek. Freshwater input to the lagoon during the summer has also been lost. In addition, sedimentation within the creek bed has reduced the number of deep pools, which are required by the aquatic animals to survive the long, dry California summers. The overall result of the reduced surface water and increased sedimentation is the near disappearance of all five aquatic vertebrates in the lower Santa Rosa Creek. To recover these unique taxa, perennial water must be restored to the lower reaches of the creek and lagoon, and sedimentation of the arroyo channel reduced.*

Coastal creeks (arroyos) and their lagoons are relatively unique habitats in central and southern California (Macdonald, 1988). Most arroyos are small, island habitats separated by extensive woodlands, chaparral, and grasslands (Carpelan, 1969). The Mediterranean weather regime of the area results in most coastal drainages being seasonal with small, well-defined freshwater wetlands being restricted to lagoon systems behind sandbars. There are about 1,780 hectares of freshwater marsh in the coastal counties of California (Alexander, et al., 1986, cited in Josselyn et al., 1990), and we estimate 5-7% of this occurs in San Luis Obispo County. The land area of the county is about 861,800 hectares, and about 0.01 - 0.001% of this area is coastal freshwater marsh.

Even though these habitat islands are small and isolated, they support a disproportionately rich diversity of plants and animals, many of which are unique to central and southern California (Peabody and Savage, 1958; Zedler,

1991). Unfortunately, small and isolated habitats are vulnerable to adverse alteration. Because the areas are limited, they can only support relatively small populations of many species. These small populations are especially susceptible to disturbance, which increases the likelihood of extirpation. The massive urbanization of southern California has resulted in the loss of coastal arroyos and lagoons, and the decline of associated flora and fauna (Zentner, 1984).

The creeks and streams of central and southern California support several aquatic vertebrates, but of particular interest is a subset that has declined over most of its distribution, especially in southern California. Five sensitive taxa (Table 1) still have viable populations in many of the coastal arroyos and lagoons of San Luis Obispo County. A notable exception is the recent decline of this community of vertebrates, and other species, in the lower reaches of Santa Rosa Creek.

The California Department of Fish and Game has periodically assessed the instream flow and fish populations of Santa Rosa Creek during the last 30 years. In addition, the herpetofauna of the creek has been informally surveyed for nearly ten years by Dan Holland in conjunction with his graduate studies (Holland, 1985; Holland, unpublished data). In August 1991, the California Department of Parks and Recreation and the U.S. Fish and Wildlife Service entered into a cooperative agreement to study the status and life history of sensitive reptiles and amphibians in the lower reaches of San Simeon Creek (San Simeon State Park) and one other local arroyo, for comparison. In preparation for this research, some trial surveys were completed in the lower Santa Rosa Creek.

In this report, we briefly summarize the important aspects of each species' life history, present a summary of past information on the status of the five declining vertebrates in the lower reaches of Santa Rosa Creek, and present the results of recent surveys. We conclude with some suggestions for restoring the declining taxa in the lower section of the arroyo.

LIFE HISTORY SUMMARIES

Tidewater goby (*Eucyclogobius newberryi*): This lagoon-dwelling member of the family Gobiidae historically was found from the Smith River in Del Norte County south to Agua Hedionda Lagoon in San Diego County (Swift, et al., 1989). It has been recorded from 93 localities, but is now limited to approximately 47 sites. Of the 47 populations, only 43 are thought to be large enough to be self-sustaining (Swift, 1990).

Tidewater gobies are typically found in brackish water lagoons at the mouths of coastal creeks, although they have been recorded as far as eight kilometers upstream (Irwin and Stoltz, 1984; Holland, 1991b). They usually occur in

salinities from 0 to 10 parts per thousand, but can withstand much higher salinities (Swift, et al., 1989; Robert Lea, personal communication). Tidewater gobies are typically found in water less than one meter deep and are often seen moving across the bottom in short bursts, or hovering in mid-water adjacent to aquatic vegetation or next to steep banks (Swift, et al., 1989).

Eucyclogobius feeds on a variety of small invertebrates, including snails, ostracods, chironomid larvae and pupae, amphipods, dipteran larvae, and mayfly nymphs (Swift, et al., 1989).

In San Luis Obispo County, breeding appears to peak in April and May (Worcester, unpublished data). Spring spawning peaks have also been observed elsewhere, but females in reproductive condition have been noted year-round and ovarian studies have shown that individuals may spawn more than once a year (Goldberg, 1977). Adult survival following spawning appears to be low. In Aliso Lagoon, Orange County, large reductions in numbers of mature fish occur from mid-summer through winter; numbers in early spring are about one-tenth those of midsummer (Swift, et al., 1989). Similar reductions have been observed in Pico Creek, San Luis Obispo County (Worcester, unpublished data).

Tidewater gobies breed in burrows, constructed and attended by male fish. The burrows are built in coarse sand, cemented with mucus, and in some cases are restricted to a small portion of the lagoon where suitable substrate exists. Eggs are attached to the sides of the burrow by the female and then fertilized by the male. There is some evidence that males mate with more than one female. Females produce between 179 and 594 mature eggs, which hatch in approximately nine days, depending on temperature (Swift, et al., 1989). Larval fish are pelagic in lagoon vegetation until metamorphosis at 16 to 18 millimeters standard length, at which time they begin orienting towards the bottom (Swift, et al., 1989).

