



California Red-legged Frog Surveys of Lower Redwood Creek, Golden Gate National Recreation Area

Prepared for:

National Park Service

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
WESTERN ECOLOGICAL RESEARCH CENTER

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By Gary M. Fellers¹ and Greg Guscio¹

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Introduction

The California red-legged frog (*Rana aurora draytonii*) was once an abundant frog throughout much of California and is widely believed to have inspired Mark Twain's fabled story "The Celebrated Jumping Frog of Calaveras County". Now this frog is gone from the floor of the Central Valley (Fisher and Shaffer, 1996) and rarely seen in either the Sierra Nevada foothills or the southern quarter of its range along the California coast. In a few parts of the central Coast Range, there are large, vigorous populations, some of which probably rival what were present 200 years ago (Fellers, *in press*).

Some of the largest populations are at Point Reyes National Seashore (Marin County) where there are more than 120 breeding sites with a total adult population of several thousand frogs. Most of the breeding sites are artificial stock ponds constructed on lands that have been grazed by cattle for 150 years. There are good populations elsewhere in the San Francisco Bay area (especially Alameda and Contra Costa Counties) and in some of the coastal drainages from San Mateo County (just south of San Francisco) south to Santa Barbara County. One of the largest single populations consists of an estimated 350 adult frogs at Pescadero Marsh (San Mateo County) (Fellers, *in press*).

The California red-legged frog was Federally listed as a Threatened species on June 24, 1996. The listing was necessary because the frog was largely absent from more than 70 percent of its original range and threatened within its remaining range by a wide variety of human activities including urban encroachment, construction of reservoirs and water diversion, contaminants, agriculture, and livestock grazing (U.S. Fish and Wildlife Service, 2002). The role of non-native bullfrogs (*Rana catesbeiana*) is unclear. While bullfrogs have frequently been called a threat, or even one of the primary causes of the declines, there is almost no direct evidence that this is the case. Most reports of bullfrog impacts (e.g., Moyle, 1973) have been based merely on a correlation between the presence of bullfrogs and the lack of red-legged frogs. It is at least as likely that contaminants (Sparling et al., 2001) or non-native

fish (e.g., bass, sunfish, catfish, mosquitofish) play a significant role in the decline of native ranid frogs (Hayes and Jennings, 1986).

The California red-legged frog recovery plan (U.S. Fish and Wildlife Service, 2002) described breeding habitat as follows:

Breeding sites of the California red-legged frog are in a variety of aquatic habitats; larvae, tadpoles, and metamorphs have been collected from streams, deep pools, backwaters within streams and creeks, ponds, marshes, sag ponds, dune ponds, and lagoons. Breeding adults are often associated with deep (greater than 0.7 meter [2 feet]) still or slow moving water and dense, shrubby riparian or emergent vegetation (Hayes and Jennings 1988), but frogs have been observed in shallow sections of streams that are not cloaked in riparian vegetation. Reis (1999) found the greatest number of tadpoles occurring in study plots with water depths of 0.26 to 0.5 meters (10 to 20 inches). While frogs successfully breed in streams, high flows and cold temperatures in streams during the spring often make these sites risky environments for eggs and tadpoles. California red-legged frogs also frequently breed in artificial impoundments such as stock ponds. It is assumed, however, that these ponds must have proper management of hydroperiod, pond structure, vegetative cover, and control of non-native predators, although some stock ponds support frogs despite a lack of emergent vegetation cover and the presence of non-native predators (N. Scott and G. Rathbun *in litt.* 1998). Additional research on the habitat requirements of the California red-legged frog in artificial ponds may clarify this issue.

The recovery plan also described non-breeding habitat as:

California red-legged frogs often disperse from their breeding habitat to forage and seek summer habitat if water is not available. This summer habitat could include spaces under boulders or rocks and organic debris, such as downed trees or logs; industrial debris; and agricultural features, such as drains, watering troughs, abandoned sheds, or hay-ricks.

California red-legged frogs use small mammal burrows and moist leaf litter (Jennings and Hayes 1994); incised stream channels with portions narrower and deeper than 46 centimeters (18 inches) may also provide habitat (U.S. Fish and Wildlife Service 1996a). This depth may no longer be an accurate estimate of preferred depth for this species as individuals have been found using channels and pools of various depths. Most observations are associated with depths greater than 25 cm (10 inches). For example, M. Allaback (*in litt.* 2000) has observed numerous red-legged frogs inhabiting stream channels with pools that are less than 46 centimeters (18 inches) deep, particularly in north coastal Santa Cruz

County and generally from late spring to the fall. Some of the observations have been along tributaries where there are no pools that are 46 centimeters (18 inches deep) for several thousand feet. At one site, along a tributary to Liddell Creek (Santa Cruz County), the same individuals were seen at the same streamside locations for several weeks in late summer during a monitoring project. Pool depth averaged approximately 30 centimeters (12 inches). In 2000, an adult red-legged frog was observed in shallow, 5 centimeter (2 inch) deep riffle habitat in a disturbed drainage in lower Little Bull Valley (Contra Costa County). Here, no pool or pond habitat was present within approximately 300 meters (1,000 feet).

California red-legged frogs use large cracks in the bottom of dried ponds as refugia. Approximately 25 red-legged frogs were observed using open cracks in the bottom of three separate dried ponds. At least one pond was dry for more than 2 months when adult frogs were found deep in the cracks of the pond bottom. Many cracks within which frogs were found were damp at a depth of 46 centimeters (18 inches). These cracks may have provided moisture for frogs that were also avoiding predation and solar exposure (J. Alvarez *in litt.* 2000). Dispersal and habitat use, however, is not observed in all studied red-legged frogs and is most likely dependent upon climatic conditions, habitat suitability, and varying requisites of each life stage.

Our experience in Marin County indicates that California red-legged frogs use ponds or pools for breeding during the wet season (December through March), and ponds or riparian zone pools, thickets logjams, and root tangles during the rest of the year. At Point Reyes, stock ponds are the most commonly used breeding sites. There is much less information on non-breeding habitat requirements. In order to evaluate movements to and from breeding sites and to evaluate non-breeding habitats, we outfitted frogs with radiotransmitters at several sites in Olema Valley at Point Reyes National Seashore (Fellers and Kleeman, *in prep.*). We tracked 117 frogs at nine sites. Individual frogs were continuously tracked for up to 16 months.

Dispersal of red-legged frogs from breeding sites was highly variable. Some frogs remained at breeding ponds all year, while others spent only a few days. Frogs at sites that held water only seasonally were forced to disperse, but frogs often lingered until the site was on the verge of completely drying.

Since all our study sites were in an area where summer fog is the norm, frogs could disperse throughout the summer with little risk of desiccation. Many of the frogs traveled little more than the minimum distance to suitable non-breeding habitats. At our most intensively studied site, frogs moved to dense riparian vegetation associated with a permanent creek less than 150 m away. Once along the riparian corridor, frogs used a range of habitats that provided both cover and moisture. The most commonly used cover included blackberry thickets, logjams, and root tangles at the base of standing or fallen trees.

When frogs dispersed beyond the minimum distance to reach a suitable area, some followed riparian corridors, while others dispersed directly toward their ultimate destination. It would seem that dispersal across closely grazed pastures would expose frogs to predation. Since we have evidence for only a limited number of predation events, it is not possible to conclude which pattern is riskier. We observed more predators along the riparian corridor, but direct dispersal across open fields incurs both the risk of predation and accidental trampling by livestock. It does appear, however, that crossing open pastures incurs a higher risk of predation when the transit is not completed within one night. Frogs that spend the day in a pasture would seem to be at greater risk.

There was a wide range of dispersal distances (30-1400 m). There was no difference between males and females, but there was a difference related to frog size. The greatest distances were covered by the smaller frogs. This is a common pattern amongst other amphibians (Breden, 1987; Sinsch, 1992, 1997, Sinsch and Seidel, 1995). It was not possible to determine whether the large, non-breeding frogs were excluding smaller frogs, or if the subadults were dispersing further for other reasons.

During our nocturnal surveys of Olema Creek, some frogs were well hidden by cover while others sat fully exposed on top of logs or even on the sandy edge of the creek, places where red-legged frogs would never be seen during the day. It is unclear why frogs spent hours at sites so exposed to predation. By contrast, at a nearby marsh (not included in this study) that was regularly frequented by black-crowned night herons (*Nycticorax*

nycticorax), red-legged frogs were so wary that we have never been able to capture a single red-legged frog.

We documented red-legged frog predation by a great blue heron (*Ardea herodias*), and had evidence of predation by a raptor and small mammals. Additionally, during nocturnal surveys along Olema Creek, we regularly observed potential predators including raccoons (*Procyon lotor*), black-crowned night herons, river otters (*Lutra canadensis*), and non-native rats (*Rattus* sp.).

Because of the interest in restoring Big Lagoon along the lower portions of Redwood Creek (Golden Gate National Recreation Area) to a more natural condition, we conducted a short-term study of California red-legged frogs in that area during 2002-2003. The goals of this work were to estimate population size for the California red-legged frogs in that drainage, to evaluate both breeding and non-breeding habitat, and to make recommendations on how the restoration could be accomplished with the least impact on red-legged frogs.

Methods

Habitat Assessment

During November and December 2002, we visited the lower reaches of Redwood and Green Gulch Creeks to assess the extent of potential red-legged frog breeding and non-breeding habitat. All areas that were holding water, or appeared to have the potential to hold water, were considered potential red-legged frog habitat. Each area that could be surveyed was given a site designation. Site boundaries were based on features that could be easily mapped, and features that could be recognized during both diurnal and nocturnal surveys (e.g., ditches, streams, ponds, and wetlands). Each site was small enough to be completely surveyed on a single visit.

Eighteen sites were delineated (Fig. 1). These included 11 sites along Redwood Creek and 7 sites within the Green Gulch Creek watershed. Other areas were evaluated informally, but not systematically surveyed due to dense vegetation that would make our survey techniques ineffective. These sites included the ditch west of and parallel to the upper stretch of Redwood Creek (P-161A), the wooded area east of Redwood Creek between Highway 1 and Pacific Way (P-161B), and the ditch on the south side of Green Gulch Creek that drains the hillside reservoirs (P-302 and P-303).

Surveys for adult frogs were conducted throughout the breeding season to maximize the number of adult frogs detected. Similarly, egg surveys were timed to coincide with egg laying at other nearby sites within Golden Gate NRA and Point Reyes NS. Tadpole surveys were initiated a few weeks after egg hatching. Tadpole surveys at earlier dates were unlikely to detect amphibians, since the tadpoles were not likely to be captured and/or identified. Note that some of our surveys fall well outside the dates that have been suggested in protocols developed by Fish and Wildlife Service and others (Table 1). We felt it was preferable to conduct surveys during the optimal time, rather than following guidelines intended to cover red-legged frog activity across the entire species range. In addition, the draft Fish and Wildlife Service protocol was designed to detect presence, not to estimate population size. Our work was much more extensive, and greatly exceeded the normal expectations of other protocols. By timing our surveys to local phenology, the surveys were appropriate for both detecting frogs and for providing data on population size. All biologists conducting surveys for red-legged frogs (Greg Guscio, Patrick Kleeman, and Gary Fellers) were highly qualified field ecologists with extensive experience with red-legged frogs in coastal habitats.

