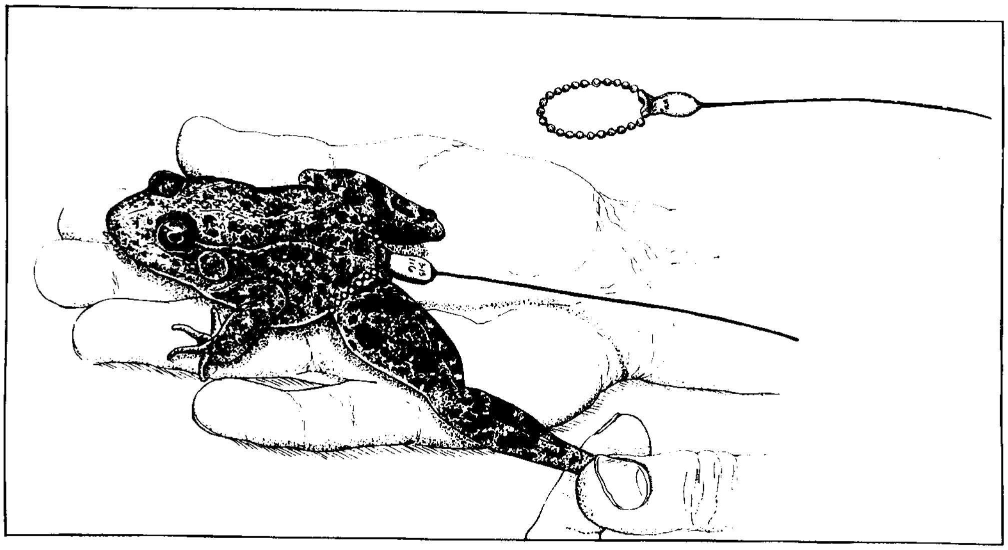
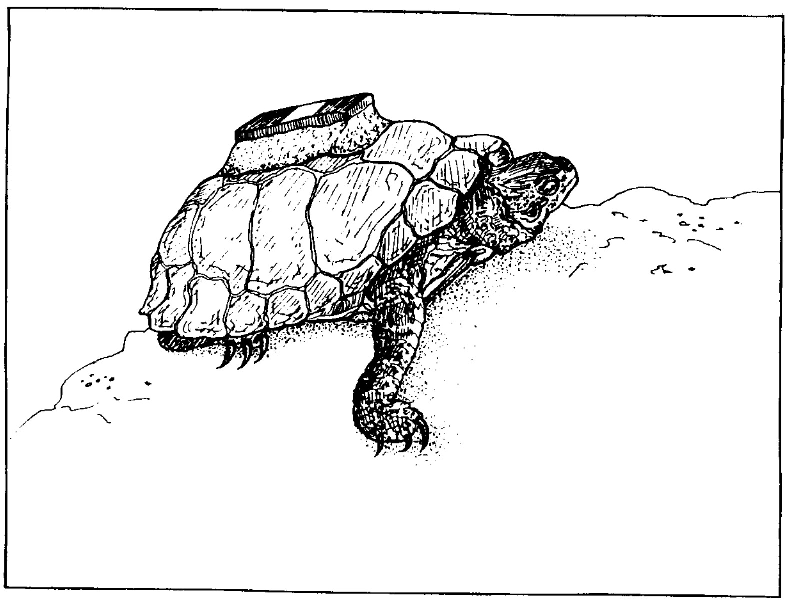
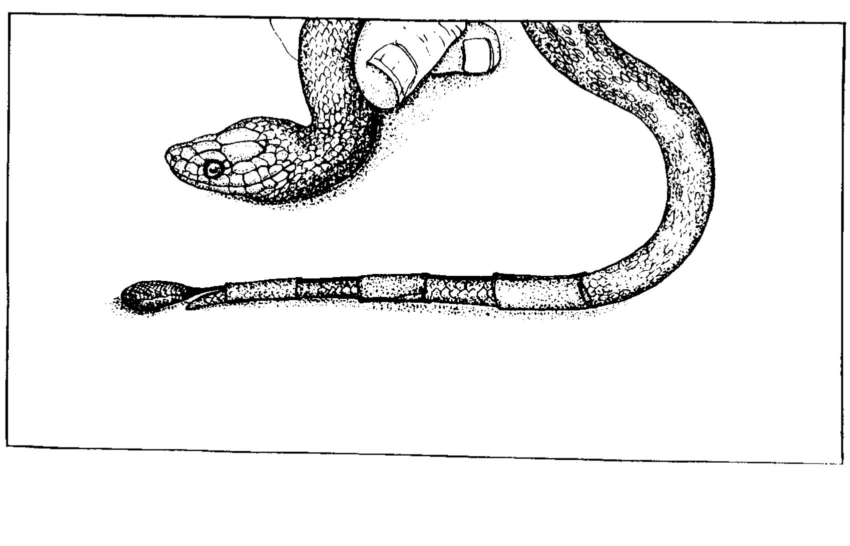






# PREFACE

This report was produced as the result of a cooperative research project between the U.S. Fish and Wildlife Service, National Ecology Research Center, Fort Collins, Colorado and the California Department of Parks and Recreation, Sacramento, California. The project was funded by both agencies in order to obtain basic information on the status and ecology of sensitive aquatic vertebrates in the lower reaches of San Simeon and Pico Creeks, San Luis Obispo County, California.

Suggested citation: Rathbun, G.B., M.R. Jennings, T.G. Murphey, and N.R. Siepel. 1993. Status and ecology of sensitive aquatic vertebrates in lower San Simeon and Pico Creeks, San Luis Obispo County, California. Final Report under Cooperative Agreement 14-16-0009-91-1909 between U.S. Fish and Wildlife Service and California Department of Parks and Recreation. Publ. No. PB93-230779, National Technical Information Service, Springfield, VA, ix + 103 pp.

# CONTENTS

## TABLES

## FIGURES

## APPENDICES

**SUMMARY**

Many native aquatic vertebrates are susceptible to population declines and extirpation as their habitats are degraded by human activities. For this reason, there is concern by state and federal agencies that four aquatic vertebrates may be threatened with extirpation in California; the tidewater goby (*Eucyclogobius newberryi*), California red-legged frog (*Rana aurora draytonii*), southwestern pond turtle (*Clemmys marmorata pallida*), and two-striped garter snake (*Thamnophis hammondii*). In addition, the decline of steelhead rainbow trout (*Oncorhynchus mykiss*) populations is of concern to sportsmen as well as government agencies. All five of these taxa are found in coastal creeks in San Luis Obispo County. The lower San Simeon Creek, within San Simeon State Park, is among the relatively few creeks that supports all five vertebrates.

In order to determine the status, habitats, and relative abundance of these sensitive vertebrates in San Simeon State Park, we carried out replicated visual surveys over a year in San Simeon Creek. For comparison we also surveyed Pico Creek, which has been less modified by human activities.

Water depths, flow, salinities, temperatures, and various water chemistry parameters were also measured in the two creeks to gain a better understanding of the aquatic habitats of these species. In addition, we used radio-tracking methods to determine some of the important aspects of the life histories of the turtle, frog, and snake.

With the exception of steelhead, the sensitive taxa are relatively abundant in San Simeon Creek, and breed within the state park. In general, all of the sensitive vertebrates require similar aquatic habitats, including deep pools with vegetative cover.

Data were collected indicating that riparian areas, as well as upland grassland and chaparral habitats, are used by the turtle and snake for nesting and sheltering. It is also likely that well-vegetated terrestrial areas within the riparian corridor provide important sheltering habitat for the frog.

A natural regime of water flow is probably important in maintaining salinities within the tolerances of the frog, and possibly other animals. Furthermore, it may also be important in controlling introduced aquatic predators.

We recommend several management steps to protect the sensitive vertebrates in San Simeon State Park. These include reducing current and future impacts by people on the animals and their habitats, and more importantly, protecting and restoring a natural water regime to San Simeon Creek.

## INTRODUCTION

California has one of the most diverse biotas in the United States, but it has rapidly declined over the past 100 years due to agricultural and urban development (Jones and Stokes, 1987). The existence of several unique communities, including coastal wetlands and lagoons, is threatened in southern and central California (Brattstrom, 1988; Zedler, 1991). These disjunct aquatic habitats support several native vertebrates that rely on suitable instream flows, tidal lagoons, groundwater seeps, marshes, and riparian vegetation. In central California, the native aquatic vertebrates that are declining along with their habitats include steelhead rainbow trout (*Oncorhynchus mykiss*), tidewater goby (*Eucyclogobius newberryi*), California red-legged frog (*Rana aurora draytonii*), foothill yellow-legged frog (*Rana boylii*), two-striped garter snake (*Thamnophis hammondii*), and southwestern pond turtle (*Clemmys marmorata pallida*) (Moyle, et al., 1989; U.S. Fish and Wildlife Service, 1991; California Department of Fish and Game, 1991; Brewer and Brown, 1992; Sorensen and Propp, 1992; Table 1).

Only the larger coastal arroyos of central California support all of these sensitive taxa, although some are allopatric within a stream. However, within each arroyo at least some of these vertebrates interact ecologically, such as through predator-prey relationships. In addition, there are numerous negative interactions with exotic species, especially cattle and humans (Meehan and Platts, 1978; Warner and Hendrix, 1984).

Although these sensitive taxa still occur in the lower portions of San Simeon Creek (Figure 1), with the continuing development of the San Simeon/Cambria area, the drainage has been affected by several human activities that might in turn adversely affect the sensitive species. The creek has been modified by: 1) drafting of ground water for domestic and agricultural use, 2) disposal of secondarily treated sewage effluent onto a spray field adjacent to the creek, 3) gravel mining within the high flow channel and flood plain, 4) farming and livestock grazing on lands on, and adjacent to, the creek, 5) construction of highway and foot bridges, and 6) development of camping facilities on the flood plain near the mouth.

The California Department of Parks and Recreation manages much of the land surrounding the lower reaches of San Simeon Creek. The state requires information on the status and habitat requirements of the sensitive vertebrates that occur in the creek so that it can manage the natural resources of San Simeon State Park for their long-term maintenance. The U.S. Fish and Wildlife Service needs basic life history information to develop management plans to prevent these species, which are federal candidates for listing as threatened or endangered, from further declining throughout their range.

To better understand the life histories and habitat requirements of the aquatic vertebrates in San Simeon Creek, knowledge of a similar community that has not been greatly altered by humans is needed. Pico Creek, the first large arroyo north of San Simeon Creek (Figure 1), was chosen as a study site for comparison. Pico Creek has not been impacted by human activities as greatly as most of the other large coastal arroyos, and therefore its hydrology has not been modified to a great degree. Pico Creek has populations of steelhead rainbow trout, tidewater gobies, California red-legged frogs, two-striped garter snakes, and southwestern pond turtles, which further suggests that the habitat and community are relatively intact. Physically, Pico Creek is similar to San Simeon Creek, i.e. the two arroyos are about 5 kilometers (km) apart with perennial lagoon systems at their mouths. Other arroyos in the area do not have the full complement of species (e.g., Arroyo de la Cruz, Arroyo Laguna, Santa Rosa Creek), or they have recently been adversely impacted by human activities (e.g., the new highway bridge at Little Pico Creek).