Though predation on tidewater gobies is poorly documented, there is evidence that both steelhead trout and sculpin species may prey upon them (Swift, et al., 1989). Predation by double-crested cormorants (*Phalacrocorax auritus*) and garter snakes (*Thamnophis* spp.) has been observed at Pico and Little Pico creeks (Worcester, Holland, unpublished data). Other fish-eating predators, such as the belted kingfisher (*Ceryle alcyon*), egrets, herons, and the raccoon (*Procyon lotor*), undoubtedly prey upon gobies. In aquaria, backswimmers (Notonectidae) have been observed to prey on gobies (Worcester, unpublished data). At Old Creek, San Luis Obispo County, an entire population may have been lost as a result of predation by introduced bass (*Micropterus* spp.) and bullfrogs (*Rana catesbeiana*). Circumstantial evidence suggests that tidewater gobies cannot coexist with introduced centrarchids (Swift, et al., 1989). Extirpation of populations statewide can also be

attributed to water diversion, drought, bridge construction, channelization, and other forms of habitat alteration.

Steelhead rainbow trout (*Oncorhynchus mykiss*): Steelhead trout are the anadromous form of the rainbow trout, found in coastal streams and rivers from the Kuskokwim River in Alaska to northwestern Mexico (Moyle, 1976). Though they historically ranged throughout southern California, few viable populations remain south of San Luis Obispo County. Steelhead typically enter coastal streams in central California during winter, when high flows break the sandbars at the mouths of lagoons and permit passage from the ocean. Steelhead are dependent upon clean, cool, flowing, well-oxygenated water, and are generally associated with gravel riffle areas. However, studies by Smith (1987) indicate that lagoons provide extremely important nursery habitat for juvenile fish. These areas can support both higher densities of fish and faster growth rates than upstream waters because of the greater availability of food.

Young steelhead trout feed primarily on drift invertebrates, although they may also take benthic organisms. Their diverse diet may include adult terrestrial and aquatic insects, aquatic insect larvae, snails, amphipods, and small fish. With increasing size, fish become a more prevalent part of their diet (Moyle, 1976).

Steelhead generally return to their natal stream to spawn after spending about one to two years in the ocean (Shapovalov and Taft, 1954). They may travel a considerable distance upstream before spawning, usually sometime between November and May. Spawning takes place in a clean gravel riffle area, or "redd" site, where several nests are dug by the female. After the eggs are deposited and fertilized, they are covered with gravel. Depending on temperature, eggs hatch in about three to four weeks, but larvae do not emerge from the gravel for another two to three weeks, after absorbing their yolk sacs. Fry live in quiet stream waters near the shore (Shapovalov and Taft, 1954). Juvenile fish may spend one to three years in fresh water before migrating out to the ocean, or they may spend their entire lives in fresh water (Shapovalov and Taft, 1954). Studies on Santa Rosa Creek showed that downstream migration of juvenile fish to the lagoon occurs primarily before March (Puckett, 1970). The flexible life cycle of steelhead has probably contributed to their success in small coastal arroyos.

Eggs and juvenile fish may be preyed upon by sculpin (particularly *Cottus asper*), garter snakes, crayfish, and giant water bugs (Belastomatidae) (Shapovalov and Taft, 1954), as well as some introduced fish species. Larger fish are also preyed upon by raccoons, wading birds, and other fish-eating species. In some circumstances, take by anglers can be substantial, although steelhead season in San Luis Obispo County is currently limited by season (November 16 to February 28), area (generally west of Highway 1), and number (two fish per angler, on weekends, Wednesdays, holidays, and opening and closing days of the season).

Habitat alterations have severely reduced steelhead populations in parts of the state, particularly southern California. Water diversion and siltation of spawning gravel can greatly reduce or eliminate carrying capacity. Other impacts include water control projects, removal of bank vegetation, competition or predation by introduced species, and pollution.

Western pond turtle (*Clemmys marmorata*): This turtle is distributed along the western coast of North America, west of the Cascade-Sierra divide, from Washington south to northern Baja California (Bury, 1970; Stebbins, 1985). The subspecies found in central and southern California (*C. m. pallida*) is distinct from that found north of the San Francisco Bay Area (*C. m. marmorata*; Stebbins, 1985; Brattstrom and Messer, 1988). Adults on the central California coast attain an average carapace length of about 12.5 centimeters (Holland, 1985). Individuals with carapace lengths greater than about 11.0 centimeters are sexually dimorphic (Holland, 1985, unpubl. key). Pond turtles are known to live for at least 20 years (Holland, 1985), although it is likely that they attain ages of over 40 years (Holland, unpublished data).

The turtle's aquatic habitat requirements include standing or slow-moving water that forms pools at least one meter deep and two meters in diameter with some type of bank cover, such as vegetation, tree roots, or rip rap boulders (Storer, 1930; Bury, 1972; Holland, 1985). Typically, exposed basking sites, where the turtles haul out onto emergent vegetation, rocks, logs, or mud banks, are also present (Storer, 1930; Bury, 1972; Holland, 1985). While basking, intraspecific aggression is common (Bury and Wolfheim, 1973; Holland, 1985). In suitable habitat, western pond turtle densities can reach an estimated 3700 individuals/hectare (Holland, 1991c), however densities of 500-1,000 animals/hectare are more common on the central California coast (Holland, 1985, 1991c).

Although western pond turtles can move long distances within riparian corridors (up to several kilometers; Bury, 1972; Rathbun, et al., in review), they are normally rather sedentary and do not move further than several hundred meters (Bury, 1972). Bury (1972) found that the home ranges of adult males were about twice the size of adult females, and juveniles were more sedentary than adults.