Diurnal surveys

Diurnal surveys were conducted by systematically searching all sites for red-legged frogs, egg masses, and/or larvae (Fellers and Freel, 1995). This entailed walking slowly through the site while visually scanning banks, rocks,

logs, pond or stream bottoms (water clarity permitting), and the surface of floating vegetation. Surveys included stopping intermittently to look ahead with binoculars, increasing the likelihood of detecting frogs that might otherwise have been startled before detection. Starting in late March, surveys included frequent dip netting for tadpoles. On April 9, minnow traps were deployed in sites P-143A, B, C, and D, and site P-583 to sample for tadpoles.

Most sites were surveyed at least once before the onset of breeding. Once egg laying had begun at nearby sites in Marin County, surveys of the Redwood Creek and the associated wetlands were performed on a regular basis. Data on the presence and abundance of other amphibians were recorded, along with information on reptiles, fish, and potential predators. Daylight surveys were not performed in rainy conditions, as disturbance of the surface of the water by raindrops greatly reduces visibility in the water column and hence eggs and frogs could easily be overlooked.

Nocturnal Surveys

Nocturnal surveys of each site were conducted by walking through the site, stopping approximately every 5 m. At each stop, a 30-Watt sealed beam light (358 lux at 5 meters) and binoculars were used to look for the eye shine of red-legged frogs (Corben and Fellers, 2001). The binoculars were focused on the main spot of light, and the light and binoculars were moved in tandem to scan nearby habitat (up to about 30 meters away). Unidentified eye shines were investigated by slowly approaching the animal until a positive identification could be made. If identification was not possible, the frog was recorded as an unidentified species. Data on the presence and abundance of other amphibians were recorded along with information on reptiles, fish, and potential amphibian predators. Nocturnal surveys were not performed if the visibility was less than 100 meters due to fog or rain, or if the temperature dropped below 5° Celsius.

Radiotelemetry

We captured and radiotagged frogs at all locations where red-legged frogs were found. Typically, frogs were caught at night, either by hand or with a dipnet. Frogs were processed either that night or, less frequently, the next day. All frogs were released at the point of capture. Each frog was marked with a passive integrated transponder (PIT) tag (model TX1400L, Biomark, Meridian, ID, www.biomark.com) for individual identification, and weighed and measured (snout-vent length). Frogs were radiotagged by attaching a radiotransmitter (model BD-2G, Holohil Systems Ltd., Carp, Ontario, Canada, www.holohil.com) to a belt of aluminum beads. The belt was slipped over the frog's rear legs and remained around its waist (Rathbun and Murphey 1996). Total weight of the radiotransmitter and belt was approximately 2.1 g. We followed the general rule that the transmitter should not exceed 10% of the animal's body weight (Richards et al., 1994). The transmitter and belt weighed only 3.6% of the weight of the smallest frog (58.2 g) in this study.

Radiotagged frogs were located at least once weekly through the end of April, and every 2-3 weeks thereafter. Both a TR-2 receiver (Telonics, Mesa, AZ, www.telonics.com) and an R-1000 receiver (Communication Specialists, Inc., Orange, CA, www.com-spec.com) with either a directional "H" antenna or a three-element yagi antenna were used to locate the radiotransmitters. Fine scale location of transmitters was often accomplished with a partially stripped coaxial cable inserted into a length of PVC pipe that was used as a probe (Fellers and Kleeman, 2003). Whenever possible, frogs were captured every 3-4 weeks to ensure proper fit of the waist belt. Some frogs moved into areas of such dense vegetation that it was not possible to recapture them routinely.

Locations of radiotagged frogs were mapped based on coordinates obtained from a Garmin 12XL GPS unit (Garmin International Inc., Olathe, KS, www.garmin.com). Coordinates were plotted on a digitized air photo provided by Golden Gate NRA. Unless otherwise noted, the distances of the frogs' movements represent the straight-line distance between successive locations confirmed by telemetry.

Results

Diurnal and nocturnal surveys

Seventy daylight and 89 nocturnal surveys were conducted (Table 1). Red-legged frogs were found at sites P-143A, P-143B, P-143C, P-143D, P-161B, and P-583 (Tables 2 and 3). The maximum number of red-legged frogs found during a single survey was seven (sites P-143A and B). Three red-legged frog egg masses were found, one in each of sites P-143A, B, and C. One red-legged frog tadpole was found in site P-143B. No red-legged frogs were found in the Green Gulch drainage or along the upper reaches of Redwood Creek upstream from Highway 1 during either diurnal or nocturnal surveys. However, that one adult frog was radiotracked to the lower section of Green Gulch Creek.

Radiotelemetry

Nine red-legged frogs were fitted with radiotransmitters (Table 4). They were tracked from December 26, 2002 through June 3, 2003 (Table 5, Fig. 2 - 10). The median distance moved was 70 m, with a range of 0 – 390 m. If frogs that did not move at least 30 m are excluded, the median distance moved was 105 m. The longest move was 390 m, with another frog moving 250 m.

In general the frogs with transmitters lost weight (Table 4). The five frogs that lost weight lost an average of 8.8% of their initial weight, while the one frog that gained weight gained 6.5% of its initial weight.

Population size

There was a minimum of 14 red-legged frogs at Big Lagoon in 2002. We caught nine frogs and outfitted them with radiotransmitters. These frogs were all male. Since there were three egg masses, we assume that at least three females were present in the marsh in 2002. Two additional males were captured in May, after the study had formally ended. These two frogs were marked with PIT tags, but not fitted with radiotransmitters.

Habitat evaluation

During the initial survey for each of the 18 sites within the study area, we recorded physical characteristics of the site. We recorded information on the dimensions of aquatic habitat within the site, water depth, turbidity, shade, and percent cover of both rooted and floating vegetation (Table 6).

After completing all field work, we also made a subjective evaluation of each site with respect to the quality of both breeding and non-breeding habitat (Table 7). These assessments were based on our experience with red-legged frogs both in the Big Lagoon area as well as 10 years of field work on this species elsewhere in Marin County.

Other amphibians and reptiles

Other amphibian and reptilian species found within the study area include Pacific treefrog (*Hyla regilla*), ensatina (*Ensatina eschscholtzii*), rough-skinned newt (*Taricha granulosa*), California newt (*Taricha torosa*), western fence lizard (*Sceloporus occidentalis*), racer (*Coluber constrictor*), and western terrestrial garter snake (*Thamnophis elegans*) (Table 3).

Discussion

The Big Lagoon wetland project area falls within the Point Reyes Critical Habitat Unit (Unit 12) as defined by the U.S. Fish and Wildlife Service. This unit “consists of watersheds within and adjacent to Bolinas Lagoon, Point Reyes, and Tomales Bay in Marin and Sonoma counties . . .” and “. . . contains one of the largest known populations of California red-legged frogs” (Federal Register, 2001).

Our study during the fall, winter, and spring of 2002-2003 showed that red-legged frogs were present, and reproducing within Big Lagoon, but that they are not evenly distributed. Most of the frogs were found in the freshwater

marsh on the east side of the levee (sites P-143A and B, Fig. 1). We occasionally found frogs in other parts of the marsh east of the levee (P-143C and D), and in one pond west of the levee (sites P-161B). Eggs and the one tadpole had a similar distribution. Egg laying took place in a moderately restricted area east of the levee (sites P-143A, B, and C; one egg mass each). Parts of the marsh that appeared to be suitable for egg and tadpole development during the winter became dry well before tadpoles had a chance to metamorphose. It is unlikely that there was any successful reproduction during 2003.

While California red-legged frog egg masses can be difficult to see, they are not typically laid in areas of dense vegetation. Slow, methodical surveys by experienced observers have proven to be an effective survey method. Hence, it seems unlikely that we overlooked egg masses given the timing and intensity of our surveys (Table 1). The low numbers of tadpoles (= one) reflects both the limited amount of reproduction, and the difficulty of finding tadpoles while they are still relatively small. Late spring/early summer surveys (after the end of this project) might have resulted in more tadpoles, but it is unlikely that we would have detected them in areas where we never saw adults or eggs. Hence, the limited number of frogs, egg masses, and tadpoles no doubt reflect the presence of only a modest number of red-legged frogs. Our maximum count was seven adult frogs, but we know there were at least 14 adults present in the marsh in during our study. This is based on having marked 11 male frogs, and the presence of three egg masses that would have been laid by three females.

We expected to find red-legged frogs in two other parts of the study area, Redwood Creek upstream from Highway 1, and in the ponds or stream on the Green Gulch property. The lack of frogs along the upper reaches of Redwood Creek is somewhat surprising. The general habitat looked moderately good, but there was only a narrow riparian corridor along the creek. Winter flows might be sufficiently high to make the riparian zone unsuitable for frogs, and the narrowness of the habitat might leave few retreats during periods of high flow.

The lack of red-legged frogs at Green Gulch throughout most of our study probably reflects the lack of suitable habitat. The stream is in a narrow, concrete ditch. The ponds have either little emergent vegetation, or harbored Sacramento blackfish (*Orthodon microlepidotus*). Moyle (2002) describes this fish as “. . . most abundant in warm, usually turbid, waters of the Central Valley floor, often occurring in highly modified habitats otherwise dominated by nonnative fishes.” Moyle also describes the feeding habits as “. . . primarily suspension feeders on planktonic algae and zooplankton, including rotifers, cladocerans, copepods, insect larvae, and suspended detritus.” The presence of this fish is probably not a significant concern for red-legged frogs. We tracked one adult frog to the lower reaches of Green Gulch Creek, but no other frogs were seen there throughout our study.

Records of red-legged frogs found during surveys by Ed Ely indicate the Big Lagoon has provided breeding habitat for a small population of this frog over the last 10 years (Ely, 1993). On April 29, 1993, Ely found two red-legged frogs in the same cattail thicket where several of our frogs with radiotransmitters spent several months. Ely described this area as a pond with emergent vegetation – cattails. The cattails have grown in so that we would now describe the area as a cattail thicket with a few somewhat open areas with 1.0 - 1.5 m deep water.