This study focused on four of the six sensitive species found in the region (Table 1): The tidewater goby, California red-legged frog, the two-striped garter snake, and the southwestern pond turtle. The specific objectives were to:

1. Determine and compare the distribution, relative abundance, and habitat requirements of each taxon in San Simeon and Pico Creeks.

2. Determine the following aspects of each taxon's life history in San Simeon Creek and Pico Creek:

   a. Tidewater goby: The timing and habitat associations of each developmental stage, including nesting, larvae, and adults.

   b. California red-legged frog: The timing and habitat associations of each developmental stage, including oviposition, larvae, and juveniles.

   c. Two-striped garter snake: Foraging behavior, diet, and sheltering/hibernating habits.

   d. Western pond turtle: Nesting habits and seasonal activity patterns.

3. Prepare recommendations for the long-term management of the habitats used by each sensitive taxon within San Simeon State Park.

## METHODS

The objectives of the study were achieved by implementing two basic types of surveys: visual surveys replicated in time and space for each species, and radio-tracking of individuals for those species that could be radio-tagged (all except fishes).

### Visual Surveys

Fishes were surveyed once a month during daylight hours by one person walking transects perpendicular to the flow of the creek from the mouth to the upstream end of the study area (see "Study Area" below). The transects were about 2 meters (m) apart. Most observations were made by looking down through the surface of the water, unless water depths were too deep (> 1.3 m), or there were extensive mats of surface algae or ditch grass (*Ruppia maritima*). In deep water (> 1.3 m) and at times of high flow, observations were done underwater with mask and snorkeling gear. During all surveys, care was taken to look under all surface vegetation and flotsam by either slowly moving the material aside on the surface of the water or by gently lifting it with a long stick. As fishes were seen, the observer would call out the data to another person on shore, who recorded the information on standardized data sheets (Appendix 1).

Visual surveys for frogs, turtles, and snakes were done every other week in each creek, except in Pico Creek where turtle and snake surveys were done only once a month from July through December 1992. Each survey was dedicated to one of the three species, which enabled the observer to develop a search image for each species. Snake and turtle surveys were done by a single observer walking up the streambed or along the bank from the mouth to the end of the study area. To maximize visibility these surveys were scheduled on warm, sunny days with minimal wind, which is when the animals were most active. During snake surveys, the observer concentrated on searching the stream banks, where possible. On turtle surveys, binoculars were used to scan turtle habitat (haul-outs, vegetation mats, and deep pools) as far ahead as practical. Frog surveys were done by two observers after dark to take advantage of the eye-shine from frogs. Each observer carefully searched one side of the creek with a high-powered light (Wheat Cap Lamp, Koehler Manufacturing, Marlborough, MA) held as close to eye level as possible. The creek was searched while walking upstream <u>and</u> downstream. On the downstream (return) leg, frog sightings that were within one segment of an up-stream sighting were considered duplicates and not recorded (unique captures excepted).

Because of the frequency of surveys in each creek, particular care was taken to minimize the disturbance to the bank vegetation, especially those areas with dense willow (*Salix* spp.) cover or cattails (*Typha* sp.). When a survey was cancelled due to poor weather (heavy rain) or creek conditions (dangerously high water flow), the survey was not rescheduled. No attempt was made to coordinate the frog surveys with the moon cycle.

We generally used standard definitions for evaluating the creek and riparian conditions (Platts, et al., 1983) during surveys. Because we used standardized data forms (Appendix 2), and relatively few people were involved with the visual surveys, there was high consistency among the surveys for each species. For example, all of the fish surveys were done by Jennings with the assistance of Denise Woodard or Siepel. Similarly, most of the snake and turtle surveys were done by Murphey or Rathbun, while most of the frog surveys were completed by Rathbun with the assistance of Murphey or Siepel.

The data from the same set of visual surveys for a species were not always consistent in different analyses because some parameters were not measured for some reason, including inappropriateness to particular situations. Obvious recording errors were deleted, which also resulted in some inconsistencies.

## Capture and Marking

During all surveys for frogs, snakes, and turtles, as well as during other data collection activities, an attempt was made to capture every animal sighted, when possible. Each animal caught was individually marked, and a set of morphometric data was recorded (see data sheet, Appendix 3). Animals were released as soon as possible at their capture sites, usually within 15 minutes. Radio-attachment on turtles and snakes required more time, and some individuals were held overnight before release.

Passive integrated transponder (PIT) tags were used to individually mark all reptiles and amphibians (Camper and Dixon, 1988). We used tags and readers manufactured by Destron IDI (Boulder, CO). The glass chips (2.1 X 11 millimeters) were injected in frogs subcutaneously anterior to the sacral hump. Once inserted, the PIT was manually worked to a position just dorsal and anterior to the urostyle. In turtles, we implanted the chips subcutaneously anterior to the right rear leg. Because we lost at least one chip, and perhaps more, we later injected them into the body cavity anterior to the rear leg insertion. Intraperitoneal injection was also used on the snakes; implantation was done between ventral scales about one third of the snout/vent length anterior to the vent.

Each reptile and amphibian captured was also marked visually to indicate that it had been tagged with a PIT. In frogs greater than 45 millimeters (mm) snout/urostyle length, the distal tip of the right, rear, fourth (longest) digit was clipped between the first and second joint. Frogs shorter than this were not PIT tagged, but were toe-clipped on the left, rear, fourth digit. Turtles were notched on the margin of the right femoral scute. These marks were made about 2 mm deep with a triangular file. In snakes, the right, fifth subcaudal scale was clipped with folding, pocket fingernail clippers.

The reproductive status of female turtles was determined by a combination of palpation by two of us and examination of x-ray exposed film (Gibbons and Greene, 1979).

Radio-tagging

The principal challenge for biologists in radio-tracking is developing an effective, safe method of attaching long-lived radio-transmitters, which are readily available commercially. Pond turtles were relatively easy to radio-tag. We attached 45 X 20 X 15 mm radio-transmitters to the carapace of large (> 140 mm carapace length) turtles with 5-minute epoxy (Hardman, Belleview, NJ) and then contoured the unit to the carapace with dental acrylic colored black with xerographic toner. We centered the transmitters on the carapace so that the turtles would not list to one side in water. In females, we placed the units perpendicular to the long axis, anterior to the mid-point, so that mating would not be inhibited. The radios were attached parallel to the long-axis at the mid-point of the carapace in males (Figure 2). The radio package, including the transmitter (pulse rate about 40/minute, pulse duration about 15 milliseconds), battery (estimated life 150 days), and helical antenna (range about one km) were manufactured by Advanced Telemetry Systems (Isanti, MN) and weighed about 20 g. Transmitters were removed and replaced as needed.

When we started this project, the methods of attaching radios to frogs and small snakes had not been satisfactorily developed. The snake lacks any external feature that could easily be used to attach a radio, such as a neck, and is not quite large enough for radio-implantation. Similarly, the frog is too small for implantation, and its skin too delicate for normal, externally mounted radios. Therefore, part of our research was to develop radio-tracking methods for California red-legged frogs and two-striped garter snakes. We used mini-micro radio-transmitters for both animals, manufactured by Holohil Systems, Ltd. (Woodlawn, Ontario, Canada). The transmitters (model BD-2A and BD-2) weighed about 0.8 and 1.2 g, respectively, without the attachment materials. The lighter model was designed to last about 30 days, while the heavier about 70 days. Both radios had a pulse rate of about 40/minute and a pulse duration of about 15 milliseconds. The transmitters, with a 10-cm-long whip antenna, produced a signal that could be received at a distance of about 100 m.

We taped the whip antenna to the tail skin of snakes greater than 550 mm snout/vent length with 3 to 4 bands of 5-7 mm wide surgical tape (3-M, Minneapolis, MN). To prevent the antenna from slipping from beneath the tape, we bent 3-4 mm of the antenna tip into a small hook that was incorporated into the second layer of three layers of tape. The shape of the transmitter itself was modified into a tear-drop with black dental acrylic. The antenna was positioned along the mid-dorsal surface of the tail so that the transmitter slightly overlapped the tip of the tail by 2-3 mm (Figure 2). The overlap was carefully taped to reduce the possibility of snagging on rocks or vegetation.

The frog attachment was constructed of aluminum ball chain painted black. The chain was attached to an aluminum connector attached to the end of the transmitter with epoxy. The chain was then cut to length and fitted around the "waist" of the frog (Figure 2; Appendix 4). Only large frogs over about 80 mm snout/urostyle length were radio-tagged. We continue to refine the attachment techniques briefly described above for the snake and frog.

Study Area

The lower portions of San Simeon and Pico Creeks were mapped (Figures 3 and 4) from aerial photographs (Ecoscan, Watsonville, CA) taken on 1 July 1991. The stream bed of each creek was divided into 25-m-long segments from the mouth to the top of the study area (Figure 5). The segments were ground-truthed and flagged in the field. In San Simeon Creek, the study area extended along the slough (Figure 5, top) from segment 1 through 10, and along the main channel from segment 11 through 49. We also completed herpetological surveys from segment 49 to segment 100 from January through April 1992 in San Simeon Creek. In Pico Creek, all surveys terminated at segment 36. When we refer to San Simeon Creek in this report, we include the slough and lagoon; similarly the lagoon is included in Pico Creek. In San Simeon Creek, turtles were radio-tracked as far upstream as segment 190, whereas no tagged turtles moved above segment 36 in Pico Creek. All spatial information on the animals and their environment were recorded to at least the nearest segment. In some instances, we plotted actual locations on the study area maps.

At the beginning of the study we decided to exclude Pico Ponds (Figure 5, bottom) from all visual surveys because the methods we proposed to use for the creeks could not be used effectively in the ponds. To include the ponds would have required more time and people than were available, as well as different survey techniques. We did, however, radio-track turtles in Pico Ponds.

Water Quality

Water depth, flow, temperature, and salinity in the two creek systems were measured once a week from January through December 1992. In San Simeon Creek, we took measurements about 10 cm from the surface and 10 cm from the bottom at segments 02, 08, 10, 15, 17, 25, 31, 36, and 40 (Figure 5 top). In Pico Creek, measurements were taken at segments

06, 10, 17, 23, and 28 (Figure 5 bottom). In addition, from June 1992 through May 1993, Woody Elliott, Resource Ecologist for San Simeon State Park, sampled and measured water chemistry at sites in San Simeon and Pico Creeks each week (Appendix 5). The instruments used to take the various water quality values included a Yellow Springs Instrument model 33 salinity/conductivity/temperature meter; a Marsh-McBirney model 2000 portable water flow meter; a Yellow Springs Instrument model 51B dissolved oxygen meter; a Barnant model 20 digital pH meter; and various Hach kits for water chemistry.