In central and southern California, western pond turtles are thought to remain active throughout the year, but in more northern latitudes they may hibernate (Storer, 1930). However, there is some evidence that a significant proportion of individuals in some populations spend at least up to several weeks on land within vegetated riparian corridors, perhaps hibernating (Holland, 1991c; Rathbun, unpublished data).

Western pond turtles feed on a wide variety of small invertebrates, carrion, and plant material, but not

necessarily in proportion to occurrence (Holland, 1985; Bury, 1986).

The reproductive habits of western pond turtles are not particularly well known. Courtship and breeding, which occurs in April and May, have not been completely described (Holland, 1988). Eggs, which are hard-shelled and number up to 13 per clutch, are laid from May through August (Holland, 1985,1991c). Females leave riparian corridors and travel up to 400 meters into upland habitats to nest (Storer, 1930). One or more pear-shaped nests are excavated in the hard, dry soil at dusk or night by a female (Holland, 1991a; Rathbun, et al., in review). Incubation takes about 73-80 days in captivity (Feldman, 1982) and 95 to 106 days in the wild (Holland, 1991a). Holland (1985) suggests that hatchlings overwinter in their nest, and Rathbun et al. (in review) and Holland (1991a, 1991c) discuss the possible evolutionary significance of this behavior. On the central California coast, the minimum carapace length of hatchlings is about 2.5-3 centimeters. In one year they reach about 5.0 centimeters, in two years about 7.0-8.2 centimeters, and in three-four years about 9.0 centimeters. They reach sexual maturity at about 12.0 centimeters in 7-9 years (Holland, 1988, 1991c).

Hatchlings and juveniles are particularly vulnerable to predation by coyotes (*Canis latrans*), raccoons, large herons, exotic fish such as largemouth bass (*Micropterus salmoides*), and introduced bullfrogs (Moyle, 1973; Holland, 1985, 1991c). Mortality from car strikes, as well as commercial collecting for the pet and food trade, should not be underestimated (Holland, 1991c). Population declines are principally due to habitat alteration (Brattstrom, 1988; Brattstrom and Messer, 1988; Holland, 1991c).

California red-legged frog (*Rana aurora draytonii*): This subspecies, which may actually be a full species (Hayes and Miyamoto, 1984), is currently found in California from Marin and Shasta counties south to northern Baja California (Jennings and Hayes, 1990). However, it has been extirpated from the majority of its historical range, especially in southern California, the Central Valley, and the Sierra Nevada. The reasons for the decline are not well understood, but probably are related to habitat degradation and predation by, or competition from, introduced exotic predators, including fish and bullfrogs (Storm, 1952; Licht, 1969a; Hayes and Jennings, 1986). The central California coast is the last stronghold of this species.

The habitat preferences and critical life history traits of the red-legged frog are fairly well documented (Altig and Dumas, 1972). Hayes and Jennings (1989) have characterized modal California red-legged frog habitat as being composed of ponds and streams that have at least some standing water year-round greater than about 0.7 meter deep. These waters normally support dense vegetative cover of willows, reeds, cat-tails, or rushes along banks. Adults will avoid salinities greater than about 6.5 parts per thousand (sea

water is about 33 parts per thousand), while the lethal threshold for eggs is about 4.5 parts per thousand (Jennings and Hayes, 1990). Reduced freshwater input to coastal lagoons results in higher salinities and decreased frog recruitment due to mortality of egg masses. Although red-legged frogs are most often found in small, intermittent creeks, this may be a relatively recent phenomenon due to habitat alteration by human activities, and predation or competitive exclusion by introduced fauna (i.e., bullfrogs and bass) in the larger, more permanent, bodies of water (Hayes and Jennings, 1986, 1989).

California red-legged frogs feed on a wide variety of invertebrates and small vertebrates (Hayes and Tennant, 1985).

Breeding occurs in January and February (Stebbins, 1954), but unlike other ranids, female receptivity only lasts a couple of weeks (Licht, 1969b). Male red-legged frogs are not territorial during the breeding season, but move from area to area. Some males may mate more than once during a season, but there is also a subpopulation that may not mate at all (Calef, 1973a). California red-legged frogs have small lateral vocal sacs and males call in the air while floating on the water during the breeding season (Licht, 1969a; Hayes and Krempels, 1986). Females call during their elaborate amplexsis release behavior (Licht, 1969a).

Egg masses, composed of 2-5 thousand eggs, are deposited in shallow water among stems of emergent vegetation in pools or slow-moving portions of creeks (Licht, 1969b; Jennings, 1988). The eggs and larvae require relatively cool water (less than 15.6^{o} C) for development (Licht, 1971; Jennings, 1988). The eggs take about 1-2 weeks to hatch and the tadpoles grow for an additional 3-5 months before metamorphosis occurs (Storm, 1960; Jennings, 1988). Because this frog breeds in relatively cool water and its larval stage is so extended, it is dependent on instream flow or standing water well into the dry summer season. After metamorphosis, sexual maturity is reached in 1-3 years. Adult snout-vent lengths may reach 13.0 - 13.5 centimeters. Juvenile and adult red-legged frogs are known to disperse long distances during winter rains, perhaps up to 1-2 km (Rathbun and Holland, unpublished data). Maximum longevity (in captivity) is 15 years (Cowan, 1941).

Licht (1969a) fed northern red-legged frog eggs (*R. a. aurora*) to captive stickleback fish (*Gasterosteus aculeatus*) and trout (*Salmo clarkii*), which suggests that egg predation in the wild may be significant. Tadpoles are known to be an important food item for several snakes, especially the more aquatic garter snakes, such as *Thamnophis hammondii* (Fitch, 1941). Tadpole predation by snakes, adult frogs, and birds is thought to be density dependent (Calef, 1973b). Adult frogs are probably eaten by a wide range of mammalian and avian predators.