Recent history of Big Lagoon

Darren Fong (NPS staff) provided a summary of recent changes to the Big Lagoon area as follows:

“. . . the area east of the levee on Green Gulch lands was historically either wetland or open water habitat, but agricultural activities have resulted in the placement of fill of several feet. Over the last several years, fine sediment has deposited in the creek channel downstream of the pedestrian bridge, resulting in a semi-permanent closure of the mouth of Redwood Creek and an approximate 0.7-meter increase in the creek base level. With this increase in the creek's base level, the pasture

east of the levee road has become wetter, probably through both ground water contribution as well as surface water backing up through the gated culvert in the levee road. This increase in base level and resultant increased ponding east of the levee road has occurred since 1996, as documented by NPS surveys and descriptions by local NPS field staff and Muir Beach residents. Hydrologic conditions in the pasture resulting from reopening of the mouth of the creek by breaching this sediment deposit are thus trending toward conditions prior to 1996.” (Darren Fong, *personal communication*).

Changes such as these would affect habitat suitability for red-legged frogs, especially the areas where red-legged frogs laid eggs in 2003, and where they congregated during the non-breeding season. It is interesting to note, however, that the area where we documented breeding in 2003 is essentially the same as where Ed Ely observed eggs in 1993, prior to the post-1996 changes described by Fong.

Comparison with other Marin County Marshes

The only other marsh in Marin County that has been intensively surveyed is the area at the south end of Tomales Bay (Fellers and Guscio, 2002). Surveys conducted in 2001-2002 indicated that a 500 x 75 m portion of the marsh provided appropriate habitat for red-legged frogs. Intensive surveys, similar to those conducted at Big Lagoon, indicated that approximately 100 adult frogs occupied that portion of the Tomales Bay marsh. Since many habitat and hydrologic features of the Tomales Bay marsh differ from those at Big Lagoon, it is not possible to make a direct comparison. Nonetheless, the abundance of red-legged frogs at Tomales Bay suggests that under suitable conditions, frog populations in coastal marshes can be fairly dense.

Frog movements and distribution

The only places where we found frogs during our surveys were the marsh to the east of the levee, and one pond immediately to the west of the levee. If we assume that our extensive diurnal and nocturnal surveys were successful in detecting frogs in all areas where they spent a significant amount of time, we can conclude that red-legged frogs are restricted to the immediate vicinity of Big Lagoon. Adult frogs spent nearly all their time closely associated with dense cattail thickets. This probably reflects both the availability of suitable habitat (cattails or similar dense cover), and the availability of water throughout the spring and summer. Hence, adult frogs moved to those areas that had a suitable combination of cover and water. In the spring of 2003, this combination was extremely limited due to the drying of the marsh.

Our radiotelemetry work largely confirmed the observations from our diurnal and nocturnal surveys. From December through May, frogs were tracked in the vicinity of the breeding sites, and to what appears to be the most significant non-breeding site, P-143D. Red-legged frogs were never found in Redwood Creek, and only one frog was tracked (June 3, 2003) to the lower reaches of Green Gulch Creek. This represents the only animal found beyond the ponds and marsh in the immediate vicinity of the levee. The presence of one frog along lower Green Gulch Creek suggests that others might have occupied the same area, but numbers were probably quite modest since no frogs were observed during our nocturnal surveys.

Five of six frogs that we tracked lost weight during our study. This is not surprising since we tagged male frogs during the breeding season, a time when the males were likely defending territories. This is a typical trend for a wide variety of vertebrate species.

Incidental observations

We found one other species of frog, three species of salamanders, one lizard, and two species of snakes during our field work (Table 3). There are almost certainly other species of amphibians and reptiles in the study area, but

our field work focused on the aquatic environment, so only pond breeding species were likely to be detected. Pacific treefrogs are the most common frog in Marin County, so their presence was expected. Garter snakes feed on a variety of small vertebrates and garter snakes are often observed around frog breeding sites.

We did not observe any predation on red-legged frogs, and only occasionally did we observe potential predators. Interestingly, no bullfrogs (*Rana catesbeiana*) were observed during our surveys. We did find great blue herons within the study area. Observations elsewhere in Marin County confirm that great blue herons will prey on red-legged frogs (Fellers and Long, *in press*). Herons did not appear to be present in unusually high numbers, and their presence was both expected and welcome.

Short-term Recommendations

Recent activities by the National Park Service have degraded conditions for the Federally-listed California red-legged frog. In particular, the dredging of the stream channel between the pedestrian bridge and the beach has lowered the water table in the lower portion of Redwood Creek. This has caused the breeding area (sites P-143A, B, and C; east of the levee) to dry up, almost certainly before any red-legged frog tadpoles were able to metamorphose. This situation needs to be remedied, or red-legged frogs will be extirpated from the Big Lagoon area.

Recommendations - Marsh restoration

The National Park Service is planning to restore the Big Lagoon portion of Redwood Creek to a more natural condition. This should benefit the red-legged frog, a species that was probably more common there at one time. Restoration plans should take into account 1) impacts on red-legged frogs during the restoration, and 2) conditions within the lagoon after restoration.

Sites P-143A, B, C, and D (Fig. 1) need to be protected during restoration. These include not only the egg laying sites, but also the most

significant non-breeding habitat for red-legged frogs at Big Lagoon (site P-143D). Protection needs to include not only the preservation of the vegetation, but also maintenance of the water table at levels suitable for survival and reproduction (e.g., egg laying through metamorphosis of the tadpoles). The current lowering of the water table is the primary threat to the survival of red-legged frogs in the Redwood Creek drainage.

Both breeding and non-breeding habitat appear to be quite limited at Big Lagoon. Restoration of the lagoon could benefit red-legged frogs if the extent and quality of both breeding and non-breeding sites were improved (U.S. Fish and Wildlife Service, 2002). Non-breeding habitat needs to remain moist throughout the warm, dry summer and fall. Most, but not all, non-breeding sites elsewhere in Marin County have deep pools where frogs can periodically immerse themselves to rehydrate, and perhaps escape predators. Vegetative cover is important to 1) moderate extreme temperatures, 2) provide protection from predators, and 3) support a prey base on which frogs can feed. At Big Lagoon, the cattails are apparently fulfilling this role, but in other parts of Marin County (and to some extent the lower reaches of Green Gulch), red-legged frogs spend the non-breeding season in blackberry thickets, willow thickets, and various combinations of poison oak, nettles, and sword fern.

Red-legged frog breeding habitat is quite variable. Breeding sites need to have a combination of open water with emergent vegetation, and sufficient water to last well into the summer, thereby allowing tadpoles sufficient time to grow and metamorphose. Water depth generally needs to be at least a meter deep. Sites 143A, B, C, and D are good examples of sites with suitable habitat and these sites could serve as a model. However, at all of these sites, water depth is marginally adequate, especially considering that the marsh dried up during summer 2003, and there was apparently no successful reproduction. Given the complexity of the marsh ecosystem, frog habitat requirements, and hydrology, we recommend that the details of marsh restoration be developed in consultation with a herpetologists, hydrologist, and restoration ecologist.

Bullfrogs are not currently present in the Redwood Creek watershed. Restoration of Big Lagoon might favor bullfrogs, especially if permanent pools were to become established. We recommend that the restoration be designed to allow for any standing water to dry during the fall of the driest years (e.g. every 3 - 5 years). Since bullfrog tadpoles need about 16 months to metamorphose, periodic drying of the marsh would break this cycle and reduce the likelihood of a population becoming established. Periodic drying of the marsh would also eliminate any fish that might become established in the marsh.

Summary

Big Lagoon has supported a population of California red-legged frogs for more than a decade, and probably for many hundreds of years. The current population is modest (14 adult frogs), and did not breed successfully in 2003. The lack of breeding success was almost certainly due to an artificial lowering of the water table caused by the dredging of Redwood Creek below the pedestrian bridge. Because of the dredging, most of the marsh dried prematurely, before the red-legged frog tadpoles could metamorphose. The general drying of the marsh has also concentrated nearly all the adult frogs in one small area. It is important to correct this situation, or it is likely that red-legged frogs will become extirpated within the Redwood Creek drainage.

Restoration of Big Lagoon has the potential to enhance the habitat for red-legged frogs. This could be accomplished if the lagoon held more water, and held it for a much longer period of time (e.g., well into the summer). With an improvement in the water-holding capacity of the lagoon, the existing cattails are likely to expand and provide good non-breeding habitat for frogs, as well as habitat for other wildlife.

Unfortunately, it is not practical to attempt to remove frogs prior to construction since they are difficult to catch, and inhabit an area where locating them is extremely difficult. Hence, during restoration, it is important

to avoid disturbance to the southeast portion of the lagoon, since this is where non-breeding red-legged frogs congregate. With care, it should be possible to undertake such as activities as removal or breaching of levees, but activities that would dry the marsh or entail the use of equipment in these areas need to be avoided.

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Table 1. Red-legged frog surveys at Big Lagoon, Redwood Creek, and Green Gulch Creek, Marin County, California. See Figure 1 for locations of sites.

Site	Date	Start Time	Observer Names	Weather	Wind	Air Temp	Water Temp	Site Length	Comment
P-143A	11/12/2002	18:50	P. Kleeman	Overcast/ Rain	Calm, 0	14	13	20	Pairs of TAGR attempting to copulate near gated culvert. Partial moon obscured by clouds.
P-143A	12/5/2002	18:57	G. Guscio	Overcast	Light, <5	12	11	2	South side of levee road at culvert w/ flood gate, Muir Beach
P-143A	12/21/2002	13:26	G. Guscio	Mostly Cloudy/ Rain	Light, <5	11		160	Water highest I have seen. Surveyed shallowest areas around edges, mainly on S side. Much of site too deep for hip waders and probably chest waders too. Staff gauge completely submerged. Water flowing over levee road.
P-143A	1/7/2003	18:09	G. Fellers	Clear	Light, <5	17	11		
P-143A	1/7/2003	14:55	G. Fellers	Clear	Light, <5	19	11		
P-143A	1/15/2003	19:35	P. Kleeman	Clear	Light, <5	9	12	60	Nearly full moon.
P-143A	1/27/2003	19:17	G. Guscio	Clear	Light, <5	11		50	Caught one small RAAU male and one gravid RAAU female.
P-143A	1/28/2003	18:51	G. Guscio	Partly Cloudy	<5	9	12	40	RAAU egg mass found, very new - still compact as if laid within last 24 hours. Caught, radioed, and released male RAAU.