### Data Management

All information gathered in the field was entered onto standardized data forms and study area maps (Appendices 1 - 3). All forms that required coded entries were accompanied by definitions and protocols to ensure continuity of data collection by all members of the research team. Field data were entered into personal computer files using dBase III+ and proofed against the original data sheets; all files were then corrected and proofed a second time. Graphics were done on a personal computer with Sigmaplot software, and statistical tests were completed with the Statistix software. Probabilities of 0.05 or less are considered significant.

## RESULTS

### Surface Hydrology

The total rainfall during 1992, measured at the Cambria Community Services District sewer treatment plant at the mouth of Santa Rosa Creek in Cambria, was 538.99 mm (21.2 in). This compares favorably with the 1957-1972 yearly average at Rancho Piedra Blanca, San Simeon, of 594.4 mm (23.4 in; Yates and Van Konynenburg, 1990). The seasonal distribution of the 1992 rainfall at the sewer plant (Figure 6) was typical for the region, with most of the precipitation occurring during the winter months of November through March. This rainfall pattern resulted in a highly seasonal pattern of stream flow (Figures 7 and 8).

Most of the rainfall along the central California coast comes from frontal systems out of the north (Major, 1988). This results in a series of heavy rainfall events separated by periods of several days to several weeks of little or no rainfall. This pattern causes many of the smaller coastal streams to have low or no flows during the dry summer months, followed by great oscillations of flow during the winter (Figures 7 and 8). The flashy nature of the winter flows in the coastal creeks is well-illustrated by data collected by the Engineering Department of San Luis Obispo County at segment 72 on San Simeon Creek during February and March 1992 (Figure 9). During this period, flows increased

1-2 orders of magnitude within a few hours of large winter rain storms.

Another characteristic feature of the coastal streams that cross coastal terraces before entering the Pacific Ocean are lagoons at their mouths. Although San Simeon and Pico Creeks do not have lagoons as large or complex as those at Morro Bay and Moss Landing, these small lagoons (Figures 3 and 4) are important habitats for aquatic vertebrates.

Data were collected on stream flow, salinity, water depth, and water chemistry in both creeks with the intent of better understanding the suitability of the lagoons as habitat for the various aquatic vertebrates. Predictably, the nature of the lagoons changed dramatically throughout the year. Of particular interest was changes in salinity in both time and space. In San Simeon Creek, fresh water was dominant in the lagoon for most of the year (Figure 10). During late winter and spring, sufficient fresh water flowed down the creek (Figure 7) to keep the sand bar at the mouth open from about 10 February through about the first week in May 1992. During this time there was little or no sea water intrusion into the lagoon through the mouth of the creek. As soon as the sandbar began to form, however, some salinity was detected in the lagoon (Figure 10). Similar patterns were observed at Pico Creek, but there was more salinity due to overwash at the mouth during the spring and summer months (Figures 8 and 11).

Freshwater also precolated through the sandbar. We measured the salinity on the two sides of the sandbar at the mouth of San Simeon Creek on 12 January 1992. The salinity on the lagoon side of the sandbar at 10 centimeters (cm) depth was 0.5 parts/thousand (PPT); at 50 cm it was 1.0 PPT. On the outside of the sandbar a hole dug in the sand had a salinity reading of 10 PPT, at the upper margin of a wave on the beach it was 25 PPT, and in the surf it was 29 PPT. The same measurements taken on the beach 500 m south of the sandbar were 28, 28, and 33 PPT, respectively.

Because fresh water is less dense than salt water, a salt water lens often formed on the bottom of the lagoons (Figures 12 and 13). The concentration of salt water, when present, was usually greatest at the mouths of the creeks (Figures 14 and 15).

The situation in the slough at San Simeon Creek (Figure 5, top) was slightly different than the lagoon. First, the slough only flowed from about 9 February 1992 through about 26 April 1992. Secondly, the slough was buffered from oceanic and creek influences by the shallow opening at its mouth. This "plug" was about 116 cm above sea level and restricted back-flow from the lagoon/estuary during much of the year, especially the summer months (Figure 12).

The salinity in the slough followed the same general pattern as that found in San Simeon Lagoon (Figure 16), with peaks occurring in the fall followed by flushing with rainfall runoff in late winter/spring. Salinities were generally higher at the bottom than at the surface (Figure

16). However, salinities (especially during the summer months) were generally higher at the upper end of the slough than at the mouth, opposite of what occurred in the lagoon (Figures 14 and 16). The differences between the minima and maxima in the slough (Figure 16) were less than those in either San Simeon or Pico Lagoons (Figures 10 and 11). There was also less stratification in the slough.

The seasonal extremes in water temperature were about 15 degrees Celsius ($^{o}$ C) different, with winter lows of about 10$^{o}$ C and highs of about 25$^{o}$ C. Only in summer (June) was there a decline in water temperatures from the lagoons of both creeks to upstream sampling sites (Figures 17 and 18). During June there was also a notable difference between surface and bottom temperatures. The mean water temperature near the bottom of the lagoon at San Simeon Creek (segment 17) was 16.4$^{o}$ C, while the mean temperature near the bottom of the slough at segment 8 was 16.2$^{o}$ C. These temperatures were not significantly different ($P = 0.7$, t-test). The mean surface temperatures at these two locations were 17.0$^{o}$ C and 17.1$^{o}$ C, which were not significantly different ($P = 0.8$, t-test). Bottom temperatures were nearly the same or even higher than those at the surface at most sites when a saltwater lens was present, such as in November (Figures 10, 11, 17, and 18). The temporal patterns of bottom water temperatures in the two creeks were very similar (Figure 19), with average maxima in all segments being reached in July and August and minima in January and December. Both creeks exhibited up to a 2$^{o}$ C average decline at all stations in June 1992. The four sampling sites illustrated in Figure 19 for San Simeon Creek were quite similar, with maximum spreads of about 3$^{o}$ C. Only Segment 40 was shaded in San Simeon Creek. The maximum spread for Pico Creeks was about 4$^{o}$ C. In this creek only segment 28 was shaded. In both creeks, the sites that were shaded generally had the lower temperatures (Figure 19).

The general spatial and temporal hydrological patterns described above for San Simeon and Pico Creeks should be considered close to a "natural" water regime for coastal streams in central California. (For more detailed descriptions of creek hydrology in the area, see Yates and Van Konynenburg, 1990).

The values for water chemistry in both creeks were unremarkable (Appendix 5), with the exception of dissolved oxygen. In San Simeon Creek, summer values in the lagoon and creek, and at the surface and bottom, were depressed compared to winter values (Figure 20). The same pattern was found at Pico Creek, but the actual values were higher in Pico Creek compared to San Simeon Creek during the summer months (Figure 21). The overall trends in both creeks correspond with the seasonal patterns of stream flow (Figures 7 and 8).

Tidewater Goby

We completed 12 surveys for tidewater gobies. In San Simeon Creek we sighted a total of 7,962 juvenile (< 31 mm total length) and 3,573 adult (≥ 31 mm total length) gobies, and in Pico Creek 13,555 juveniles and 4,148 adults. Over 59% of the juvenile fish observed were larvae (< 10 mm total length). We found tidewater gobies in both creeks every month except for February, when high waters (Figures 7 and 8) precluded us from observing any fishes (Figure 22). Although we did not survey the slough at San Simeon Creek, based on opportunistic observations and trapping, gobies are not common in this area. In the creek itself, gobies were essentially restricted to the lower reaches of each creek, although a few fish were seen up to about 500 m upstream from the mouths when these upper creek segments contained water (Figures 23 and 24). Tidewater goby numbers peaked during the summer months (Figure 22), after the adults had successfully reproduced in the lagoons. With the first winter storms (Figure 6), most individuals disappeared (Figure 22). Only a few subadults were observed during the winter months of January through late March/early April (Figure 22).

Adult male tidewater gobies exhibited breeding behavior and coloration from April through September, 1992, in both creeks. Gravid female tidewater gobies were also found during the same time period. No breeding tidewater gobies were observed from January through April 1993. Breeding males and their nesting burrows were clustered around sandy or gravel substrates in segments 1-3 of the lagoon at Pico Creek (Figure 5) and lagoon segments 11-13 at San Simeon creek. These clusters were often near patches of ditch grass, which were located just downstream from the Highway 1 bridges.

Juvenile tidewater gobies were almost exclusively found in the lagoon areas of San Simeon and Pico Creeks (Tables 2 and 3). Adults showed a preference for lagoon and glide habitats in both creeks (Tables 2 and 3). Overall, juvenile and adult tidewater gobies showed a distinct preference for sandy substrates, although a large portion of the juvenile and adult gobies in Pico Creek were also observed on other substrate types (Tables 4 and 5).

No associations between tidewater goby presence/absence and water quality variables could be discerned.

Steelhead Rainbow Trout

We sighted 1 juvenile steelhead rainbow trout in San Simeon Creek and 190 juveniles in Pico Creek during the surveys. At no time did we observe any adults during the 12 replicated fish surveys, although they have been found at night in both creeks during amphibian surveys prior to 1990 (Jennings, unpubl. data). We also encountered single fish (> 40 cm) during frog surveys in Pico Creek (segment 12) on

28 January 1992 and San Simeon Creek (segment 18) on 12 November 1992. All trout observed during our fish surveys were juvenile (< 150 mm total length) steelhead rainbow trout in their first, second, or third year of life.

During the spring months, juvenile steelhead rainbow trout in Pico Creek were found in all habitat types (lagoon, pools, riffles, and glides; Table 6) that were well-shaded by bank vegetation, such as willows. Although 97% of fish sighted had migrated to deep pools or to the lagoon by late June, a few fish (< nine) were stranded in shallow areas by the desiccating stream. These fish were gone by mid-summer, when virtually all of Pico Creek above segment 22 was dry (Figure 8).

Examination of water quality variables (Appendix 5) and the virtual absence (only one fish observed) of juvenile steelhead rainbow trout in the lagoon at San Simeon Creek indicated a possible association between low dissolved oxygen levels (< 5.0 PPM; Figure 20) and the lack of trout (see discussion). No other trout/water-quality associations were discernable.

## Other Fishes

Of the 179,724 fishes observed during the 12 surveys, threespine sticklebacks (*Gasterosteus aculeatus*) were actually the most common (Table 7). Sticklebacks were often observed in the same aquatic habitats with tidewater gobies. As the season progressed from spring to late summer, we observed a large number (> 200 individuals per survey) of sticklebacks in San Simeon Creek that were heavily parasitized with larval tapeworms (*Ligula* sp.) and trematodes. Only a few such parasitized fish were observed in Pico Creek.