The decline of California red-legged frogs can be related to numerous human activities, including various types of

water diversion and stream modification, mining, farming and ranching activities, introduction of exotic fauna, and commercial exploitation for food (Jennings and Hayes, 1985; Jennings, 1988).

Two-striped garter snake (*Thamnophis hammondii*): The systematics of the garter snakes on the western coast of North America is complex and changing (see brief review in Rossman, 1979; Larson, 1984). However, the two-striped garter snake is relatively distinct and has been considered a subspecies of *Thamnophis couchii* or, as is presently the case, a full species (Rossman and Stewart, 1987).

Thamnophis hammondii occurs along the central and southern California coastal drainages from Monterey County south to northern Baja California (Fitch, 1941; Stebbins, 1985). A disjunct population occurs on Santa Catalina Island off San Diego, California (Brown, 1980). Five color morphs have been described, which have well-defined habitat associations. The dark, all-gray form is associated with the cool, coastal fog belt of Santa Barbara, San Luis Obispo, and Monterey counties (Larson, 1984).

The two-striped garter snake is highly aquatic, usually only being found near permanent water (Fitch, 1941). It is active during both day and night (Stebbins, 1985; Holland, unpublished data). It appears to prefer deep, relatively slow-moving waters in small streams where a plentiful prey base of tadpoles, frogs, or fish occur (Fitch, 1941; Fox, 1952; Bell and Haglund, 1978; Drummond, 1983; Holland and Rathbun, unpublished data). Highest densities seem to be associated with arroyos or coastal lagoons with relatively open areas of bare soil, short grass, or large, flat boulders with southern exposures that are adjacent to deep pools with plentiful prey. The exposed areas are used for basking (Holland and Rathbun, unpublished data).

Females give birth to live young in mid to late summer, and by September or October adults and young-of-the-year are no longer seen (Rathbun, unpublished data). Adults reach an average snout-vent length of about 65.0 - 70.0 centimeters. Glenn Stewart (personal communication) indicates that in the fall the snakes move to upland areas adjacent to creeks and hibernate in rodent burrows or under large logs and boulders.

Habitat modification, especially loss of permanent water, seems to be the primary cause of this species' decline.

HISTORICAL PERSPECTIVE

There are no published historical data on the distribution or abundance of the five declining taxa in Santa Rosa Creek. In general, however, it is known that in the recent past the lower portions of the creek supported at least moderate populations of these vertebrates.

Tidewater gobies were abundant in the lagoon in 1977 (Swift, Los Angeles County Museum, Catalog No. 36667, 15 June 1977). Surveys by Swift found them present, but not

numerous, in 1981 (Catalog No. CCS81-21, 31 January 1981). A study conducted in October 1988 documented only three small pools below the Windsor Street Bridge, two of which contained tidewater gobies (Dudley, 1988). Gobies were again documented in the creek in 1989 by Swift, although in small numbers (Catalog No. CCS89-22, 26 June 1989).

Based on California Department of Fish and Game unpublished reports and field logs, steelhead trout were abundant in the Santa Rosa Creek drainage as recently as the early 1980's. The lagoon served as an important nursery for juvenile fish. In 1970, the population of steelhead in the lagoon alone was estimated at 6,800 juveniles, based on returns of marked fish by anglers, who caught 2,290 fish (Puckett, 1970). A study of Santa Rosa Creek during the summer of 1973 documented steelhead densities ranging between 871 fish in mile 2 to 12,197 fish in mile 12, as measured from the mouth of the creek (Bailey, 1973). Overall, densities averaged 5,282 fish per mile, which exceeded estimates for any of eight other creeks evaluated in Santa Cruz, Monterey, and San Luis Obispo counties. This same study estimated the population in the first mile of Santa Rosa Creek, including the lagoon, at 2,851 fish.

Although no extensive surveys for steelhead have been conducted in Santa Rosa Creek since Puckett's (1970) and Bailey's (1973) studies, local fishermen indicate that fishing effort for steelhead was still intense at the mouth of the creek as recently as 1986 (David Raff, personal communication). Based on observations and reports by fishermen, the numbers of adult fish that entered the creek from 1987 through 1991 have declined significantly. A qualitative survey in 1988 noted rainbow trout as "fairly numerous" in the upper watershed, but observed none in lower Santa Rosa Creek (Dudley, 1988). Only a few juvenile steelhead were observed in one pool during a survey from the mouth to the Main Street Bridge in March, 1990 (Russell, 1990). Downstream migration should have been well underway at this time, according to historical data from Puckett (1970). Since 1988, the Department of Fish and Game has received only a few reports of spawning adults. The lagoon has not supported juvenile steelhead during the last several summers (Holland, unpublished data).

Yearly herpetological surveys of Santa Rosa Creek from the Main Street (Old State Highway One) bridge downstream to the lagoon, from the mid-1970's to the present (D. Holland, unpublished data), reveal an interesting pattern: California red-legged frogs were consistently seen, albeit in decreasing numbers, until 1989. In the late 1970's, 12 to 14 western pond turtles were consistently observed hauled out on logs in the lower end of the lagoon, and during the same period numerous two-striped garter snakes were seen in the same area. Western pond turtle numbers have decreased steadily from 1986, until a single turtle was observed just west of the State Highway One bridge in 1990. The two-

striped garter snake was apparently eliminated in the lower reaches of the system prior to 1985.