P-143A	2/5/2003	11:20	P. Kleeman	Clear	Mod, 5-20	16	10	40	Water is low at site. Could not locate the RAAU egg mass that was found at this site last week.
P-143A	2/5/2003	20:31	P. Kleeman	Clear	Light, <5	4	8	40	Quarter moon present in the sky. Frog in deepest part of site: "the ditch".
P-143A	2/13/2003	18:59	G. Guscio	Overcast	Light, <5	13	11	100	No moon visible due to overcast skies.
P-143A	2/14/2003	14:19	G. Guscio	Mostly Cloudy	Mod, 5-20	16	14	100	
P-143A	2/20/2003	16:00	G. Guscio	Partly Cloudy	Mod, 5-20	12	12	85	RAAU egg survey.
P-143A	2/20/2003	19:15	G. Guscio	Clear	Light, <5	7	12	85	Attempted to catch RAAU. No moon visible.
P-143A	2/27/2003	19:20	G. Guscio	Clear	Light, <5	6	11	85	No moon visible.
P-143A	3/1/2003	15:53	G. Guscio	Partly Cloudy	Light, <5	14	16	70	Most of site thickly matted with saltgrass.
P-143A	3/12/2003	19:06	G. Guscio	Overcast	Light, <5	12	15	60	Moon not visible - overcast
P-143A	3/19/2003	15:42	P. Kleeman	Overcast	Light, <5	16	16	30	Taricha seen at culvert gate.
P-143A	3/26/2003	17:00	G. Guscio	Clear	Light, <5	12	17	50	No moon visible. Tadpole survey. Water level low and site thickly matted with saltgrass and pennywort - difficult to survey.
P-143A	3/26/2003	21:11	P. Kleeman	Clear	Light, <5	12	13	30	No moon visible. The one RAAU seen ducked under shortly after being sighted.
P-143A	4/7/2003	21:21	G. Guscio, G. Fellers	Clear	Light, <5	8	13	30	Crescent moon
P-143A	4/7/2003	18:44	G. Fellers	Clear	Light, <5	13	13	30	Newts concentrated at culvert.
P-143A	4/9/2003	17:44	G. Guscio	Partly Cloudy	Light, <5	16	15	30	2 minnow traps set at 1509. Checked at 1744. Retrieved at 1946.

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P-143A	4/30/2003	17:06	G. Guscio	Partly Cloudy	Mod, 5-20	16	18	60	
P-143A/B	12/17/2002	18:55	G. Guscio	Partly Cloudy	Light, <5	6	11	120	Flooding has joined sites P-143 A and B. UTMs and locality description define point in middle of flooded area encompassing both sites. Nearly full moon. Cold. RAAU seen in site P-143A near culvert. RAAU seen in site P-143A.
P-143A/B	12/26/2002	16:20	G. Guscio, K. Rawlings	Overcast	Mod, 5-20	12	11	110	Getting dark and thus difficult to see into water toward end of survey.
P-143A/B	12/26/2002	18:22	G. Guscio, K. Rawlings	Overcast/ Rain	Mod, 5-20	12	11	110	RAAU M caught and fitted with telemetry.
P-143A/B	1/23/2003	18:36	P. Kleeman, G. Guscio	Overcast	Calm, 0	13	13	150	No moon visible due to cloud cover. Fog made spotlighting difficult. All but one RAAU found in P-143A, the other in P-143B. Two male RAAU caught and fit with radio transmitters.
P-143A/B	1/23/2003	14:45	P. Kleeman, G. Guscio	Overcast	Calm, 0	14	14	150	RAAU egg survey, none found. Water level up a bit from the recent rain. P-143A and B done as one site since the water was high.
P-143B	11/12/2002	18:45	P. Kleeman	Overcast/ Rain	Calm, 0	14	13	7	Pond has formed in the past week since the first rains of the winter season. Partial moon obscured by clouds.
P-143B	12/11/2002	18:14	G. Guscio	Partly Cloudy	Light, <5	8	10	7	

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P-143B	1/7/2003	15:16	G. Fellers	Clear	Light, <5	19	10		
P-143B	1/7/2003	18:32	G. Fellers		Light, <5	17	10		
P-143B	1/28/2003	18:16	G. Guscio	Partly Cloudy	Light, <5	9	12	45	
P-143B	2/5/2003	20:17	P. Kleeman	Clear	Light, <5	4	8	50	Quarter moon present in the sky. Caught and put a new radio on frog 407F5A174F.
P-143B	2/5/2003	11:39	P. Kleeman	Clear	Mod, 5-20	15	10	50	Found RAAU egg mass in about 0.25 m of water next to patch of cattails in the pond. About 15% of the embryos are not developing properly, possibly because of fungus (photo). Virginia rail calling.
P-143B	2/13/2003	18:27	G. Guscio	Overcast	Light, <5	13	11	35	No moon visible due to overcast skies. 3 RAAU caught, All have pit tags but no transmitters. TATO eggs seen incidentally. Gauge reads 0.82.
P-143B	2/13/2003	16:40	G. Guscio	Overcast	Calm, 0	14	12	35	Not a thorough survey. HYRE heard and TATO eggs seen during a RAAU telemetry check.
P-143B	2/14/2003	16:00	G. Guscio	Mostly Cloudy	Mod, 5-20	15	14	45	Gauge reads 0.74
P-143B	2/20/2003	15:19	G. Guscio	Partly Cloudy	Light, <5	12	12	45	RAAU egg survey and telemetry check. Gauge reads 0.87ft.
P-143B	2/20/2003	19:33	G. Guscio	Clear	Light, <5	7	12	45	1 RAAU caught for telemetry. No moon visible.
P-143B	2/27/2003	19:09	G. Guscio	Clear	Light, <5	7	11	45	No moon visible. Gauge reads 0.70
P-143B	3/1/2003	16:09	G. Guscio	Partly Cloudy	Light, <5	14	14	40	Gauge reads 0.64.

P-143B	3/12/2003	19:13	G. Guscio	Overcast	Light, <5	12	15	35	Gauge reads 0.30. Moon not visible - overcast.
P-143B	3/19/2003	15:53	P. Kleeman	Overcast	Light, <5	16	20	30	Water levels becoming quite shallow at site.
P-143B	3/26/2003	16:29	G. Guscio	Clear	Light, <5	13	17	40	Tadpole survey. Gauge reads 0.50
P-143B	3/26/2003	21:24	G. Guscio	Clear	Light, <5	12	13	40	No moon visible.
P-143B	4/7/2003	19:14	G. Fellers	Clear	Light, <5	12	18	40	
P-143B	4/7/2003	21:16	G. Guscio, G. Fellers	Clear	Light, <5	10	18	40	Gauge reads 0.38. Crescent moon.
P-143B	4/9/2003	17:37	G. Guscio	Partly Cloudy	Light, <5	17	20	10	Staff gauge dry. 2 minnow traps set at 1505. Checked at 1737. Retrieved at 1937.
P-143B	4/30/2003	16:39	G. Guscio	Partly Cloudy	Mod, 5-20	16	24	5	Gauge reads 0.28
P-143C	12/26/2002	15:48	G. Guscio, K. Rawlings	Overcast/ Rain	Mod, 5-20	13	11	110	Intermittent rain. First survey of this site. Gauge currently reads 1.56ft. Five days ago, water covered this area from Hwy 1 to levee road, and gauge was completely submerged.
P-143C	12/26/2002	17:57	G. Guscio, K. Rawlings	Overcast/ Rain	Light, <5	12	11	110	
P-143C	1/7/2003	15:39	G. Fellers	Clear	Light, <5	20	12		Two mallards and a great blue heron
P-143C	1/7/2003	18:56	G. Fellers		Light, <5	17	12		
P-143C	2/13/2003	19:32	G. Guscio	Overcast	Light, <5	12	11	50	No moon visible due to overcast skies. 1 RAAU caught for telemetry
P-143C	2/14/2003	14:35	G. Guscio	Mostly Cloudy	Mod, 5-20	16	20	50	
P-143C	2/20/2003	16:27	G. Guscio	Partly Cloudy	Light, <5	12	14	65	RAAU egg survey. Much algae made site difficult to survey.

P-143C	2/20/2003	18:45	G. Guscio	Clear	Light, <5	9	14	65	Attempted to catch two RAAU. Missed both. No moon visible.
P-143C	2/27/2003	18:53	G. Guscio	Clear	Light, <5	7	11	85	No moon visible.
P-143C	3/1/2003	15:16	G. Guscio	Clear	Light, <5	14	17	100	Egg search; one RAAU mass found about 5m N of gauge - same area where 2 adult frogs have been found.
P-143C	3/26/2003	21:10	G. Guscio	Clear	Light, <5	12	13	50	No moon visible.
P-143C	3/26/2003	15:55	G. Guscio	Clear	Light, <5	15	17	50	Tadpole survey. Abundance of algae in site made dip netting ineffective - nets full of algae.
P-143C	4/7/2003	21:02	G. Guscio, G. Fellers	Clear	Light, <5	10	15	50	Crescent moon
P-143C	4/9/2003	17:21	G. Guscio	Partly Cloudy	Light, <5	17	23	50	2 minnow traps set at 1500. Checked at 1721. Retrieved at 1929.
P-143C	4/30/2003	16:06	G. Guscio	Partly Cloudy	Light, <5	16	16	50	Much algae
P-143D	3/19/2003	14:23	P. Kleeman	Overcast	Light, <5	16	14	10	Came across one RAAU without radio transmitter while I was searching for two radioed frogs that have been using this area; unable to catch it.
P-143D	3/26/2003	17:25	P. Kleeman	Partly Cloudy	Light, <5	16	10	10	Attempted to visually survey this site since radiotagged RAAU have been using it. Impossible to survey from trail and visual survey from within cattails is next to useless. Caught one "new" RAAU here in the daytime and fitted radio

									transmitter to it.
P-143D	4/7/2003	21:41	G. Guscio	Clear	Light, <5	8	13	10	Crescent moon
P-143D	4/9/2003	17:50	G. Guscio	Partly Cloudy	Light, <5	16	13	10	1 minnow trap set at 1514. Checked at 1750. Retrieved at 1952.
P-143D	4/30/2003	19:30	G. Guscio	Partly Cloudy	Light, <5	14	13	10	One RAAU with transmitter seen. One RAAU caught, pit tagged, and fitted with transmitter.
P-161A	11/12/2002	17:50	G. Fellers	Mostly Cloudy/ Rain	Calm, 0	14	13	1000	Seemed like a nice night and habitat for red-legged frogs, but none seen with a careful survey.
P-161A	3/26/2003	19:33	P. Kleeman	Clear	Light, <5	12	13		No moon visible. A fair number of pools along this stretch of creek, and some complex cover along stream banks.
P-161B	11/12/2002	18:25	P. Kleeman	Overcast/ Rain	Calm, 0	14	13	230	Some of these backwater pools are completely independent of Redwood creek at this time of year. Partial moon obscured by clouds.
P-161B	11/12/2002	17:54	G. Guscio, P. Kleeman	Rain	Light, <5	14	13	1000	Partial moon obscured by clouds. Attempting to catch frogs for telemetry but none were found.
P-161B	12/5/2002	18:15	G. Guscio	Overcast	Light, <5	12	11	110	Site known as "backwater" of Redwood Creek

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P-161B	12/11/2002	19:02	G. Guscio	Partly Cloudy	Light, <5	8	11	900	Area adjacent to Muir Beach parking area densely vegetated and difficult to crawl through, let alone survey - did my best. Flow rate same as during previous survey - Low. Again, no RAAU.
P-161B	1/27/2003	18:06	G. Guscio	Clear	Light, <5	12	14	500	Surveyed portion of site from Pacific Way downstream.
P-161B	1/27/2003	15:54	G. Guscio	Partly Cloudy	Mod, 5-20	15	14	500	Surveyed portion of site from Pacific Way downstream. Looked briefly at stream channel, but mainly focused on slowest areas by beach parking lot. Depth and emergent veg look good, but thickly overgrown and slow flowing.
P-161B	3/12/2003	20:11	G. Guscio	Overcast	Light, <5	13	14	50	Surveyed only section including 25m up- and down-stream from culvert from site P-143A. Two telemetered frogs located here as well as two other RAAU. None captured, Half-full moon obscured by clouds.
P-161B	3/31/2003	19:17	G. Guscio	Partly Cloudy	Light, <5	12		1000	No moon. Stream has changed channels over the winter and is now flowing through what was a still backwater late last fall.