Other fishes sighted during the survey include three species of sculpin (*Cottus aleuticus*, *C. asper*, and *Leptocottus armatus*), adult and juvenile starry flounders (*Platichthys stellatus*), and brown bullheads (*Ictalurus nebulosus*; a kind of catfish) (Table 7). The two freshwater sculpins (*C. aleuticus* and *C. asper*) were regularly observed in low numbers throughout the year in rocky areas of both creeks. Adult staghorn sculpins and adult and juvenile starry flounders were only sighted during the summer in lagoon areas where the adults are known to reproduce. Brown bullheads have been recently introduced to the drainage, and eight were found dead in the lagoon area of San Simeon Creek after periods of heavy rainfall and stream flow (Figures 6 and 7). These bullheads probably washed down from a stock pond on one of the side drainages upstream.

## Red-legged Frog

We completed 26 visual surveys for frogs in San Simeon Creek during 1992, and made 379 sightings of red-legged frogs (125 were "small", < 60 mm snout/urostyle length, and

254 were "large"). Four of the 379 sightings (1.1%) were of paired animals (within 30 cm of each other); the rest were of lone individuals. No frogs were sighted during surveys of segments 50 through 100. We captured 87 individuals during 1992.

We searched for egg masses in both creeks beginning in April 1992. We found no eggs in Pico Creek (the ponds were not searched), but in San Simeon Creek we located one egg mass on 12 March 1992 in segment 6 of the slough. Tadpoles were only observed in the slough of San Simeon Creek.

The distribution of the small and large frog sightings in San Simeon Creek segments 1 through 49 (Figure 25) illustrates several trends. Frog sightings were obviously not distributed homogeneously along the creek - some segments or areas of the creek accounted for many sightings while other areas were devoid of sightings. If we divide the study area into three basic regions: slough (segments 1-10), lagoon (segments 11-29), and creek (segments 30-49), the distribution of total sightings by region is significantly different than an even distribution ($P < 0.0001$, chi squared = 40.6, df = 2). Relatively few sightings were made in the lagoon (Table 8). The distributions by region for the two size classes are also significantly different ($P < 0.0001$, chi squared = 56.5, df = 2). Large frogs were sighted most frequently in the creek, whereas small frogs were sighted most commonly in the slough (Table 8).

We sighted 180 frogs in Pico Creek during 24 surveys, and captured 50 individuals in 1992. All sightings were singletons, except for two (1.1%) that were paired. The spatial distribution of the 180 sightings (24 surveys completed in 1992) showed slightly different trends compared to San Simeon Creek (Figure 26). Total sightings were less, but more importantly there were relatively fewer sightings of small frogs ($N = 17$; 9.4% compared to 33.0% for San Simeon). The sightings were obviously not homogeneously distributed, but compared to San Simeon Creek they were less clumped by creek component (Table 9; there was no slough at Pico Creek). The difference in total sightings between lagoon (segments 1-13) and creek (segments 14-35) regions (Table 9) were not significantly different ($P = 0.6$, chi square = 0.4, df = 1), but the distinct distributions of small and large frogs are significantly different ($P = 0.04$, Chi-square = 4.3, df = 1). Most large frogs were seen in the creek, but small animals were mostly sighted in the lagoon (Table 9).

The locations of frog sightings made during the visual surveys in each of the two creeks can be used to further characterize frog habitat. The distributions of adult frog sightings between land (> 50 cm from water edge), bank (within 50 cm of water), shore (within 50 cm of land), and water (> 50 cm from land) were too sparse for valid chi square analysis (Table 10). However, combining habitats into terrestrial (land plus bank) and aquatic (shore plus water), there was no significant difference in the terrestrial and aquatic distributions of sightings between the two creeks (P = 0.3, chi square = 1.2, df = 1). However, within San Simeon Creek, the distribution of sightings in terrestrial and aquatic habitats by small and large frogs was significant (P = 0.01, chi square = 6.6, df = 1). Small frog sightings were more aquatic than those of large frogs (Table 10).

Large frog sightings in San Simeon and Pico Creeks were associated with average water depths (within 1 m of each sighting) of 48.3 cm (N = 238, SD = 26.0, range = 4-140) and 52.9 cm (N = 154, SD = 32.7, range = 2-200), respectively. These depths are not significantly different (P > 0.1, two-sample t-test). In San Simeon Creek, the average depth for 238 large frog sightings was 48.3 cm (SD = 26.0), while that of 94 small frog sightings was 39.6 cm (SD = 15.7). These depths are significantly different (P < 0.003, two-sample t-test).

The frequency of frog sightings were not evenly distributed between pools, glides, and riffles in San Simeon and Pico Creeks (P < 0.0001, chi square = 267.9, df = 2 and P < 0.0001, chi square = 95.1, df = 2, respectively). In both creeks, the great majority of sightings were made in pools (Table 11). The difference in distributions was also highly significant between the two creeks (P = 0.005, chi square = 10.6, df = 2). In San Simeon Creek, relatively few sightings were made in glides and riffles compared to Pico Creek (Table 11).

The basic structural component of the vegetation (not including the aquatic nature of the habitat) that each frog sighting was associated with (in, on, or among) can also be used to characterize their habitat. Four basic types were defined: Type 1 was open, with no vegetation; Type 2 included algae, flotsam, ditch grass, and low herbs and grasses such as cinquiefoil *(Potentilla* sp.), Jaumea *(Jaumea carnosa*) and saltgrass (*Distichlis spicata*); Type 3 was characterized by tall, vertical reed-like plants, such as cattails, rushes, and sedges; Type 4 included both living and dead tangles of woody roots and branches, such as willows and blackberry (*Rubus* sp.). The total sightings within each creek by vegetation type are obviously not homogeneously distributed - most were in vegetation Types 3 and 4 (Tables 12 and 13). The number of small frogs in Pico Creek are too few for valid chi square analysis. However, comparing large frog sightings in San Simeon and Pico Creeks, the two distributions are significantly different (P = 0.002, chi square = 15.0, df = 3). In general, large frogs sighted in Pico Creek were associated with more structurally complicated vegetation (Types 3 and 4) than in San Simeon Creek (Tables 12 and 13). Similarly, comparing small and large frog sightings in San Simeon Creek (Table 12), there is a highly significant difference in the two distributions (P = 0.0001, chi square = 43.2, df = 3). Again, large frogs were more commonly seen in structurally more complicated vegetation (Type 4) than small frogs (Type 3). In both creeks, frogs were rarely sighted in areas lacking vegetative cover (Type 1).

In lower San Simeon Creek, we sighted frogs during all bimonthly periods of the year (Figure 27), but both large and small frog sightings peaked during September/October 1992. This is not unexpected for small frogs because they metamorphosed from tadpoles during late summer. In lower Pico Creek, a similar pattern was documented (Figure 28), with two notable exceptions. Adult sightings peaked in July/August 1992, one period earlier than in San Simeon Creek, and there were two peaks of small frog sightings, the smaller in March/April 1992 followed by another in September/October 1992. The latter peak corresponded in time with the single peak in small frog sightings in San Simeon Creek (Figures 27 and 28).

We radio-tagged three individual frogs and tracked them once a day during daylight hours. Of the six radios that we deployed, two were shed. One came off an animal after 10 days, and the other failed due to corrosion of the chain after 54 days (Appendix 4). The rest lasted their predicted life, or until they were removed by us.

Male frog 3C0A was radio-tagged on 16 October, and his radio was replaced on 5 November and again on 3 December 1992. During the 103 days that he was tagged, we tracked him 78 days. He was initially captured in the slough at segment 7. He remained in this segment until 24 October when he moved to segment 8. Two days later he was located in segment 9. On 3 November 1992, he was radio-located about 26 m from the southern shore of the lagoon within the dense riparian corridor dominated by blackberry, German ivy (*Senecio mikanioides*), and willows adjacent to segment 19. We continued to locate him at this terrestrial site until 5 November, when we excavated him to ensure that the transmitter was indeed attached to a live frog; it was. He was located about 10 cm below the surface in a small mammal (mole?) burrow that was ill-defined in the deep, loamy, moist soil. When removed, he assumed a crouched, defensive posture, and made no attempt to escape. We replaced the transmitter and returned him to the reconstructed site. Between 2 and 3 December, 3C0A moved about 13 m upstream, parallel to the lagoon edge, but still in dense blackberry/willow thicket. On 3 December we again excavated the frog to replace its transmitter. This time the frog was above the soil, but buried in about 10 cm of moist leaf letter. It again remained in the defensive position and made no attempt to flee. The next day the frog was located about 13 m further upstream, and about 5.5 m from the lagoon edge, in dense blackberry, German ivy and nettles (*Urtica dioica*). Between 6 and 7 December, he moved another 6 m upstream within dense thicket vegetation, but still about 5.5 m from the lagoon edge. He remained at this location in segment 20 until we radio-located him back in the slough at segment 7 on 7 January 1993. On 15 January 1993, we found him at segment 6, where he remained until about 23 January 1993; we recovered his unattached transmitter in the water at segment 6 on 26 January 1993.

Male 4D1C was radio-tagged on 21 August 1992 on the northern side of the lagoon at segment 17. His radio was replaced on 9 September. His third transmitter assembly was found intact on the bottom of the lagoon at the northern shore of segment 17, 11 days after it was attached on 9 October 1992. During the 61-day period that he was radio-tagged, we located him on 54 days. During this entire period he remained closely associated (during the day) with the cattails along the northern shore of the lagoon in segments 16, 17, and 18. He moved 14 times between segments, with an average residency within a segment of 3.9 days (range = 1-13 days).

The third frog, 6D36 male, was radio-tagged at segment 4 in the slough on 27 July 1992. His radio died before it was replaced on 17 August 1992. He was radio-tagged for 22 days, and we tracked him on 21 days. During this time, he moved between segments four times, with stays of 1, 1, 5, and 14 days (mean = 5.3 days).

We also opportunistically surveyed Van Gordon Creek below San Simeon Creek Road, and the Cambria Community Services District holding pond (Figures 3 and 5 top). Both sites were surveyed several times during the day for eggs and tadpoles, and at night for adult frogs. Adults were sighted at both sites, and three egg masses were seen in the holding pond on 4 March and one on 23 March, 1992. However, neither tadpoles nor small frogs were sighted in the creek or pond.

Pond Turtle

We completed 17 visual surveys in Pico Creek, with at least one survey each month. Only five turtle sightings (all singletons) were made during the entire year; one in segment 10, three in segment 12, and one in segment 18. The temporal distribution was single sightings in January, March, and August; two in June. However, we captured 31 individuals in Pico Ponds and the creek during 1992.