CURRENT STATUS

No tidewater gobies were found in Santa Rosa Creek during surveys by Dan Holland in 1990 or by Karen Worcester in 1991, and they may have been extirpated entirely, from the combined impacts of drought and water diversion. Neither gobies nor steelhead were seen during a mid-July survey we conducted in 1991 of the lower two miles of the creek, although thousands of three-spined stickleback (Gasterosteus aculeatus) were present. By early November, even stickleback numbers were greatly reduced because of loss of pool habitat and increased predation.

Although steelhead trout still inhabit the upper watershed of Santa Rosa Creek, the lagoon is no longer serving as important nursery habitat. No juvenile steelhead have been seen in the lagoon for several years (Worcester, Holland, unpublished data). It is also apparent that overall numbers of steelhead in the drainage have been drastically reduced from historic numbers.

Between 10 July and 22 August 1991, Jennifer Martin and Galen Rathbun completed two types of surveys along the streambed of Santa Rosa Creek, from the new State Highway One bridge down to the lagoon at the mouth. Six of these surveys were done at night with spot-lights, specifically searching for red-legged frogs. The other seven surveys were done during the day for frogs, western pond turtles, and two-striped garter snakes. When the surveys were initiated in mid-July 1991, the water flow in Santa Rosa Creek at the Windsor Street bridge was less than 0.25 cubic foot per second. When the last survey was completed on 22 August 1991, only narrow, shallow, widely spaced pools of water remained in the stream bed. The shallow water in these pools was highly turbid from the nearly constant foraging activities of raccoons. By November 1991, only a couple of puddles and damp spots remained in the creek bed. The lagoon was highly turbid, with a uniform salinity of 5 parts per thousand.

No garter snakes of any kind were sighted on any of the surveys. Pond turtles were sighted on only two surveys. One individual was seen on 1 August resting on the bank of the deep pool associated with the bank erosion about 200 meters downstream from the State Highway One bridge. On 9 August 1991, two turtles were sighted at this same pool. Two red-legged frogs were seen, both on the 10 July 1991 survey. A dead individual was found on the creek bottom in the middle of a wide, shallow (10 centimeters) glide about 175 meters downstream from the Windsor Street bridge; it was badly decomposed. On the same survey, a live frog was observed in a 60-cm-deep pool about 700 meters downstream from the State Highway One bridge.

During a daylight survey on 17 July 1991, a bullfrog was sighted about 100 meters downstream from the State Highway One bridge. During a survey at night on 26 July 1991, a bullfrog (presumably the same individual sighted on 17 July) was captured about 50 meters downstream from the State Highway One bridge; this individual is now a specimen in the herpetology collection of the Los Angeles County Museum.

Although no data were collected on the occurrence of tree frogs (*Pseudacris regilla*), it was our subjective assessment that there were relatively few tadpoles and adults in the stream, especially when compared with Pico Creek, near San Simeon Acres.

An extended survey of Santa Rosa Creek, from the mouth to the Main Street bridge (old Highway One) was done on 10 July 1991. We saw no snakes, turtles, or red-legged frogs. However, during a walk up the Santa Rosa Creek from the State Highway One bridge to the deep pool behind the high school on 17 July 1991, Rick Hawley (personal communication) found a decomposing red-legged frog in a shallow glide just below the deep pool behind the high school.

Although there was instream flow in the arroyo in June and July 1991, there was only one deep, shaded pool suitable for red-legged frogs, and one pool where turtles might be expected. One frog and two turtles were seen in each of these respective pools. By August 1991, there was NO suitable habitat (i.e, water and cover) to support any of the aquatic taxa in the creek.

The lagoon at the mouth of Santa Rosa Creek is devoid of cover adequate for frogs. In addition, instream flow ceased by August, and by November freshwater input had declined to the point where the lagoon was entirely brackish, with no freshwater component. Without fresh water and cover, the lower creek cannot support frogs and turtles, and few, if any, fishes--including gobies. Without a prey base, the creek is also unsuitable for two-striped garter snakes.

The principal cause of the declines is the loss of instream flow and perennial standing water in the lower portions of the arroyo, including its lagoon. There is little doubt that increased agricultural and urban use of the water is the main cause of the problem. It might be argued that the declines are more closely related to several years of below-average precipitation in the region. If the drought were the principal factor, however, similar declines in the goby, frog and snake in other drainages, such as Little Pico, Pico, and San Simeon creeks, would be expected. This is not the case (Rathbun and Holland, unpublished data).

RECOVERY NEEDS

If an objective is to restore breeding populations of the native fishes and herpetofauna to Santa Rosa Creek, sufficient water must be restored to the lower reaches of the arroyo and the lagoon on a year-round basis. Restoring

the lagoon sufficiently will be impossible without major alterations of water use patterns in the drainage by the Cambria Community Services District and farmers. Although surface flow during the summer need not be maintained for restoration of all the taxa but steelhead, sufficient subsurface flow must occur to keep water in pools along the stream bed, and maintain the lagoon at the mouth largely fresh, or at least with a deep salt water lens. All taxa will also require undisturbed pools with sufficient depth and vegetative cover to protect the animals from predation. Currently, there is too much sedimentation in the creek bed to allow adequate pools to form.

If a healthy population of small fishes, including sticklebacks, gobies, steelhead, and freshwater sculpins, can be reestablished and maintained in the lagoon, or in pools along the stream bed, it is possible that two-striped garter snakes will become reestablished.