P-161B	4/7/2003	21:46	G. Guscio, G. Fellers	Clear	Light, <5	8	14	100	Surveyed only ponded area near gated culvert from P-143A. Crescent moon
P-161B	4/9/2003	17:58	G. Guscio	Partly Cloudy	Light, <5	16	14	100	1 minnow trap set at 1522. Checked at 1758. Retrieved at 2004.
P-161C	12/11/2002	18:35	G. Guscio	Partly Cloudy	Light, <5	8	10	170	"Big Lagoon" - surveyed from outlet to ocean up to downstream end of recently dug channel. Some still water ponding in area of old trail from beach to parking lot, but mostly narrow, stream-like, and flowing.
P-161C	1/27/2003	18:36	G. Guscio	Clear	Light, <5	11	14	70	Water in main channel flowing rapidly. Hyla and Taricha found in small pools east of flowing channel and west of parking area.
P-161C	3/6/2003	16:14	G. Guscio	Clear	Mod, 5-20	14	12	170	Small pools by parking lot all dry. Only water in flume-like channel that meets tidal outlet at beach.
P-302	11/13/2002	19:03	G. Guscio	Partly Cloudy	Calm, 0	10	13	30	Photo taken earlier in evening
P-302	12/10/2002	19:53	G. Guscio	Partly Cloudy	Light, <5	8	10	30	Eastern reservoir
P-302	12/21/2002	14:56	G. Guscio	Partly Cloudy	Light, <5	11	12	100	Water level much higher than last survey. Reservoir full. Difficult to survey - can only look from shore as banks drop off rapidly.

P-302	1/15/2003	13:04	P. Kleeman	Partly Cloudy	Calm, 0	17	14	75	Approximately 25% of the shoreline could not be surveyed for possible egg masses because of overhanging trees and/or steep drop offs into pond.
P-302	1/15/2003	18:48	P. Kleeman	Clear	Calm, 0	10	12	75	Nearly full moon.
P-302	2/5/2003	19:12	P. Kleeman	Clear	Calm, 0	3	10	75	Quarter moon present in the sky. Several ducks left the pond once I began the survey.
P-302	2/5/2003	13:52	P. Kleeman	Clear	Light, <5	14	12	75	Approximately 25% of pond edge could not be surveyed for RAAU egg masses because of overhanging trees/deep water. Water still high enough to reach cattails and decent oviposition sites.
P-302	3/5/2003	14:04	G. Guscio	Clear	Mod, 5-20	17	15	65	
P-302	3/6/2003	19:20	G. Guscio	Clear	Light, <5	8	13	65	Crescent moon. Six mallards seen on pond. One saw-whet owl heard calling.
P-302	4/1/2003	16:18	G. Guscio	Partly Cloudy	Mod, 5-20	12	18	65	Tadpole survey - much dip netting.
P-302	4/30/2003	21:52	G. Guscio	Overcast	Light, <5	10	17	65	
P-303	11/13/2002	17:30	G. Guscio	Rain	Calm, 0	12		20	Photo taken earlier in evening
P-303	12/17/2002	18:06	G. Guscio	Partly Cloudy	Light, <5	6	11	40	Nearly full moon and very little cloud cover. Cold
P-303	1/15/2003	18:02	P. Kleeman	Clear	Calm, 0	11	12	85	Nearly full moon.
P-303	1/15/2003	13:56	P. Kleeman	Partly Cloudy	Calm, 0	17	15	85	Most of the TATO egg masses were attached to a piece of floating tarp that once lined the pond.

									Photo of a TATO in amplexus with what looks like a TAGR.
P-303	2/5/2003	13:16	P. Kleeman	Clear	Light, <5	14	12	85	Water still high enough in pond to reach decent oviposition sites for RAAU.
P-303	2/5/2003	18:34	P. Kleeman	Clear	Calm, 0	6	9	85	Quarter moon present in the sky.
P-303	3/5/2003	15:11	G. Guscio	Clear	Light, <5	16	15	50	Most TATO eggs found on east side of pond. West shore in shade.
P-303	3/6/2003	19:44	G. Guscio	Clear	Light, <5	8	11	50	One mallard seen on pond. Crescent moon.
P-303	4/1/2003	15:15	G. Guscio	Partly Cloudy	Mod, 5-20	11	18	50	Tadpole survey - much dipnetting
P-303	4/30/2003	22:20	G. Guscio	Overcast	Light, <5	10	16	50	
P-577	11/13/2002	19:48	G. Guscio	Partly Cloudy	Calm, 0	10	13	15	Site almost completely overgrown by cattails.
P-577	12/10/2002	18:53	G. Guscio	Partly Cloudy	Light, <5	9	11	15	Parking lot pond, very little of site surveyable (1m x 2m area)
P-577	1/15/2003	19:06	P. Kleeman	Clear	Calm, 0	10	12	15	Nearly full moon.
P-577	3/5/2003	13:30	G. Guscio	Partly Cloudy	Light, <5	13	12	10	Upstream end of site (previously flowing) is now a pool.
P-577	3/6/2003	18:51	G. Guscio	Clear	Light, <5	8	11	10	Crescent moon
P-577	4/1/2003	19:35	G. Guscio	Partly Cloudy	Mod, 5-20	8	14	10	
P-578	12/21/2002	14:31	G. Guscio	Partly Cloudy	Light, <5	11	12	30	Egg survey. Almost completely overgrown with cattails. Water very high, flowing, and highly turbid.
P-578	4/1/2003	19:17	G. Guscio	Partly Cloudy	Light, <5	8	14	45	Boards have been placed at outflow - Water level up about two feet. No moon.

P-579	11/13/2002	18:27	G. Guscio	Mostly Cloudy	Calm, 0	11	15	40	"Zendo Pond" - photo taken earlier in evening.
P-579	12/10/2002	19:04	G. Guscio	Mostly Cloudy	Light, <5	9	12	40	Zendo pond
P-579	1/15/2003	18:27	P. Kleeman	Clear	Calm, 0	11	12	85	Nearly full moon.
P-579	1/15/2003	14:41	P. Kleeman	Clear	Calm, 0	15	14	85	
P-579	2/5/2003	14:37	P. Kleeman	Clear	Light, <5	14	12	85	The Green Gulch people have removed a fair amount of the non-native floating veg (Elodea?) from the pond and have it sitting on tarps next to the pond.
P-579	2/5/2003	19:36	P. Kleeman	Clear	Calm, 0	3	9	85	Quarter moon present in the sky.
P-579	3/5/2003	16:03	G. Guscio	Clear	Light, <5	13	19	65	
P-579	3/6/2003	19:04	G. Guscio	Clear	Light, <5	8	13	65	Crescent moon
P-579	4/1/2003	17:02	G. Guscio	Partly Cloudy	Mod, 5-20	11	16	60	Tadpole survey. Boards have been place at outflow - Water level up about two feet.
P-579	4/1/2003	18:56	G. Guscio	Partly Cloudy	Light, <5	8	16	60	
P-580	11/13/2002	17:57	G. Guscio	Mostly Cloudy	Calm, 0	11	13	15	
P-580	12/10/2002	19:27	G. Guscio	Mostly Cloudy	Light, <5	9	11	15	Pond by American Airlines Storage shed. American airlines shed pond.
P-581	3/26/2003	20:01	G. Guscio	Clear	Light, <5	12	12	860	No moon visible. Bedrock is checked as predominate for substrate, but it is actually concrete that lines a portion of the streambed.
P-583	12/5/2002	18:05	G. Guscio	Overcast	Light, <5	13	11	75	RAAU found in water next to log at (537490E, 4190513N - NAD27)
P-583	12/17/2002	19:33	G. Guscio	Partly Cloudy	Light, <5	6	10	70	Nearly full moon. Cold

P-583	12/21/2002	12:50	G. Guscio	Mostly Cloudy/ Rain	Light, <5	12	11	75	Egg survey. Light rain
P-583	12/26/2002	15:18	G. Guscio, K. Rawlings	Overcast	Mod, 5-20	13	11	100	
P-583	12/26/2002	18:21	G. Guscio, K. Rawlings	Overcast	Mod, 5-20	12	11	100	Intermittent light rain
P-583	1/7/2003	16:17	G. Fellers	Clear	Light, <5	19	11		
P-583	1/7/2003	19:27	G. Fellers	Clear	Calm, 0	17	10		
P-583	1/23/2003	20:28	G. Guscio	Overcast	Light, <5	13	12	65	No moon visible.
P-583	2/20/2003	18:28	G. Guscio	Clear	Light, <5	10	12	40	
P-583	3/1/2003	14:50	G. Guscio	Partly Cloudy	Light, <5	14	12	80	Vegetation covering surface of water throughout much of site.
P-583	3/26/2003	15:24	G. Guscio	Partly Cloudy	Light, <5	15	13	80	Tadpole survey. Thick growth of pennywort and duckweed made dipnetting difficult.
P-583	3/31/2003	20:29	G. Guscio	Partly Cloudy	Light, <5	12	13	80	No moon.
P-583	4/7/2003	20:51	G. Guscio, G. Fellers	Clear	Light, <5	10	13	80	Crescent moon
P-583	4/9/2003	17:01	G. Guscio	Partly Cloudy	Light, <5	17	14	80	3 minnow traps set at 1450. Checked at 1715. Retrieved at 1914.
P-584	1/7/2003	16:02	G. Fellers	Clear	Light, <5	19	12	20	
P-584	1/7/2003	19:16	G. Fellers		Light, <5	16	11	20	
P-584	1/25/2003	14:33	G. Guscio	Partly Cloudy	<5	19	21	30	Shallow and scummy. HYRE masses silt-covered and difficult to see.
P-584	2/13/2003	18:07	G. Guscio	Overcast	Light, <5	13	14	25	No moon visible due to overcast skies.
P-584	2/13/2003	15:17	G. Guscio	Overcast/ Rain	Light, <5	14	14	25	
P-584	3/5/2003	17:17	G. Guscio	Clear	Light, <5	13		25	

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P-584	3/26/2003	14:54	G. Guscio	Partly Cloudy	Light, <5	15	26	30	Tadpole survey.
P-584	4/7/2003	19:30	G. Fellers	Clear	Light, <5	11	16	30	
P-585	1/23/2003	20:52	P. Kleeman	Overcast	Calm, 0	13	13	65	Overcast skies blocking out the moon. One inch PVC piping and garden hose extending into ditch from somewhere upstream on other side of Hwy. 1.
P-585	1/25/2003	15:08	G. Guscio	Partly Cloudy	<5	19	14	65	
P-586	1/23/2003	20:52	G. Guscio	Overcast	Light, <5	13		80	First survey of site. Shallow and slow flowing. HYRE calling from smaller ditch that drains into this site.
P-586	1/25/2003	14:10	G. Guscio	Partly Cloudy	Light, <5	19	15	80	
P-586	3/6/2003	16:44	G. Guscio	Clear	Light, <5	14		3	A few small shallow puddles, but otherwise dry.