Visual surveys in San Simeon Creek (N = 22, none in March) were much more productive, with 15 sightings of small turtles < 10 cm carapace length, and 283 large turtles. These sightings were scattered along the entire stretch of the lower study area (Segments 1-49; Figure 29). Although the most common group size observed was of single animals, groups of two or more were also seen often (Figure 30). During the four surveys of the creek from segment 50 through 100, during January through April 1992, we only sighted two turtles; one at segment 78 on 1 April and another at segment 85 on 16 April 1992. During 1992, we captured 83 individuals in the lower reaches of the creek.

In San Simeon Creek, turtles were sighted during visual surveys during all bimonthly periods of the year (Figure 31), although there were two dips in sightings, one during the winter months from November through February, and a shorter and less pronounced decline during May/June. The temporal distribution of small turtles was unremarkable, except none were sighted during November/December.

The distribution of the 298 turtle sightings from the visual surveys in each of the three regions (see frog section above, or Table 8) of lower San Simeon Creek were: 176 (59.1%) in the slough, 110 (36.9%) in the lagoon, and 12 (4.0%) in the creek. Of these sightings, only one was associated with a riffle (0.3%), 10 were sighted in glides (3.4%), and 287 were in pools (96.3%). The mean depth at the location of 66 sightings (both size classes) was 57.4 cm (SD = 30.16, range = 2 - 169 cm).

Of the 298 turtles sightings at San Simeon, most were in water (Table 14). Clearly, neither size class (small < 10 cm) was homogeneously distributed, although sparsity precluded valid chi square analysis. However, combining habitats, as was done with the frog data, there is no difference in the sighting distributions for small and large turtles in the terrestrial and aquatic habitats ($P = 0.4$, chi square = 0.67, df = 1).

The vegetation types (see frog section above, or Table 12, for definitions) associated with 296 turtle sightings (two sightings had undetermined habitats) in San Simeon Creek were not evenly distributed by size class (Table 15), but sparsity precludes chi square comparisons, and combining categories is not meaningful.

During the study period, we radio-tagged 17 turtles in San Simeon Creek and 10 in Pico Creek. Fifteen were females, and 12 were males. We radio-tracked these animals throughout the study period to determine their use of terrestrial habitats. Two basic patterns emerged, which were related to the type of water body that was occupied. Turtles in Pico Ponds remained in the ponds essentially throughout the year, as exemplified by 0311M (Figure 32). Turtles in creeks spent more time in terrestrial habitats, as illustrated by 6034F in Pico Creek and 6048F in San Simeon Creek (Figures 33 and 34). Generally, nearly all San Simeon turtles were active in water during mid-summer, and were dormant on land in mid-winter (Figure 35), while at Pico, most of the turtles were present in water during both of these periods (Figure 36). We have no data on their behavior while in the ponds.

During the study period in San Simeon Creek, all of the radio-tagged turtles were initially captured below segment 65, opposite the upper end of the Cambria Community Services District (CCSD) spray field. They all remained below this area while they were radio-tracked, except for one (male 6022). This animal moved upstream to segments 160 - 200 (250-750 m above the first car bridge over San Simeon Creek), where he stayed for the duration of the study. In Pico Creek, all the radio-tagged turtles were captured in the ponds or between segments 6 and 17. None moved further upstream than segment 32.

Four basic behaviors were associated with terrestrial activity, and the terrestrial sites for each behavior were unique (Table 16). "Basking" turtles hauled out onto relatively exposed banks for 1 or 2 days and became inactive (Figure 34). Although these sites were usually exposed to the sun, they were almost always next to some low cover, such as willow branches, bush lupine (*Lupinus* sp.), field mustard (*Brassica* sp.), blackberry, etc. "Dormant" turtles left the water for many days at a time and often travelled long distances from water (Figure 34, Table 16). These sites were usually associated with relatively thick cover, such as willow/blackberry thickets, patches of coyote bush (*Baccharis pilularis*) , or Monterey pine (*Pinus radiata*) stands where the limbs reached the ground. The turtles usually buried themselves in the leaf litter, although on occasions they exposed themselves to direct sunlight and basked with their heads and limbs extended. "Nesting" turtles left the water and travelled inland to relatively exposed sites, where they dug, or attempted to dig, pear-shaped nesting holes in firm, dry soil. These excursions usually lasted only hours, but some involved multi-day walk-abouts (Figure 34).

Obviously, males did not nest, but they did bask and become dormant (i.e., 6133M; Figure 37). Although virtually all the turtles we radio-tracked in San Simeon Creek exhibited winter dormancy (Figure 35), some also became dormant at terrestrial sites during the summer months (i.e., 6133M and 6022M; Figures 37 and 38). These turtles, however, were in the upper reaches of the creek where surface water-flow disappeared for much of the summer.

The average elevation above creek water for 54 dormancy sites was 5.3 m (SD = 7.4, range = 0 - 42 m), and the mean incline of 41 sites was 18.4 degrees (SD = 21.5, range 0 - 60 degrees). The frequency distribution for slope orientation of 41 sites was none (flat, $0^{o}$) 18, north-facing (+/- 45 degrees) 6, east-facing 10, south-facing 4, and west-facing 3.

We attempted to determine the precise nest location for the 10 gravid turtles (mean clutch size = 5.3, SD = 1.8, range = 3 - 8) that we radio-tagged (Figure 39, Table 17), but were only successful in locating four nests (three at San Simeon and one at Pico). There were two basic patterns of nesting behavior. Three of our San Simeon females (6048, 6051, 2285) made 4, 3, and 2-day terrestrial treks (walk-abouts) associated with oviposition. Each travelled at least 30 m from water (Tables 16 and 17) and spent at least four hours at 2, 3, and 3 sites (respectively) during these walk-abouts. In all three cases, the actual site of oviposition was not determined, but the lack of nest sites discovered early in the walk-about suggests that eggs were laid towards the end. The other pattern was illustrated by four San Simeon females (1B38, 2281, 6009, 6048) that made eight terrestrial excursions to oviposit, each less than four hours long and all within 35 m of water.

The temporal and spatial pattern of nesting was relatively flexible. Of the eight short excursions, six (including the three nests with eggs) were initiated between 1600 and 1800 hours, while two started between 0800 and 1000 hours. Two of these females (1B38 and 2281) made multiple, short excursions to different locations. Female 1B38 attempted to nest on 11 June at 1630 hours, and successfully nested three days later at 1735 hours. The two sites were about 100 m apart on different sides of the slough at San Simeon (Figure 39). Female 2281 made four attempts to nest on 5, 6, and 8 June. On the 8th, she made two attempts to oviposit - one at 0800 and another at 1645 hours. Although all four sites were within 25 m of each other, three were on one side of the slough and one was on the other side (Figure 39). She successfully evaded our attempts to observe her successfully nest; on 10 June she was captured and palpated - and found to have no shelled eggs. We suspect that she finally nested at night.

Three females each laid two clutches of eggs during the same nesting season in 1992:

> In Pico Creek, female 0372 was found in a grassy meadow about 25 m north of Pico Ponds on 28 April. We palpated her and determined she contained shelled eggs. On 29 April we x-rayed and then released her; she had 4 eggs. On 12 May we recaptured 0372 and by palpation determined she had no shelled eggs. On 8 June we accidently discovered 0372 depositing eggs in a nest in the same meadow where she was originally captured.
>
> San Simeon female 6048 was captured, palpated, and x-rayed on 29 April. She had 4 shelled eggs. She went on a terrestrial walk-about from 4 through 8 May. On 11 May we recaptured her and determined by palpation that she no longer contained shelled eggs. On 9 June we recaptured 6048, and after palpation and x-ray, determined she had 6 shelled eggs. We observed her successfully nest on 13 June.
>
> On 29 April we captured, palpated and x-rayed San Simeon female 6009, and determined she carried 6 shelled eggs. On 12 May, she was recaptured and palpated; no eggs were felt. An x-ray taken on 9 June showed 4 shelled eggs that could also be easily palpated. We observed 6009 successfully nest on 13 June.

We visually checked the condition of the four successful nest sites nearly daily. The fates of these nests (Figure 39, Table 17) were very different. The nest site near Pico Ponds (female 0372) was destroyed by a predator 9 days after oviposition. We have no information on the predator, although the nest was so neatly excavated and the site was so clean (no broken egg shells), that we suspect a snake. We discovered the nest of female 6048 open (not excavated) and empty on 29 October 1992, 138 days after oviposition. We believe the nestlings successfully dispersed. This occurred on 29 October 1992, the same day as the first heavy rain of the season (Figure 6). We excavated the nest of female 6009 on 8 January 1993 (209 days post oviposition), and found a single, live hatchling in the hole. There were no remains of other turtles in the hole, and it was not clear from the egg fragments present whether other turtles had been present. The last nest (female 1B38) remained undisturbed until 12 April 1993, when we excavated it. We found a rodent burrow close to where the hole had been dug, but no evidence of turtles or egg shells.

There was no evidence that females repeatedly used the same nest sites within a season. Although the females that made short-term excursions tended to nest, or attempted to nest, in the same general region (within 100 m, see above). One turtle used both sides of the slough. Of the three females that double clutched, the exact locations of each pair of nests were not determined. Only in San Simeon female 6048 do we know that the two sites were at least 250 m apart.

All nest sites had good solar exposure, with little or sparse annual grass or herb cover. The soils were variable, from fine, poorly-drained soil, to course, road-bed gravel, but all were well-compacted. We determined the elevation above creek water for 17 sites, which averaged 4.8 m (SD = 4.2, range = 1.0 - 15.0). The frequency distribution of slope orientation for 14 sites was none 6, north-facing 2, east-facing 5, south-facing 0, and west-facing 1. The incline (flat = $0^o$) at 14 sites averaged $12.9^o$ (SD = 13.3, range = 0 - $30^o$).

Garter Snake

We completed 17 surveys for garter snakes in Pico Creek (not including the ponds) during 1992 - and saw only a single snake in segment 4 (lagoon) on 24 September 1992. We also made several opportunistic observations of two-striped garter snakes during frog and turtles searches. Snakes were seen in the lagoon area of the creek, and also in the ponds.

We completed 20 surveys in San Simeon Creek for two-striped garter snakes during 1992. All sightings were of single animals. The spatial distribution of both small (N = 13) and large (N = 32) snake sightings were concentrated in two areas: mid-slough and the deep hole in the lagoon at segments 17 and 18 (Figure 40). No sightings of snakes were made during the visual surveys above segment 26, although one opportunistic sighting was made at segment 32.

Similar to the frog and turtle surveys, the greatest number of large (> 30 cm) garter snakes was sighted during the summer months in San Simeon Creek, peaking in May/June. Small individuals were seen during a more well-defined period from the last week in August through the first week in November (Figure 41).