In addition, the turtles will continue to require upland areas with southern exposures as nesting habitat. As the urban and agricultural areas of Cambria continue to expand, upland habitat may become scarce to the turtles in the lower Santa Rosa Creek drainage.

It will be important to prevent the establishment of exotic fishes and the bullfrog in Santa Rosa Creek. Currently, bullfrogs are only found regularly as far north along the coast as Villa Creek south of Cambria (Holland, unpublished data). Bullfrogs and bass have been implicated in the demise of the Old Creek goby population. Bluegill (Lepomis macrochirus), another introduced centrarchid that has been seen on Santa Rosa Creek (D. Holland, unpublished data), may also be a serious predator on tidewater gobies and red-legged frog eggs. Since both bluegill and bullfrogs are favored by warmer water temperatures, efforts to provide cooler water temperatures by way of adequate cover and flows should benefit native species.

Although the Department of Fish and Game will not permit stocking of warm water gamefish adjacent to steelhead waters, illegal stocking is common, and efforts to educate farmers and ranchers of its negative effects could be beneficial.

If tidewater gobies have indeed been extirpated from the drainage, recovery efforts should include eventual translocation of gobies from the nearest adjacent population; currently this is San Simeon Creek.

It may be possible to construct off-stream ponds or marshes to provide greater instream flow by percolation during the summer months. These ponds might also provide habitat for turtles, and possibly red-legged frogs. However, it is also likely that bullfrogs will find these ponds ideal and will use them to expand their range into the area, to the detriment of the local red-legged frog, two-striped garter snake, and western pond turtle populations.

Methods of restoring water to the lower reaches of Santa Rosa Creek, and providing and maintaining suitable pools,

must be developed to recover the populations of declining vertebrates. The restoration will require a well-coordinated, team effort between hydrologists, restoration biologists, the Cambria Community Services District, and the residents, ranchers, and farmers of the community.

BIBLIOGRAPHY AND LITERATURE CITED

Alexander, C., M.A. Broutman, and D.W. Field. 1986. An inventory of coastal wetlands of the United States of America. National Oceanic and Atmospheric Administration, Washington, District of Columbia.

Altig, R., and P. C. Dumas. 1972. *Rana aurora*. Pages 160.1-160.4 *in* R. G. Zeifel, editor. Catalogue of American amphibians and reptiles. Society for the Study of Amphibians and Reptiles.

Bailey, R. 1973. An estimate of the standing crop of steelhead trout (*Salmo gairdneri richardson*), Santa Rosa Creek, San Luis Obispo County, California. Senior Thesis, Natural Resources Management Department, California Polytechnic State University, San Luis Obispo. 23 pp.

Bell, M. A., and T. R. Haglund. 1978. Selective predation of threespine sticklebacks (*Gasterosteus aculeatus*) by garter snakes. Evolution **32**(2):304-319.

Brattstrom, B. H. 1988. Habitat destruction in California with special reference to *Clemmys marmorata*: a perspective. Pages 13-24 *in* H. F. DeLisle, P. R. Brown, B. Kaufman and B. M. McGurty, editors. Proceedings of the Conference on California Herpetology. Southwestern Herpetologists Society, Van Nuys, California.

Brattstrom, B. H., and D. F. Messer. 1988. Current status of the southwestern pond turtle, *Clemmys marmorata pallida*, in southern California. Final Report, California Department of Fish and Game Contract C-2044, 60 pp.

Brown, T. W. 1980. The present status of the garter snake on Santa Catalina Island, California. Pages 585-595 *in* D. M. Power, editor. The California Islands: Proceedings of a multidisciplinary symposium. Santa Barbara Museum of Natural History, Santa Barbara. 787 pp.

Bury, R. B. 1970. *Clemmys marmorata* (Baird and Girard) Western pond turtle. Pages 100.1-100.3 *in* Catalogue of American amphibians and reptiles. American Society of Ichthyologists and Herpetologists.

Bury, R. B. 1972. Habits and home range of the Pacific pond turtle, *Clemmys marmorata*, in a stream community. Ph.D. Thesis. University of California, Berkeley. 205 pp.

Bury, R. B. 1986. Feeding ecology of the turtle, *Clemmys marmorata*. Journal of Herpetology **20**(4):515-521.

Bury, R. B., and J. H. Wolfheim. 1973. Aggression in free-living pond turtles (*Clemmys marmorata*). BioScience **23**(11):659-662.

Calef, G. W. 1973a. Spatial distribution and "effective" breeding population of red-legged frogs (*Rana aurora*) in Marion Lake, British Columbia. The Canadian Field-Naturalist **87**:279-284.

Calef, G. W. 1973b. Natural mortality of tadpoles in a population of *Rana aurora*. Ecology **54**(4):741-758.

Carpelan, L. H. 1969. Physical characteristics of southern California coastal lagoons. Pages 319-344 *in* A. A. Castanares and F. B. Phleger, editors. Coastal lagoons, a symposium. Universidad Nacional Autonoma de Mexico, Mexico, D.F.

Cowan, I. M. 1941. Longevity of the red-legged frog. Copeia **1941**(1):48.

Deibel, R.H. 1979. Evaluation of Santa Rosa Creek as a possible spawning and rearing stream for Coho salmon (*Oncorhynchus kisutch*, Walbaum). Senior Thesis, Natural Resources Management Department, California Polytechnic State University, San Luis Obispo. 40 pp.

Drummond, H. 1983. Aquatic foraging in garter snakes: a comparison of specialists and generalists. Behaviour **86**:1-30.