Table 2. Summary of red-legged frog surveys at Big Lagoon, Redwood Creek, and Green Gulch Creek, Marin County, California. See Figure 1 for locations of sites.

Site	Diurnal Surveys	Nocturnal Surveys	Adults (maximum # detected during a single survey)	Egg Masses (estimated total for season)	Tadpoles (maximum # detected during a single survey)
P-143A	10	16	6	1	0
P-143B	12	15	5	1	1
P-143C	8	7	2	1	0
P-143D	4	1	3	0	0
P-161A	0	2	0	0	0
P-161B	1	9	4	0	0
P-161C	1	2	0	0	0
P-302	5	6	0	0	0
P-303	4	6	0	0	0
P-577	2	4	0	0	0
P-578	1	1	0	0	0
P-579	6	4	0	0	0
P-580	0	2	0	0	0
P-581	0	1	0	0	0
P-583	8	8	1	0	0
P-584	5	3	0	0	0
P-585	1	1	0	0	0
P-586	2	1	0	0	0

Table 3. Red-legged frog surveys at Big Lagoon, Redwood Creek, and Green Gulch Creek, Marin County, California. See Figure 1 for locations of sites.

Species	Site	Date	Adult	Subadult	Larvae	Egg Masses	Comment
<i>Hyla regilla</i>	P-143A	12/5/2002	1				
<i>Hyla regilla</i>	P-143A	12/21/2002	2				
<i>Hyla regilla</i>	P-143A	1/7/2003	4				
<i>Hyla regilla</i>	P-143A	1/7/2003	25				
<i>Hyla regilla</i>	P-143A	1/15/2003	40				
<i>Hyla regilla</i>	P-143A	1/27/2003	40				
<i>Hyla regilla</i>	P-143A	1/28/2003	35				
<i>Hyla regilla</i>	P-143A	2/13/2003	25				
<i>Hyla regilla</i>	P-143A	2/14/2003	2				
<i>Hyla regilla</i>	P-143A	2/20/2003				2	
<i>Hyla regilla</i>	P-143A	2/20/2003	50				
<i>Hyla regilla</i>	P-143A	2/27/2003	40				
<i>Hyla regilla</i>	P-143A	3/12/2003	30				
<i>Hyla regilla</i>	P-143A	3/26/2003	2		12	1	
<i>Hyla regilla</i>	P-143A	3/26/2003	1				
<i>Hyla regilla</i>	P-143A	3/26/2003	12				
<i>Hyla regilla</i>	P-143A	4/7/2003	15				
<i>Hyla regilla</i>	P-143A/B	12/17/2002	7				
<i>Hyla regilla</i>	P-143A/B	12/26/2002	2				
<i>Hyla regilla</i>	P-143A/B	12/26/2002	4				
<i>Hyla regilla</i>	P-143A/B	1/23/2003	10				
<i>Hyla regilla</i>	P-143A/B	1/23/2003	40				
<i>Hyla regilla</i>	P-143B	1/7/2003	1				

<i>Hyla regilla</i>	P-143B	1/7/2003	33				
<i>Hyla regilla</i>	P-143B	1/28/2003	25				
<i>Hyla regilla</i>	P-143B	2/5/2003	1				
<i>Hyla regilla</i>	P-143B	2/13/2003	10				
<i>Hyla regilla</i>	P-143B	2/13/2003	40				
<i>Hyla regilla</i>	P-143B	2/14/2003	8				
<i>Hyla regilla</i>	P-143B	2/20/2003	2			15	Egg masses difficult to see, laid in algae and silt covered.
<i>Hyla regilla</i>	P-143B	2/20/2003	50				
<i>Hyla regilla</i>	P-143B	2/27/2003	20				
<i>Hyla regilla</i>	P-143B	3/1/2003	3			5	
<i>Hyla regilla</i>	P-143B	3/12/2003	35				
<i>Hyla regilla</i>	P-143B	3/26/2003	18				
<i>Hyla regilla</i>	P-143B	4/7/2003	2		13		
<i>Hyla regilla</i>	P-143B	4/7/2003	30				
<i>Hyla regilla</i>	P-143B	4/9/2003	2				
<i>Hyla regilla</i>	P-143C	12/26/2002	2			1	1 Egg mass
<i>Hyla regilla</i>	P-143C	12/26/2002	3				
<i>Hyla regilla</i>	P-143C	1/28/2003	25				
<i>Hyla regilla</i>	P-143C	2/13/2003	20				
<i>Hyla regilla</i>	P-143C	2/14/2003	3				
<i>Hyla regilla</i>	P-143C	2/20/2003	2				
<i>Hyla regilla</i>	P-143C	2/20/2003	60				
<i>Hyla regilla</i>	P-143C	2/27/2003	40				
<i>Hyla regilla</i>	P-143C	3/1/2003	1				
<i>Hyla regilla</i>	P-143C	3/26/2003	1		1		
<i>Hyla regilla</i>	P-143C	3/26/2003	15				
<i>Hyla regilla</i>	P-143C	4/7/2003	20				
<i>Hyla regilla</i>	P-143D	4/7/2003	4				

<i>Hyla regilla</i>	P-161B	11/12/2002	1				Single individual calling near bridge where Pacific Way crosses redwood cr.
<i>Hyla regilla</i>	P-161B	12/5/2002	2				Calling
<i>Hyla regilla</i>	P-161B	1/27/2003	2				
<i>Hyla regilla</i>	P-161B	4/7/2003	1				
<i>Hyla regilla</i>	P-161C	1/27/2003	30				
<i>Hyla regilla</i>	P-302	12/10/2002	1				
<i>Hyla regilla</i>	P-302	1/15/2003	1				
<i>Hyla regilla</i>	P-302	1/15/2003	3				
<i>Hyla regilla</i>	P-302	3/5/2003	2			2	
<i>Hyla regilla</i>	P-302	3/6/2003	10				
<i>Hyla regilla</i>	P-302	4/1/2003	1				
<i>Hyla regilla</i>	P-303	11/13/2002	1				Calling from trees west of site
<i>Hyla regilla</i>	P-303	1/15/2003	1				
<i>Hyla regilla</i>	P-303	1/15/2003	6				
<i>Hyla regilla</i>	P-303	2/5/2003	6				
<i>Hyla regilla</i>	P-303	3/5/2003	2			4	
<i>Hyla regilla</i>	P-303	3/6/2003	5				
<i>Hyla regilla</i>	P-303	4/1/2003	2				
<i>Hyla regilla</i>	P-578	4/1/2003	8				
<i>Hyla regilla</i>	P-579	4/1/2003	4				
<i>Hyla regilla</i>	P-581	3/26/2003	4				
<i>Hyla regilla</i>	P-583	12/21/2002	2				
<i>Hyla regilla</i>	P-583	12/26/2002	3				
<i>Hyla regilla</i>	P-583	12/26/2002	2				
<i>Hyla regilla</i>	P-583	1/23/2003	2				
<i>Hyla regilla</i>	P-583	2/20/2003	2				
<i>Hyla regilla</i>	P-583	3/1/2003	2				
<i>Hyla regilla</i>	P-583	3/26/2003	1				

<i>Hyla regilla</i>	P-583	3/31/2003	12				
<i>Hyla regilla</i>	P-583	4/7/2003	15				
<i>Hyla regilla</i>	P-584	1/7/2003	14				
<i>Hyla regilla</i>	P-584	1/25/2003	2		3	5	Masses and newly hatched larvae
<i>Hyla regilla</i>	P-584	2/13/2003	4		30		
<i>Hyla regilla</i>	P-584	2/13/2003	30				
<i>Hyla regilla</i>	P-584	3/5/2003			45		
<i>Hyla regilla</i>	P-584	3/26/2003			75		
<i>Hyla regilla</i>	P-584	4/7/2003			250		
<i>Hyla regilla</i>	P-586	1/23/2003	5				Calling from smaller ditch that drains into this site.
<i>Rana aurora</i>	P-143A	1/7/2003	1				Transmitted and tagged
<i>Rana aurora</i>	P-143A	1/15/2003	4				
<i>Rana aurora</i>	P-143A	1/27/2003	6				Caught one small male and one gravid female.
<i>Rana aurora</i>	P-143A	1/28/2003	4			1	
<i>Rana aurora</i>	P-143A	2/5/2003	1				
<i>Rana aurora</i>	P-143A	2/20/2003	1				
<i>Rana aurora</i>	P-143A	3/26/2003			1		
<i>Rana aurora</i>	P-143A	3/26/2003	1				
<i>Rana aurora</i>	P-143A/B	12/17/2002	1				In site P-143A
<i>Rana aurora</i>	P-143A/B	12/26/2002	1				Captured for telemetry
<i>Rana aurora</i>	P-143A/B	1/23/2003	7				
<i>Rana aurora</i>	P-143B	1/7/2003	1				
<i>Rana aurora</i>	P-143B	2/5/2003				1	
<i>Rana aurora</i>	P-143B	2/5/2003	2				
<i>Rana aurora</i>	P-143B	2/13/2003	5				3 Captured for telemetry
<i>Rana aurora</i>	P-143B	2/20/2003				1	
<i>Rana aurora</i>	P-143B	2/20/2003	4				1 Caught for telemetry
<i>Rana aurora</i>	P-143B	2/27/2003	1				