The distribution by habitat of the sightings (small and large snakes combined) were 15 (33.3%) on land, 24 (53.3%)

on banks, and 3 (6.7%) each in water within and beyond 50 cm of land. All but one of the 45 sightings were associated with water that was pooled. The exception was a sighting in a glide at segment 24. The sightings were distributed in the four vegetation types as follows: 5 (11.1%) in type 1, 27 (60.0%) in type 2, 13 (28.9%) in type 3, and none in type 4.

We radio-tagged nine individual snakes between 27 July and 14 December 1992. Three of these snakes were tagged between 2 and 3 times with different transmitters (Table 18). The average number of days that they were instrumented was 24.2 (range = 4 - 86). The average number of times that they were located per day per individual was 1.9 (SD = 0.64, range = 1.2 - 2.9). Seven individuals were tracked during the summer (August through September), while one of the seven and another two individuals were tracked during the winter (October through December; Table 18). These two groups differed significantly in the average distance to water ($P < 0.0001$, Rank Sign Test) and average distance moved per day ($P < 0.003$, Rank Sign Test; Table 5).

We radio-tracked snakes at San Simeon at 389 sites during daylight hours in 1992; 20 were in water (5.1%) and 369 were on land (94.9%). In 348 of the land locations we determined where the snakes were. At 306 sites (87.9%) they were under the ground, presumably in rodent burrows, and in the remaining cases they were either basking or active above ground.

Constructing convex polygons for the summer and winter home ranges of these garter snakes further illustrates the seasonal dichotomy in their behavior (Figures 42 and 43). The most important difference between the summer and winter home ranges was that the snakes used chaparral and grassland upland sites during the winter, compared to streamside sites in the summer.

We made numerous opportunistic observations of foraging garter snakes at San Simeon. In addition, we recovered several regurgitated food items from snakes that we had captured. All prey items were either sticklebacks, sculpins, or gobies.

## DISCUSSION

### Surface Hydrology

The overall topography of San Simeon and Pico Creeks are similar, as pointed out in the introduction. Several differences in their surface hydrology, however, need to be emphasized. Pico Creek attained about half the maximal winter flow of San Simeon Creek (Figures 7 and 8). This difference was probably related to the smaller size of the Pico Creek drainage. Although neither creek flowed naturally all year, San Simeon did flow during the entire study period from about segment 40 to the mouth, but this was due to human intervention (see below).

Historically, San Simeon Lagoon probably had surface or subsurface water input all year during most years. Current ranch, agricultural, and urban use of the creek and its aquifer have probably reduced water input to the lagoon. However, the input from the CCSD spray field has supplemented this reduced natural flow. During the spring months of April and May 1992, San Simeon Creek still flowed above and below the CCSD's well field (adjacent to segment 90). On the upstream side, the flow was from natural runoff, while below the well field the flow was undoubtedly augmented by the District's waste water spray field adjacent to the creek. The influence of the spray field could easily be observed when the locations of the sprinklers were moved, or when spraying was temporarily stopped. In both cases, the flow in the creek below the spray field changed. The disappearance of surface flow in San Simeon Creek above the spray field was reflected in our weekly stream flow records (Figure 7). We moved the location where we took measurements on 3 June 1992 from segment 48 to segment 32 because there was no longer sufficient flow to measure at the upstream site, whereas there was measurable flow at the lower site all year (Figure 7). Even through the natural, seasonal flow regime in San Simeon Creek above the lagoon has been altered (adjacent to agricultural wells and the CCSD well and spray fields), the current water management practices are probably close to replicating historical water regimes into the lagoon.

In Pico Creek, the San Simeon Community Services District also draws water from wells adjacent to the creek, south of about segment 22. This use probably contributes to reduced surface and subsurface flow into the lagoon during the summer (Figure 8). Pico Creek does not have an artificial source of water to supplement flows into its lagoon, as does San Simeon Creek.

Another notable difference between the two creeks was in the salinity regimes of their lagoons. Maximum salinities in Pico lagoon were often greater than those in the lagoon at San Simeon Creek. Pico Lagoon also had more days with saline water than San Simeon Lagoon (Figures 10 and 11). The saltwater lens in Pico Lagoon was also more extensive compared to San Simeon Lagoon (Figures 12 and 13).

The hydrology of the two lagoons is complicated and dynamic. Unfortunately, we could not measure all the factors that influenced the fresh and salt water regimes in the two lagoons. However, based on the data we did gather, plus opportunistic observations during the year, we believe we have a general understanding of the basic surface hydrology of both systems, which are similar.

Ocean water entered the lagoons when high tides, large swells, and coastal currents co-occurred to produce waves large enough to wash over the sandbars at the mouths of the creeks. These events resulted in the highly variable salinity levels in the lagoons during October through December 1992. The salinity levels that occurred in the estuaries during the winter months of January and February 1992 were due to the influx of water washing in from the ocean. However, the amplitude of the extremes were less because freshwater in the creeks was flowing out their mouths, flushing the sea water out, except during periods of particularly high wave and tidal action. During the summer, waves probably did not wash over the sandbars at San Simeon Lagoon. In Pico Creek, however, waves did break over the sandbar and enter the lagoon. This difference, coupled with the total lack of surface flow into the lagoon at Pico Creek, resulted in the different salinity regimes in the two systems during the summer months (Figures 10 and 11). Nevertheless, there was apparently sufficient surface or subsurface flow of fresh water into both lagoons, and percolation through the sandbars, to maintain the lagoons essentially fresh from July through September. Even when ocean water entered the lagoons, both maintained fresh water (< 6 PPT salinity) layers at the surface for virtually the entire year (Figures 12 and 13). (See "Overview" discussion below for the biological importance of these natural water regimes, including yearly fresh water flows and the physical property of fresh water floating on saline water.)

The levels of dissolved oxygen in Pico and San Simeon Creeks showed some significant differences. The lower concentrations near the bottom compared to near the surface were expected. Similarly, the seasonal trends at all the sites were unremarkable, with depressed levels during the summer months, compared to the winter months. However, the remarkably low concentrations at segment 17 (lagoon) in San Simeon Creek compared to Pico Creek was unexpected and is cause for concern. Although it is not clear why the dissolved oxygen levels were so low in the lagoon at San Simeon Creek, it is difficult not to implicate the different sources of water that feed the two lagoons during the summer months. In San Simeon Creek, the CCSD wastewater spray field, adjacent to segments 40-68, contributes to the surface flow into the lagoon. It is likely that this water, with its probable high nutrient concentrations, is contributing to eutrophication and depressed oxygen concentrations in San Simeon Lagoon during the summer months. A similar supply of nutrient-rich summer water does not exist at Pico Creek.

The surface hydrology of the slough at San Simeon Creek was also complicated and dynamic, with some significant differences from the lagoon. While the salinities in the lagoon were near-zero for virtually the entire summer (Figure 10), salt concentrations in the slough slowly increased through the summer (Figure 16). In addition, there was very little stratification of the salt concentrations, and salinities were lower near the mouth of the slough compared to upstream (Figure 16). These patterns suggest that the source of the salt was not back-flow from the lagoon, but rather some form of natural accumulation. The most logical source of the salt is from old marine sediments in the wetland above and surrounding the slough. This explanation is also parsimonious with the slightly saline water (2.0 PPT; Woody Elliott, pers. comm.) seeping from a hillside spring near the top of the wetlands above the slough. The concentration of salts in the slough may also be exacerbated by leaching from saline soils excavated from the slough and dumped at its edges while it was being restored by the state park, starting in March 1987.

Although we did not document sea water intrusion into the slough during the summer months, it is possible that it might occur. However, if it does, one would expect to find more stratification of the salt water, and higher salinity concentration near the mouth of the slough compared to its upper end. The elevated salinities found in the slough during the fall and early winter (Table 16), were flushed from the system with the first heavy rains that resulted in flow down the seasonal wetland drainage. This instream flow was critical in recharging the slough with freshwater during the summer months, which in turn was vital to the aquatic vertebrates that inhabited this area.

Our observations on the hydrology of the lagoons and slough indicate that the relatively unaltered freshwater and saltwater seasonal regimes are critical for the long-term survival of the goby, trout, frog, turtle, and snake in the lower reaches of both creeks (see discussions below).

## Fishes

The areas upstream from the lagoon in Pico Creek and the spray field in San Simeon Creek normally go dry by mid-summer. Therefore, the lagoon areas of these two creeks are important refugia for juvenile steelhead and tidewater gobies. Larval tidewater gobies are especially dependent on lagoons for the first few weeks of life (Tables 3 and 4; Swift, et al., 1989).

Although San Simeon Lagoon is essentially intact and contains a nearly complete community of native aquatic vertebrates, two factors observed during this study have the potential to negatively affect this aquatic community.

The first factor is the presence of introduced brown bullheads. These predatory fish are not native to California and they have the potential to adversely impact native species, especially the tidewater goby and larval and juvenile California red-legged frogs within the lagoon and slough systems. Every effort should be made to prevent the establishment of this fish in the lower part of San Simeon Creek.

The second factor is the low (< 5.0 parts/million) dissolved oxygen levels in San Simeon lagoon during much of the summer. Juvenile steelhead were historically present in large numbers in the lower portions of San Simeon Creek (see data presented in Bailey, 1973) and a portion of each year's progeny probably used to spend the entire summer in the lagoon (e.g., see Shapovalov and Taft 1954). However, the continued presence of juvenile steelhead in San Simeon Lagoon during the summer months is now unlikely because all native trout and salmon have dissolved oxygen requirements of > 5.0 PPM (See Leitriz and Lewis, 1976), which is well above the minimum dissolved oxygen levels recorded at all lagoon stations from July through October (Figure 20).

The spatial distribution of tidewater gobies in both creeks (Figures 22 and 23) is as expected based on the work of Irwin and Soltz (1984) in Santa Barbara County; Swift et al. (1989) in Orange, San Mateo, and Santa Cruz Counties; and Worcester (1992) in Pico Creek. Gobies are most abundant in lagoons and the lower parts of creeks during the summer and late fall. With winter flood events, the aquatic habitat is severely disrupted and rearranged (e.g., pools fill up with sediment, stream channels change course, etc.) and most gobies are unable to survive this stressful period. As observed during this study, the few gobies that do survive are almost always subadults (although Swift et al., 1989, found that a few adults may also overwinter). These few individuals repopulate suitable aquatic habitats again in the spring after floodwaters recede.

The freshwater fish species found in the lagoons of San Simeon and Pico Creeks (see Table 7) used different life history strategies to avoid adverse winter conditions, such as high stream flow. Tidewater gobies have evolved an essentially annual cycle, where a few subadults and adults survive the winter period to reproduce in the following spring and summer. However, this type of life history strategy, that relies on a small number of overwintering individuals to reestablish the population, could result in the extinction of local populations by natural or human causes. This is especially true when the extent of the habitats occupied is small, such as the central California coastal lagoons we studied.