Dudley, T. 1988. Report to the County of San Luis Obispo on the Aquatic and Riparian Biology Associated with the Shamel Park Bank Stabilization Project. Department of Biological Sciences, University of California, Santa Barbara. October 19, 1988. 21 pp.

Feldman, M. 1982. Notes on reproduction in *Clemmys marmorata*. Herpetological Review **13**(1):10-11.

Fitch, H. S. 1941. The feeding habits of California garter snakes. California Fish and Game **27**(2):2-32.

Fox, W. 1952. Notes on feeding habits of Pacific Coast garter snakes. Herpetologica **8**(2):4-8.

Goldberg, S. R. 1977. Seasonal ovarian cycle of the tidewater goby, *Eucyclogobius newberryi* (Gobiidae). The Southwestern Naturalist **22**(4):557-559.

Hayes, M. P., and M. R. Jennings. 1986. Decline of ranid frog species in western North America: are bullfrogs (*Rana catesbeiana*) responsible? Journal of Herpetology **20**(4):490-509.

Hayes, M. P., and M. R. Jennings. 1989. Habitat correlates of distribution of the California red-legged frog (*Rana aurora draytonii*) and the foothill yellow-legged frog (*Rana boylii*): Implications for management. Pages 144-158 *In* R. E. Szaro, K. E. Severson, and D. R. Patton (technical coordinators), Proceedings of the symposium on the management of amphibians, reptiles, and small mammals in North America, July 19-21, Flagstaff, Arizona. USDA General Technical Report RM-166, 458 pp.

Hayes, M. P., and D. M. Krempels. 1986. Vocal sac variation among frogs of the genus *Rana* from western North America. Copeia **4**:927-936.

Hayes, M. P., and M. M. Miyamoto. 1984. Biochemical, behavioral and body size differences between *Rana aurora aurora* and *R. a. draytoni*. Copeia **4**:1018-1022.

Hayes, M. P., and M. R. Tennant. 1985. Diet and feeding behavior of the California red-legged frog, *Rana aurora draytonii* (Ranidae). The Southwestern Naturalist **30**(4):602-605.

Hawley, R. Director, Greenspace; A Land Trust, Cambria, CA.

Holland, D. C. 1985. An ecological and quantitative study of the western pond turtle (*Clemmys marmorata*) in San Luis Obispo County, California. M.A. Thesis. California State University, Fresno. 181 pp.

Holland, D. C. 1988. Western pond turtle *Clemmys marmorata*: behavior. Herpetological Review **19**:87.

Holland, D. C. 1991a. Status and reproductive dynamics of a population of western pond turtles (*Clemmys marmorata*) in Klickitat County, Washington in 1991. Report prepared for the Washington Department of Wildlife. 66 pp.

Holland, D. C. 1991b. Status and distribution of the tidewater goby (*Eucyclogobius newberryi*) on Camp Pendleton, San Diego County, California, in 1990-1991. Report prepared for Natural Resources Office, Camp Pendleton Marine Corps Base, San Diego, CA. 63 pp.

Holland, D. C. 1991c. A synopsis of the ecology and status of the western pond turtle (*Clemmys marmorata*) in 1991. Unpublished report to the U.S. Fish and Wildlife Service, Piedras Blancas Research Station, San Simeon, California.

Irwin, J. F., and D. L. Stoltz. 1984. The natural history of the tidewater goby, *Eucyclogobius newberryi*, in the San Antonio and Shuman Creek Systems, Santa Barbara County, California. Contract Order No. 11310-0215-2, U.S. Fish and Wildlife Service. 52 pp.

Jennings, M. R. 1988. Natural history and decline of native ranids in California. Pages 61-72 *in* H. F. DeLisle, P. R. Brown, B. Kaufman and B. M. McGurty, editors. Proceedings of the Conference on California Herpetology. Southwestern Herpetologists Society, Van Nuys, California.

Jennings, M. R., and M. P. Hayes. 1985. Pre-1900 overharvest of California red-legged frogs (*Rana aurora draytonii*): the inducement for bullfrog (*Rana catesbeiana*) introduction. Herpetologica **41**(1):94-103.

Jennings, M. R., and M. P. Hayes. 1990. Status of the California red-legged frog *Rana aurora draytonii* in the Pescadero Marsh Natural Preserve. Report prepared under contract number 4-823-9018 with the California Academy of Sciences, for the California Department of Parks and Recreation, Sacramento, California. 56 pp.

Johansen, R. 1972. Santa Rosa Creek steelhead production; ref. Madonna Construction Company application for gravel plant. Unpubl. 5 pp. memorandum.

Josselyn, M. and J. Zedler. 1990. Wetland mitigation along the Pacific Coast of the United States. Pages 2-27 *in* J.A. Kusler and M.E. Kentula, editors. Wetland Creation and Restoration: The status of the Science. Island Press, Washington, District of Columbia.

Larson, N. M. 1984. Geographic variation in the two-striped garter snake, *Thamnophis hammondii*. M.S. Thesis. California State Polytechnic University, Pomona. 58 pp.

Lea, R. 1991. Unpublished data from laboratory studies of tidewater goby salinity tolerance, Granite Canyon Marine Laboratory, California Department of Fish and Game.

Lea, R. Granite Canyon Marine Laboratory, California Department of Fish and Game, Monterey, California.

Licht, L. E. 1969a. Palatability of *Rana* and *Hyla* eggs. The American Midland Naturalist **82**(1):296-298.

Licht, L. E. 1969b. Unusual aspects of anuran sexual behavior as seen in the red-legged frog, *Rana aurora aurora*. Canadian Journal of Zoology **47**(4):505-509.