<i>Rana aurora</i>	P-143C	2/13/2003	1				1 Caught for telemetry
<i>Rana aurora</i>	P-143C	2/20/2003	3				
<i>Rana aurora</i>	P-143C	2/27/2003	2				
<i>Rana aurora</i>	P-143C	3/1/2003				1	
<i>Rana aurora</i>	P-143D	3/19/2003	1				
<i>Rana aurora</i>	P-143D	3/26/2003	1				
<i>Rana aurora</i>	P-143D	4/7/2003	3				
<i>Rana aurora</i>	P-161B	3/12/2003	4				
<i>Rana aurora</i>	P-583	12/5/2002	1				UTMs recorded
<i>Taricha granulosa</i>	P-143A	11/12/2002	6				
<i>Taricha granulosa</i>	P-143A	12/5/2002	9				
<i>Taricha granulosa</i>	P-143A	1/7/2003	1				
<i>Taricha granulosa</i>	P-143A	3/1/2003	1				
<i>Taricha granulosa</i>	P-143A	3/26/2003					
<i>Taricha granulosa</i>	P-143A	4/7/2003	45		8		
<i>Taricha granulosa</i>	P-143A	4/7/2003	2				
<i>Taricha granulosa</i>	P-143A/B	12/26/2002	2				
<i>Taricha granulosa</i>	P-143A/B	12/26/2002	2				
<i>Taricha granulosa</i>	P-143A/B	1/23/2003	18				
<i>Taricha granulosa</i>	P-143B	1/7/2003	2				Amplexing
<i>Taricha granulosa</i>	P-143B	2/20/2003	1				
<i>Taricha granulosa</i>	P-143C	2/27/2003	1				
<i>Taricha granulosa</i>	P-143C	4/9/2003	1				Minnow trap
<i>Taricha granulosa</i>	P-143D	4/9/2003	1				Minnow trap
<i>Taricha granulosa</i>	P-161B	12/5/2002	6				Three amplexing pairs
<i>Taricha granulosa</i>	P-161B	1/27/2003	2				Pair in amplexus
<i>Taricha granulosa</i>	P-161B	3/12/2003	6				
<i>Taricha granulosa</i>	P-161B	3/31/2003	3				
<i>Taricha granulosa</i>	P-161B	4/7/2003	3				
<i>Taricha granulosa</i>	P-161B	4/9/2003	9				Minnow trap

<i>Taricha granulosa</i>	P-302	11/13/2002	24		7		Same as photo from western reservoir subs about 4cm - photos taken
<i>Taricha granulosa</i>	P-302	12/10/2002	3				
<i>Taricha granulosa</i>	P-302	12/21/2002	1				Walking near pond.
<i>Taricha granulosa</i>	P-302	1/15/2003	6				
<i>Taricha granulosa</i>	P-302	2/5/2003	2				
<i>Taricha granulosa</i>	P-302	3/5/2003	15				3 Amplexing pairs
<i>Taricha granulosa</i>	P-302	4/1/2003	1				
<i>Taricha granulosa</i>	P-303	11/13/2002	75				
<i>Taricha granulosa</i>	P-303	12/17/2002	7		3		
<i>Taricha granulosa</i>	P-303	1/15/2003	5		1		
<i>Taricha granulosa</i>	P-303	3/5/2003	27				
<i>Taricha granulosa</i>	P-303	4/1/2003	6		4		
<i>Taricha granulosa</i>	P-577	3/5/2003	6				
<i>Taricha granulosa</i>	P-577	4/1/2003	3		8		
<i>Taricha granulosa</i>	P-579	11/13/2002	7				Two amplexing pairs, others single same as photo for western reservoir
<i>Taricha granulosa</i>	P-579	1/15/2003	1				
<i>Taricha granulosa</i>	P-579	2/5/2003	3				
<i>Taricha granulosa</i>	P-579	4/1/2003	3				
<i>Taricha granulosa</i>	P-579	4/1/2003	3				
<i>Taricha granulosa</i>	P-580	11/13/2002	3				Same as photo from western reservoir
<i>Taricha granulosa</i>	P-581	3/26/2003	1				
<i>Taricha granulosa</i>	P-583	12/26/2002	2				Pair in amplexus
<i>Taricha granulosa</i>	P-583	4/9/2003			1		
<i>Taricha sp.</i>	P-143A	12/5/2002	3				
<i>Taricha sp.</i>	P-143A	12/21/2002	10				
<i>Taricha sp.</i>	P-143A	2/14/2003	2				

<i>Taricha sp.</i>	P-143A	3/1/2003	1				
<i>Taricha sp.</i>	P-143A	3/19/2003	3				
<i>Taricha sp.</i>	P-143A/B	1/23/2003	4				
<i>Taricha sp.</i>	P-143B	2/20/2003	1				
<i>Taricha sp.</i>	P-143C	12/26/2002	1				Male
<i>Taricha sp.</i>	P-161B	12/5/2002	4				
<i>Taricha sp.</i>	P-161B	4/7/2003	7				
<i>Taricha sp.</i>	P-161C	1/27/2003	2				Pair in amplexus
<i>Taricha sp.</i>	P-302	12/10/2002	11				
<i>Taricha sp.</i>	P-302	12/21/2002	1				
<i>Taricha sp.</i>	P-302	1/15/2003	5				
<i>Taricha sp.</i>	P-302	3/6/2003	2				
<i>Taricha sp.</i>	P-302	4/1/2003	2		1		
<i>Taricha sp.</i>	P-303	12/17/2002	9				
<i>Taricha sp.</i>	P-303	1/15/2003	10				
<i>Taricha sp.</i>	P-303	3/5/2003	7				
<i>Taricha sp.</i>	P-303	3/6/2003	2				
<i>Taricha sp.</i>	P-303	4/1/2003	2				
<i>Taricha sp.</i>	P-577	3/6/2003	1				
<i>Taricha sp.</i>	P-577	4/1/2003	2				
<i>Taricha sp.</i>	P-579	1/15/2003	1				
<i>Taricha sp.</i>	P-579	1/15/2003	7				
<i>Taricha sp.</i>	P-579	2/5/2003	2				
<i>Taricha sp.</i>	P-579	3/5/2003	3				
<i>Taricha sp.</i>	P-579	4/1/2003	2				
<i>Taricha sp.</i>	P-581	3/26/2003			12		
<i>Taricha torosa</i>	P-143A	2/5/2003	1				
<i>Taricha torosa</i>	P-143A	2/14/2003				2	
<i>Taricha torosa</i>	P-143A	2/20/2003				2	
<i>Taricha torosa</i>	P-143A	3/1/2003				5	

<i>Taricha torosa</i>	P-143A	3/26/2003			3		
<i>Taricha torosa</i>	P-143A/B	1/23/2003	1				
<i>Taricha torosa</i>	P-143B	2/13/2003	1			3	
<i>Taricha torosa</i>	P-143B	2/13/2003				5	
<i>Taricha torosa</i>	P-143B	2/14/2003				4	
<i>Taricha torosa</i>	P-143B	2/20/2003				2	
<i>Taricha torosa</i>	P-161B	1/27/2003	1				
<i>Taricha torosa</i>	P-161B	3/12/2003	30			25	
<i>Taricha torosa</i>	P-161B	4/7/2003	5				
<i>Taricha torosa</i>	P-161B	4/9/2003	3				Minnow trap
<i>Taricha torosa</i>	P-302	1/15/2003	1				
<i>Taricha torosa</i>	P-302	3/5/2003				2	
<i>Taricha torosa</i>	P-303	1/15/2003	7			21	
<i>Taricha torosa</i>	P-303	2/5/2003	4			7	
<i>Taricha torosa</i>	P-303	3/5/2003	1			35	
<i>Taricha torosa</i>	P-303	4/1/2003	2		10	6	Six hatched egg masses found.
<i>Taricha torosa</i>	P-577	3/6/2003	1				
<i>Taricha torosa</i>	P-579	3/5/2003	3				
<i>Taricha torosa</i>	P-581	3/26/2003	5				

Table 4. California red-legged frogs with radiotransmitters at Big Lagoon, Marin Co, CA.

Original Capture	Location	Sex	Length (cm)	Weight (g)	Weight Gain or Loss (g)	Days Tracked	Distance Moved (m)	PIT tag #
12/27/02	P-143A	M	9.0	94.0	na	41	30	407F45153F
01/07/03	P-143A	M	9.1	59.0	-5.5	71	70	407F59173C
01/24/03	P-143A	M	8.5	78.8	-15.8	130	110	407F657552
01/24/03	P-143A	M	8.5	82.7	na	48	20	407F4B7C1C
01/29/03	P-143A	M	8.5	83.5	-8.5	16	20	407F5A174F
02/13/03	P-143C	M	8.2	54.7	na	110	25	407F5B3930
02/21/03	P-143B	M	8.7	70.2	na	34	100	407F654973
03/27/03	P-143D	M	8.7	72.6	-0.9	68	0	407F476A17
05/01/03	P-143D	M	9.5	93.0	6.0	83	390	407F575074

Na = Not available because frog was not recaptured.

Table 5. Red-legged frogs with PIT tags and radiotransmitters, Big Lagoon, Marin Co., CA.

PIT Tag	Date	Site	Mapped Location	Moved	Comments
407F45153F	12/26/2002	P-143A/B	A		First capture.
407F45153F	12/31/2002	P-143B	A		Present in pond - Water level too high to search area of site where frog believed to be located.
407F45153F	1/7/2003	P-143A	B		Apparently moved, now 23m SE of culvert gate
407F45153F	1/15/2003	P-143A	A	35m NE	Underwater in ditch, ~3 m from frog 711. Seen later that evening, but unable to catch
407F45153F	1/23/2003	P-143A	A	20m ESE	In cattails.
407F45153F	1/28/2003	P-143A	A		Under water; not seen. Same UTM's as 244
407F45153F	2/5/2003	P-143A	A		Recovered transmitter from under rushes at the edge of the ditch.
407F476A17	3/26/2003	P-143D	A		First capture, was floating on surface in daytime. 23 beads.
407F476A17	3/31/2003	P-143D	A		Same location as previously.
407F476A17	4/7/2003	P-143D	A	5m NE	
407F476A17	4/22/2003	P-143D	A	~3m S	
407F476A17	4/30/2003	P-143D	A		Same location as previously.
407F476A17	5/15/2003	P-143D	A		Caught. Transmitter fitting well.
407F476A17	6/3/2003	P-143D			No signal, checked from various points in Green gulch and Redwood creek drainages on this and three successive dates. Assume transmitter failed.
407F4B7C1C	1/23/2003	P-143A	A		First capture, radioed and released this evening. 24 Beads
407F4B7C1C	1/28/2003	P-143A	A		Same location as previously.
407F4B7C1C	2/5/2003	P-143A	A		Same location as previously.
407F4B7C1C	2/13/2003	P-143A	A		Dropped transmitter - recovered.
407F4B7C1C	2/14/2003	P-143B	B		Recaptured, retransmitted, and released. 23 beads. (was freq 481)
407F4B7C1C	2/20/2003	P-143B	C	15m N	About 10m North of cattails
407F4B7C1C	2/21/2003	P-143B	C	15m E	Located in cattail stand at south end of site