Starry flounders and staghorn sculpins spend most of their life in the ocean, only entering estuaries when conditions are suitable for breeding. Steelhead avoid adverse seasonal conditions by either migrating from the ocean upstream into tributaries to spawn, or by living their entire live cycle in more remote tributary streams as resident rainbow trout. Both life cycles involve the laying of eggs in more protected stream gravels where major winter storm events are probably less severe than in the lower reaches of streams.

Our observations of breeding tidewater gobies indicated that although males set up nesting burrows for gravid females in sandy or gravel substrate situations (Swift, et al., 1989), larval gobies after hatching seem to drift into nearby patches of ditch grass, or other aquatic vegetation, and settle onto the substrate. This kind of habitat was more common in Pico Lagoon compared with San Simeon Lagoon, especially since the winter flood events of 1992/1993. Based upon the large numbers of juvenile gobies found in and around these patches of aquatic vegetation, it appears that this type of habitat may be important for the survival of juvenile gobies. If this is the case, then the seining of San Simeon lagoon for fishes by various groups (wildlife agencies, consultants, and universities) may have an adverse effect on rooted aquatic vegetation and thus the gobies.

Additionally, ditch grass and other aquatic vegetation may be an important source of dissolved oxygen in parts of the lagoon. Although dissolved oxygen levels were not measured directly in mats of ditch grass, it seems logical that these plants might raise oxygen levels in aquatic environments immediately within or next to these plants during the day.

Red-legged Frog

One potential problem with using visual surveys to determine frog (and the other aquatic vertebrate) distributions is the bias associated with visibility. For example, because our searches were restricted to the streambeds and streambanks (mostly due to practicality), there is no doubt that land-use by post-metamorphic frogs (i.e., frogs past the tadpole stage) is underrepresented. This is especially true considering the preliminary results from our radio-tagged frogs that suggests that these amphibians may be using terrestrial habitats more than has been documented before. Unfortunately, until the radio-tracking method we developed during this project is used on a larger scale, we are left with the visual assessment of habitat use. In the case of California red-legged frogs, we have probably not only underestimated the number of animals using dense terrestrial vegetation, but also dense aquatic vegetation such as cattail beds. On the other hand, it is unlikely that we missed many frog sightings in areas with little or no vegetation, or where the cover is not dense, such as in ditch grass or algal mats.

In San Simeon Creek, nearly all of our data on California red-legged frogs indicated that they had relatively well-defined habitat needs: Pools, or slow-moving water, with depths that allowed effective escape when alarmed. These depths have been determined to be > 0.7 m (Hayes and Jennings, 1988). Even though sighting conditions in shallower water, such as riffles, were better than in glides and pools, frogs were not seen in these sites as frequently. Deep pools or glides were not the only habitat features associated with frog sightings. Vegetative cover was also important, especially plants that provided good vertical structure, such as tall cattails, dense tangles of vines, and low willow root and branch tangles. Frogs were rarely sighted in areas that did not contain both of these features (i.e., deep water with vegetative cover). These habitat associations are similar to what Hayes and Jennings (1988) documented for California red-legged frogs range-wide.

We also documented differences in where we sighted large and small frogs in San Simeon Creek (i.e., Figure 25).

These differences are probably related to where the frogs oviposited. In San Simeon Creek, we only found eggs and tadpoles in the slough, which explains the abundance of small frogs in this area. Because the slough is a well-defined area with very different habitat characteristics (deep pools surrounded by cattails, sedges, and rushes), it is not surprising that most of the habitat traits associated with the sightings of small frogs were different from large frogs.

There were several remarkable differences between the frog populations in San Simeon and Pico Creeks, based on our visual surveys. For example, we found no evidence of egg masses or tadpoles in lower Pico Creek. In addition, we only documented a few small frogs in the lower creek (Figure 26). However, we know from opportunistic observations that frogs successfully bred in Pico Ponds (we captured tadpoles in June 1992). The ponds had many of the same characteristics as the slough, such as deep water and dense cattail cover. We believe that the ponds were just as important habitat for frogs in the Pico Creek system as the slough was for frogs in San Simeon Creek. Unfortunately, we did not systematically survey the ponds, and we have little comparative data.

The temporal distribution of our frog sightings in the two creeks were similar, with the expected seasonal lows during the colder winter months. However, summer sightings peaked in San Simeon Creek 1-2 months later than in Pico Creek (Figures 27 and 28). We have no explanation for this. Also, there were two peaks in small frogs sightings in Pico Creek, compared to the single peak in San Simeon Creek. Assuming small frogs did not move great distances, and the March/April peak is not an artifact of the few small frogs we sighted, this would suggest that oviposition occurred over a relatively wide period of time in Pico Ponds.

Pond Turtle

Even though we documented that turtles were more gregarious than the frogs and snakes, the groups (Figure 30) were probably not social aggregations, but rather several individuals taking advantage of a limited resource, i.e., basking sites. In fact, Bury and Wolfheim (1973) have described aggressive interactions between turtles at basking sites. The scarcity of suitable sites is suggested by the fragmented spatial distribution of our turtle sightings in San Simeon Creek (Figure 29). We rarely observed turtles in shallow waters or at sites with little or no vegetative cover nearby. Indeed, the habitats where we observed turtles were very similar to where we saw frogs - areas with deep pools or glides with vegetative cover. If these pools also contained a floating log as a basking perch, the area was usually heavily used by turtles.

The low number of pond turtles that we sighted in Pico Creek, compared to San Simeon Creek (including the slough), was corroborated by our radio-tracking results - the creek was used by few of our radio-tagged turtles. Instead, the majority of the turtles remained in Pico Ponds. The apparent avoidance of the creek was unexpected because the Pico Creek area, including the creek itself, is known to have supported large numbers (hundreds?) of turtles in the past (Holland, 1985). We have argued, in terms of red-legged frogs, that the slough at San Simeon Creek and Pico Ponds are important habitats. We believe these two areas are also important for turtles. If the turtle sightings made in the slough at San Simeon Creek are disregarded (Figure 29), the numbers and distribution of animals sighted in San Simeon Creek are more similar to what we documented for Pico Creek.

The temporal distribution of turtle sightings at San Simeon Creek were seasonal, with troughs during the months of November through February (Figure 31). The reason for the slight drop in sightings during the May/June period is not clear, unless it relates to more cryptic behavior of animals during slightly cooler weather, or females being more difficult to see during the nesting period.

One of the most significant findings of our research has been the considerable use of upland habitats by turtles, not only during relatively short nesting forays, but also longer periods during other times of year, especially winter (Table 16). It is not surprising that we sighted fewer turtles during the winter months, because many were on land, outside our survey path. Not all dormancy at terrestrial sites occurred during the winter, some also took place during the summer months. This suggests that this behavior may be related to adverse water conditions, such as peak winter flows (Figures 7-9) that might wash turtles to sea, and high salinities (Figures 10, 11, 16) or total absence of water during summer (Figures 7 and 8). The turtles that used Pico Ponds, where the aquatic conditions were presumably more stable than in the creeks, generally did not exhibit terrestrial dormancy (Figure 36), which further supports our contention that this behavior was related to adverse aquatic conditions. The Pico Ponds data also suggest that low winter water temperatures were not among those factors that the turtles were avoiding.

We had a difficult time capturing an adequate sample of gravid females, and once we caught and radio-tagged gravid females, it was very time-consuming to track them often enough to document their nesting behavior. We also discovered that females that were crossing land in search of nesting sites were extremely sensitive to unusual disturbances. We suspect that at least three of the females that we radio-tracked were disturbed by our approaching too closely during nesting, causing them to abandon each of their nest sites. Although we documented nesting occurring during most times of the day (Table 17), we believe that females that were undisturbed probably nested in late afternoon, between 1600 and 1900 hours. Several of the nest sites that we documented were on the Highway 1 embankment (Figure 39), subject to heavy summer tourist car traffic. Apparently these females habituated to this type of disturbance.

It is possible that not all abandonment was caused by human disturbances. In at least two cases, females left their nest sites with partially excavated nest holes. We discovered large stones below the surface of the soil at these sites.

There was considerable variation in the characteristics of the nest sites that we found. There seemed to be little pattern as to distance from water, elevation above water, slope, or orientation. All nests were in soils that were compact, and able to maintain a well-defined nesting chamber. All the nest sites were in the open with good exposure to the sun. These generalities are consistent with other observations (Storer, 1930; Rathbun et al., 1992).

The behavior of nestling turtles is still open to controversy (Rathbun, et al., 1992). Do they leave the nest at hatching, remain in the nest until the first rains, or overwinter in the nest? Based on the four nests that we monitored, we believe that the movement of young from the nests is variable. It is most likely that all individuals in a clutch leave the nest at the same time, but different clutches may emerge at any time between the first and last winter rains following oviposition.

<u>Garter Snake</u>

It is curious that we saw so few garter snakes in the Pico Creek system, especially as the main habitat components that we found associated with our observations at San Simeon Creek appeared to be present at Pico Creek: deep pools with an abundance of fish prey, and banks near these pools with sparse or low-profile vegetation. At San Simeon Creek, using radio-tracking, we determined that rodent burrows near the creek were important for adult snakes during the summer months (Figure 42). Although we did not quantify the density of burrows at either San Simeon or Pico Creeks, our impression was that California ground squirrel (*Spermophilus beecheyi*) and pocket gopher (*Thomomys bottae*) burrows were noticeably fewer at Pico Creek. It is possible that the human traffic and vegetation mowing regime at San Simeon State Park, surrounding the slough and lagoon, allowed relatively dense populations of rodents to develop, providing an abundance of shelter for the snakes. It is also possible that these same activities associated with controlling vegetation at the park improved visibility sufficiently so that we were able to observe and find snakes more easily at San Simeon Creek.

Overview

When we began our studies, virtually nothing was known about the status of the tidewater goby, California red-legged frog, southwestern pond turtle, and two-striped garter snake in San Simeon Creek, except that they were present and observed by park personnel from time to time. It was not an objective to estimate the populations of these species in the lower reaches of the creek, but based on the numbers we sighted during our surveys, and the total number of individual frogs, turtles, and snakes that we captured and marked during the year, we can provide minimum estimates. During their peak in abundance, adult tidewater gobies probably numbered over 1,300 individuals. The populations of the other three species were at least 50 individuals, including young of the year and juveniles. Most likely, these resident populations were several times higher, assuming minimal seasonal movements of individuals between the upper drainages, stock ponds, and the lower reaches of the creeks during 1992.

Generally, the spatial distributions and habitat uses of the red-legged frog, pond turtle, and garter snake in the two creeks were similar. All three species were frequently seen in the deeper, slow-moving waters near some type of vegetative cover. These same habitat associations have been well-documented for California red-legged frogs by Hayes and Jennings (1988), and for western pond turtles by Bury (1972) and Holland (1985). Although little natural history information has been published on the two-striped garter snake (e.g., see Grinnell and Grinnell, 1907; and Fitch, 1940, 1941), in many respects its life history is similar to other aquatic garter snakes that show similar ecological patterns (Fitch, 1940; Fox, 1952).