Licht, L. E. 1971. Breeding habits and embryonic thermal requirements of the frogs, *Rana aurora aurora* and *Rana pretiosa pretiosa*, in the Pacific Northwest. Ecology **52**(1):116-124.

Macdonald, K. B. 1988. Coastal salt marsh. Pages 283-394 *in* M. G. Barbour and J. Major, editors. Terrestrial vegetation of California. California Native Plant Society, Sacramento. 1030 pp.

Moyle, P. B. 1973. Effect of introduced bullfrogs (*Rana catebeiana*) on the native frogs of the San Joaquin Valley, California. Copeia **1973**:18-22.

Moyle, P. B. 1976. Inland Fishes of California. University of California Press, Berkeley, California. 405 pp.

Peabody, F. E., and J. M. Savage. 1958. Evolution of a coast range corridor in California and its effect on the origin and dispersal of living amphibians and reptiles. Pages 159-186 *in* Zoogeography. American Association for the Advancement of Science.

Puckett, L. 1970. Evaluation of the impact of summer trout fishing on juvenile steelhead inhabiting coastal lagoons. Memorandum to State of California Region 3 Fisheries management Office. 4 pp.

Raff, D. Local sport fisherman and member of Trout Unlimited, Sebastapol, California.

Rathbun, G. B., N. Siepel, and D. Holland. In review. Nesting behavior and movements of western pond turtles, *Clemmys marmorata*. The Southwestern Naturalist.

Rossman, D. A. 1979. Morphological evidence for taxonomic partitioning of the *Thamnophis elegans* complex (Serpentes, Colubridae). Occasional Papers of the Museum of Zoology, Louisiana State University **55**:1-12.

Rossman, D. A., and G. R. Stewart. 1987. Occasional Papers of the Museum of Zoology, 63: Taxonomic reevaluation of *Thamnophis couchii* (Serpentes: Columbridae). Louisiana State University, Baton Rouge. 25 pp.

Russell, B. 1990. A Preliminary Site Assessment and Instream Flow Study Plan, Santa Rosa Creek, Cambria, California. Prepared for Cambria Community Services

District by Tenera Environmental Services, San Luis Obispo, California. 17 pp.

Schreiber, M. R. 1960. Field notes on June 24, 1960 survey of Santa Rosa Creek, San Luis Obispo County. California Department of Fish and Game. 1 p.

Seifeldt, M. 1974. Field reports on fish seen in Santa Rosa Creek on 2 and 23 February 1974. California Department of Fish and Game. 1 p.

Shapovalov, L. and A.C. Taft. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and the silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. Fish Bulletin **98**:1-375.

Smith, J. J. 1987. Aquatic Habitat and Fish Utilization of Pescadero, San Gregorio, Waddell and Pomponio Creek Estuary/Lagoon Systems. Interagency Agreement 4-823-6004, between Trustees for California State University and the California Department of Parks and Recreation. 35 pp.

Stebbins, R. C. 1954. Amphibians and reptiles of western North America. McGraw-Hill Book Co., New York. 539 pp.

Stebbins, R. C. 1985. The Peterson Field Guide Series: A field guide to western reptiles and amphibians. Houghton Mifflin, Boston. 336 pp.

Stewart, G. Biological Sciences Department, California State Polytechnic University, Pomona, California.

Storer, T. I. 1930. Notes on the range and life-history of the Pacific fresh-water turtle, *Clemmys marmorata*. University of California Publications in Zoology **32**(5):429-441.

Storm, R. M. 1952. Interspecific mating behaviour in *Rana aurora* and *Rana Catesbeiana*. Herpetologica **8**(3):108.

Storm, R. M. 1960. Notes on the breeding biology of the red-legged frog (*Rana aurora aurora*). Herpetologica **16**:251-259.

Swift, C. S. 1990. Status of freshwater fishes of southern California with recommendations for preserves to maintain their existence. Contract Report No. FG-7455, California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, California.

Swift, C.S., J.L. Nelson, C. Maslow, and T. Stein. 1989. Biology and distribution of the tidewater goby, *Eucyclogobius newberryi* (Pisces: Gobiidae) of California. Natural History Museum of Los Angeles County Contributions in Science **404**:1-19

Wang, J. C. S. 1982. Early life history and protection of the tidewater goby, *Eucyclogobius newberryi* (Girard) in the Rodeo Lagoon of the Golden Gate National Recreation Area. Technical Report Number 7, Cooperative National Park Resources Studies Unit, National Park Service, San Francisco, CA. 24 pp.

Zedler, J. B. 1991. The challenge of protecting endangered species habitat along the southern California coast. Coastal Management **19**:35-53.

Zentner, J. 1984. Protection of riparian systems in the California coastal zone. Pages 634-641 *in* R. E. Warner and K. M. Hendrix, editors. California riparian systems. University of California Press, Berkeley. 1035 pp.

TABLE 1. Legal status of declining vertebrates found in coastal arroyos of northern San Luis Obispo County, California.

SPECIES	FEDERAL STATUS	STATE STATUS
Tidewater goby	*USFWS candidate 1	spec. concern
Steelhead trout	BLM/USFS sensitive	spec. concern
California red-legged frog	*USFWS candidate 1	spec. concern
Western pond turtle	*USFWS candidate 1	spec. concern
Two-striped garter snake	*USFWS candidate 2	none

*U.S. Federal Register. 1991. Animal candidate review for listing as endangered or threatened species. 21 November 1991, **56**(225):58804-58836.