407F4B7C1C	2/27/2003	P-143B	C		About 10m North of cattails
407F4B7C1C	3/12/2003	P-143B	C		Recovered transmitter. Same location as last two checks.
407F575074	4/30/2003	P-143D	A		First capture; pit tagged and transmittered
407F575074	5/15/2003	P-143D	A		
407F575074	6/3/2003	P-581	F	390m NE	Tracked frog to this point on Green gulch creek, did not have time to visually locate frog.
407F575074	6/12/2003	P-581	F		Caught on bank next to 0.4 m deep pool. Added 1 bead to belt since it was beginning to bind.
407F575074	6/19/2003	P-581	F		Same location as previously.
407F575074	7/17/2003	P-581	F		Was sitting on bank, 0.8 m from water, jumped into water.
407F575074	7/22/2003	P-581	F		Sitting in exact same spot as last week, removed transmitter, frog in good shape.
407F59173C	1/8/2003	P-143A	A		First capture, caught on 7 Jan 03
407F59173C	1/15/2003	P-143A	B	20 m NE	Underwater in ditch, ~3 m from frog 69. Seen later that evening, but unable to catch.
407F59173C	1/23/2003	P-143A	B		Same location as previously.
407F59173C	1/28/2003	P-143A	B		Same location as previously.
407F59173C	2/5/2003	P-143A	B		Same location as previously.
407F59173C	2/13/2003	P-143A	B		
407F59173C	2/14/2003	P-143A	B		Recovered transmitter. Same location as previously.
407F59173C	2/21/2003	P-143B	C	20m N	Recaptured, retransmittered, released. 21 beads. (Was freq 711)
407F59173C	2/27/2003	P-143A	D	50m S	Skinny
407F59173C	3/12/2003	P-161B	E		In channel of P-161B adjacent to levee road "20m W of culvert from site P-143A.
407F59173C	3/19/2003	P-161B	E		Signal seems to be from middle of channel, suspect dropped.
407F59173C	3/26/2003	P-161B	E		Suspect dropped, in middle of channel.
407F59173C	3/31/2003	P-161B	E		Same location as previously. Suspect dropped transmitter.
407F59173C	4/7/2003	P-161B	E		Recovered transmitter.
407F5A174F	1/28/2003	P-143A	A		First capture, radioed released this evening

407F5A174F	2/5/2003	P-143A	A		This frog was previously 984, lost transmitter, transmitter failed. Now freq 148, 25 beads.
407F5A174F	2/13/2003	P-143B	A		Dropped transmitter - recovered.
407F5A174F	2/14/2003	P-143B	A		Recaptured, retransmitted, and released. 23 beads. (was freq 148)
407F5A174F	2/20/2003	P-143B	A		Same location as previously.
407F5A174F	2/21/2003	P-143B	A		Located about 5m into cattail stand at south end of site.
407F5A174F	2/27/2003	P-143A	A	15m S	Located in thick salt grass about 3 meters upstream from culvert with gate
407F5A174F	3/12/2003	P-143A	A		Recovered transmitter. Same location as last check.
407F5B3930	2/14/2003	P-143C	A		First capture last night. PIT tagged, transmittered, and released today. 21 beads.
407F5B3930	2/20/2003	P-143C	A		Frog seen during site survey.
407F5B3930	2/27/2003	P-143C	A		Same location as previously.
407F5B3930	3/19/2003	P-143D	B	250 m S	In cattails near trail junction of adult red-legged frog on surface 3 m from signal, could not catch.
407F5B3930	3/26/2003	P-143D	B	2 m	May have touched the frog underwater, signal moved during search.
407F5B3930	3/31/2003	P-143D	B		Same location as previously.
407F5B3930	4/7/2003	P-143D	B	5m W	Captured during site survey. Frog looks good - no apparent wear from transmitter.
407F5B3930	4/22/2003	P-143D	B	~5m W	
407F5B3930	4/30/2003	P-143D	B		Same location as previously.
407F5B3930	5/15/2003	P-143D	B		
407F5B3930	6/3/2003	P-143D	B		No signal, checked from various points in Green gulch and Redwood creek drainages on this and three successive dates. Assume transmitter failed.
407F654973	2/20/2003	P-143B	A		First capture.
407F654973	2/27/2003	P-143D	B	100m SW	In cattails near trail junctions (coast trail - beach - levee road)
407F654973	3/12/2003	P-143D	B		Same location as previously.
407F654973	3/19/2003	P-143D	B		Same location as previously.
407F654973	3/26/2003	P-143D	B		Recovered transmitter in deepest pool of cattail patch near trail junction.

407F657552	1/23/2003	P-143A	A		First capture, radioed and released this evening. 25 Beads
407F657552	1/28/2003	P-143A	A		Same location as previously. Same UTMs. Captured frog - looks good.
407F657552	2/5/2003	P-143A	A		Same location as previously.
407F657552	2/13/2003	P-143A	A		Dropped transmitter - recovered.
407F657552	2/14/2003	P-143B	B		Recaptured, retransmitted, and released. 23 beads. (was freq 244)
407F657552	2/20/2003	P-143B	B		Same location as previously.
407F657552	2/21/2003	P-143B	B	10m E	Located in cattail stand at south end of site
407F657552	2/27/2003	P-143B	B		Same location as previously.
407F657552	3/12/2003	P-161B	C	20m W	About 5m north of culvert at water's edge by levee road
407F657552	3/19/2003	P-161B	C		At waters edge 4 m upstream of culvert, under overhung bank.
407F657552	3/26/2003	P-161B	C	0.3 m	Moved only slightly from last week.
407F657552	3/31/2003	P-161B	D	40m N	
407F657552	4/7/2003	P-143C	E	50m N	
407F657552	4/22/2003	P-143C	D	~30m SW	
407F657552	4/30/2003	P-143C	D	20m SE	Wound-small hole on side, about the size of an individual bead. Replaced belt with 23 bead belt
407F657552	5/15/2003	P-143D	B	60 m S	Moved 60 m S to P-143D
407F657552	6/3/2003	P-143D	B		No signal, checked from various points in Green gulch and Redwood creek drainages on this and three successive dates. Assume transmitter failed.

Table 6. Habitat description for survey sites along lower Redwood Creek and Green Gulch Creeks, Marin Co., CA.

Site	Date	Length Aquatic Habitat (m)	Width Aquatic Habitat (m)	Water Depth (m)	Maximum Water Depth (m)	Turbidity (0 = clear, 5 = opaque)	Mid- day Shade (% cover)	Rooted Vegetation (% cover)	Floating Vegeta- tion (% cover)
P-142	11/12/2002	230	3	0	1	3	60	30	10
P-143A	11/12/2002	20	5	0	1	3	0	70	0
P-143B	11/12/2002	7	5	0	0	2	0	50	0
P-143C	12/26/2002	110	45	0	1	3	0	90	0
P-143D	3/19/2003	10	10	0.8	1	3	5	70	20
P-161A	11/12/2002	1000	2	0	1	0	0	0	0
P-161B	11/12/2002	1000	2	0	1	3	80	10	10
P-161C	12/11/2002	170	2	0	1	3	5	25	5
P-221	4/1/2003	35	15	1	1.6	4	0	3	0
P-302	11/13/2002	30	20	0	1	3	0	0	5
P-303	11/13/2002	20	15	0	2	3	0	0	0
P-577	11/13/2002	15	10	0	1	2	20	90	10
P-578	12/21/2002	30	20	1	2	4	5	95	0
P-579	11/13/2002	40	25	1	1	3	5	10	80
P-580	11/13/2002	15	7	1	1	2	20	30	0
P-581	3/26/2003	860	1	0.1	2	3	80	20	0
P-583	12/5/2002	75	4	0	0	3	65	20	10
P-584	1/7/2003	20	8	0	1	2	10	5	2
P-585	1/23/2003	65	1.5	0.7	1	4	5	0	0
P-586	1/23/2003	80	3	0.2	0.5	4	25	10	0

Table 7. Subjective evaluation of breeding and non-breeding habitat for red-legged frogs. Sites rated zero have no obvious potential. Other sites were scored from 1 (=poor) to 5 (high) potential. Numbers in bold indicate that eggs, tadpoles, or frogs have been observed during the breeding or non-breeding season.

Site	Subjective Breeding Potential	Subjective Non-Breeding Potential	Comment
P-143A	4	2	Good breeding habitat, but the site dries so early it its not rated 5 for breeding. It does not provide much cover or moisture for non-breeding.
P-143B	4	2	Good breeding habitat, but the site dries so early it its not rated 5 for breeding. It does not provide much cover or moisture for non-breeding.
P-143C	4	2	Good breeding habitat, but the site dries so early it its not rated 5 for breeding. It does not provide much cover or moisture for non-breeding.
P-143D	1	5	Outstanding non-breeding habitat. Too dense for breeding.
P-161A	0	3	Redwood Creek flows too fast for breeding, and winter flows probably reduce good non-breeding habitat.
P-161B	3	5	This section of Redwood Creek has some breeding potential, and high non-breeding because the flows are reduced, and there is good cover along with deeper pools.
P-161C	0	3	Lower section of Redwood Creek does not offer very good habitat, though some frogs might find suitable non-breeding habitat.
P-302	0	1	Steep-sided pool offers little for red-legged frogs with little emergent vegetation.
P-303	0	1	Steep-sided pool offers little for red-legged frogs with little emergent vegetation.
P-577	0	2	Some non-breeding potential, but limited habitat with other, much better sites nearby.
P-578	0	2	Some non-breeding potential, but limited habitat with other, much better sites

			nearby.
P-579	0	1	Largely barren, lacks good cover.
P-580	0	1	Not much here for frogs.
P-581	1	5	Shady and overgrown with thickets and willows. Makes for good non-breeding habitat, but same features likely exclude breeding.
P-583	2	5	Somewhat limited in size, but appears to offer some breeding potential and high non-breeding quality. Surprisingly that no frogs were found here.
P-584	1	1	Shallow and dries too soon with little cover.
P-585	0	1	Limited in extent and quality. No pools for breeding.
P-586	0	1	Limited in extent and quality. No pools for breeding.

Figure 1. Red-legged frog survey sites along Redwood Creek, Marin Co, CA.

Figure 2. Red-legged frog location and movements for frog 153F at Big Lagoon, Marin Co., CA.

Figure 3. Red-legged frog location and movements for frog 6A17 at Big Lagoon, Marin Co., CA.

Figure 4. Red-legged frog location and movements for frog 173C at Big Lagoon, Marin Co., CA.

Figure 5. Red-legged frog location and movements for frog 3930 at Big Lagoon, Marin Co., CA.

Figure 6. Red-legged frog location and movements for frog 174F at Big Lagoon, Marin Co., CA.

Figure 7. Red-legged frog location and movements for frog 5074 at Big Lagoon, Marin Co., CA.

Figure 8. Red-legged frog location and movements for frog 4973 at Big Lagoon, Marin Co., CA.

Figure 9. Red-legged frog location and movements for frog 7552 at Big Lagoon, Marin Co., CA.

Figure 10. Red-legged frog location and movements for frog 7C1C at Big Lagoon, Marin Co., CA.