Little is known about the salt water tolerances of southwestern pond turtles and two-striped garter snakes. However, Jennings and Hayes (1990) determined that California red-legged frogs have low tolerances for salt water. Developing embryos do not survive in water with salt concentrations > 4.5 PPT and adult frogs avoid water with salinity levels > 9.0 PPT. More recent studies have found that tadpoles perish in water with salinity levels > 7.0 PPT (Jennings, unpubl. data). These relatively low tolerances for salt water, especially by developing embryos, coupled with the small and localized areas where frogs breed in both creeks, make the maintenance of natural regimes of water flow in the lower reaches of the two creeks critical. We believe that further reductions in fresh water flow in the lower sections of the creeks could result in the local extirpation of red-legged frogs. It may also result in the decline or local extirpation of the other aquatic vertebrates that rely on the lagoons and slough. Increasing salinities could adversely affect the riparian vegetation, which provides critical cover for the aquatic vertebrates and the other animals that they feed on.

Perhaps the most significant overall finding of our research is the importance of terrestrial habitats for the two aquatic reptiles and the single amphibian that we studied. Most of the published literature indicates that aquatic vertebrate populations would be secure if their aquatic habitat, including some nearshore riparian vegetation, is not radically disrupted. Obviously, this is largely the case for fishes. However, based on the information we have gathered over the last year, there are periods in the life histories of the pond turtle and garter snake, and possibly red-legged frog, that require upland, terrestrial habitats as nesting and sheltering areas. These habitats extend well beyond the riparian vegetation that secures stream banks and provides shade over the water. They include upland grasslands, chaparral, and pine/oak woodlands. This information on the use of upland habitats is especially important to consider in developing and implementing plans for managing land and people in San Simeon State Park.

There is little argument that introduced, novel aquatic predators, such as centrarchid fishes (i.e., bass and sunfish), bullfrogs, catfish, crayfish, etc., prey on our native fauna. Indeed, it is likely that at least some of the declines of native fishes, amphibians, and reptiles are due to non-native aquatic predators (Moyle, 1976; Hayes and Jennings, 1986).

There is some circumstantial evidence that many of the introduced aquatic predators are not as well adapted as native species to survive the environmental extremes of the Mediterranean climate, nor the estuarine conditions of coastal lagoons. For example, bullfrogs require perennial aquatic habitats and several weeks of warm water temperatures (> 23$^{o}$ C) for successful reproduction (Bury and Whelan, 1984). The maintenance of natural water regimes has probably been an important factor in explaining why communities of aquatic vertebrates in relatively undeveloped regions of coastal California are not declining as rapidly as in inland areas of the state, where unaltered streams and rivers are rare. Most drainages have either been dammed, creating permanent water where introduced species thrive, or destroyed, leaving virtually no water and where both native and introduced aquatic species perish.

We believe that natural water regimes, with their inherent seasonal variations in water flow and salinity, are important in preventing the establishment of exotic predators, which eventually decimate native faunas. Perhaps the most significant action that could be taken to prevent the decline of the local aquatic communities along the central California coast, and specifically in San Simeon State Park, is the protection and restoration of natural hydrological regimes.

## MANAGEMENT RECOMMENDATIONS

Our recommendations for San Simeon State Park are based on the results of our research and our assessment of the needs of the sensitive species that inhabit the lower reaches of San Simeon Creek. However, research and monitoring should be continued. Our studies have only established a baseline of information. Future research will be needed to understand natural and human-caused variation and trends, as well as assess whether any management actions that are implemented are working as planned.

1. A consistent flow of fresh water (which essentially mimics the natural hydrological regime) into lower San Simeon Creek must be maintained through the summer months. The lagoon community requires some fresh water throughout the year. This constant input of fresh water is also important in maintaining adequate riparian and bank vegetation, which provides cover for juvenile steelhead, red-legged frogs, pond turtles, and two-striped garter snakes. Similarly, a natural regime of freshwater flow through the slough at San Simeon Creek must be ensured to maintain the quality of this important habitat.

2. Exotic predators, such as feral cats, bullfrogs, and brown bullheads, should be eliminated.

3. The causes of the depressed dissolved oxygen levels in the lagoon need to be identified and corrected. Until suitable oxygen levels can be restored to the lagoon, it can not function as juvenile steelhead habitat.

4. Human use of the day-use/overflow campground area should be assessed in terms of impact on turtle nesting habitat and rodent burrows used by garter snakes. The April through July nesting period is especially important for turtles. The existing fences around the slough and day-use area should be maintained to protect this area from excessive human traffic.

5. Trails used by park visitors along the banks of the lagoon, slough, and creek decrease the amount of vegetation overhanging the water. This cover is important to all aquatic organisms, but especially the aquatic vertebrates. To encourage streamside vegetation, the riparian willow thicket along the northern side of the lagoon, adjacent to the camp ground, should be fenced; and the public access openings through the fence along the southern side, adjacent to the day-use/overflow area, should be closed. A plan to reduce foot traffic along the banks

of the lagoon, between the Washburn Bridge and the Highway 1 bridge, should be developed and implemented.

6. Control of rodents (ground squirrels and pocket gophers) should not be done using any form of poison in burrows. Rodent burrows are used by garter snakes (and many other animals) for shelter.

7. Bicycles should not be allowed up the creek bed. Such forms of recreation disturb turtles (and other wildlife) and bring people into habitats that are relatively sensitive and normally receive little impact from people.

8. Raccoons are known predators of all the sensitive taxa. There is some evidence that raccoon predation is a problem for turtles and frogs. The park should consider reducing the raccoon population, first by discouraging campers from feeding these animals and second, by ensuring that the raccoons are not supplementing their diet with scraps from trash cans. If raccoon numbers can not be reduced by managing the food supplied by humans, a trapping/removal program should be assessed and possibly implemented.

9. The use of axes and machetes by the public to cut willows (for fire wood?) should be stopped. Willows overhanging the creek and lagoon are essential components of the habitat required by the aquatic vertebrates. The public should be informed about current state park regulations against damaging vegetation.

10. The hydrological regime of the slough should be protected against alteration. Especially important is winter and spring flushing with fresh water runoff. The slough is perhaps the most important aquatic habitat for the frog and turtle in lower San Simeon Creek, and is the only area where we recorded frogs breeding.

11. Inform the public about current state park regulations against the capture and removal of fauna, specifically the sensitive aquatic vertebrates. A training session for park personnel covering the basic natural history of the lagoon community and sensitive species would help park staff inform the public and enforce park regulations. In conjunction with this training, visitors to the park should be provided with an informational leaflet explaining the importance of the lagoon to the community of animals that live there. Also, the importance of riparian and upland habitats to some of the aquatic vertebrates should be stressed.

12. Close San Simeon Creek to steelhead fishing at all times. The steelhead population in San Simeon Creek is arguably on the verge of collapse and there is no justification for a fishery under these circumstances.

13. Remove all patches of ice plant (*Carpobrotus*) that are becoming established in the region of the slough and lagoon. If allowed to spread, this exotic, invasive plant will not only exclude native plants, but may eventually impact turtle nesting areas and garter snake winter habitat.

14. The expansion and control of fennel (*Foeniculum vulgare*) and exotic thistles should be assessed. It is possible that pure stands of these plans destroy areas as turtle nesting habitat.

15. The stream bank adjacent to the small parking lot and rest rooms on the north side of the lagoon, just upstream of the Highway 1 bridge, is especially important habitat for the two-striped garter snake. This area should be managed for snakes by protecting the cattail beds. The numerous burrows of ground squirrels and pocket gophers in this area provide shelter for garter snakes. The public should be discouraged from trampling the cattails and small willows and disturbing/capturing basking snakes in this area. Managing human traffic in this area will also serve to stabilize the bank by encouraging bank vegetation to grow.

16. All known nesting areas of turtles and wintering areas of snakes should be protected. To the extent possible, protect open chaparral and grassland areas, within at least 100 m of the creek and ideally up to 500 m of the creek, as potential turtle nesting habitat and two-striped garter snake wintering habitat.

17. The current water conditions in the lagoon should not be allowed to deteriorate to the point where goby populations are affected. This is also important for stickleback populations, because these fish are the main prey for two-striped garter snakes in the lagoon.

18. Activities in the lagoon should be assessed in terms of protecting dense and widespread mats of ditch grass, especially downstream from the Highway 1 bridge. Fish seining, heavy use by swimmers, and excessive boating might result in less aquatic vegetation (cover) and less habitat for all of the aquatic vertebrates.

**ACKNOWLEDGMENTS**

Woody Elliott's guidance and assistance with this study are greatly appreciated. Denise Woodard, who worked as a temporary technician for us, assisted with the initial fish surveys. Jon Pedotti gave us permission to radio-track turtles on his ranch. Sean Grauel of the Cambria Community Services District provided rainfall data, and Grauel and Don Alley advised us on methods of sampling water flow. Bob VanWagenen of Ecoscan in Watsonville, CA, provided the study area maps. Glen Britton of the San Luis Obispo County Engineering Department provided some water flow data for San Simeon Creek. Dean Hilger, DDS, of Cambria helped us in obtaining dental acrylic for attaching radio-tags to the turtles. Glenn Sproule, MD, John Truax, DVM, and Camelle Hirst graciously x-rayed gravid turtles for us. We benefited from comments by Woody Elliott, Don Alley, and Cathy Langtimm on a draft of this report.

**LITERATURE CITED**

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

Brattstrom, B.H. 1988. Habitat destruction in California with special reference to *Clemmys marmorata*: a perpesctive (sic). Pages 13 - 24 *in* Proceedings of the Conference on California Herpetology. (Eds: DeLisle, H.F.; Brown, P.R.; Kaufman, B.; McGurty, B.M.). Southwestern Herpetologists Society, Special Publication (4):1-143.

Brewer, D.C., and C. Brown. 1992. Endangered and threatened wildlife and plants; proposed endangered status for the tidewater goby. Federal Register 57(239):58770-58774. [11 December 1992].

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

Bury, R.B., and J.A. Whelan. 1984. Ecology and management of the bullfrog. U.S. Fish and Wildlife Service, Resource Publication (155):1-23.

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

California Department of Fish and Game. 1991. Special Animals. California Department of Fish and Game, Natural Diversity Data Base, Sacramento, California. 22 pp.

Camper, J.D. and J.R. Dixon. 1988. Evaluation of a microchip marking system for amphibians and reptiles. Texas Parks and Wildlife Department, Austin Texas. 22 pp.

Fitch, H.S. 1940. A biogeographical study of the *ordinoides* Artenkreis of the garter snakes (genus *Thamnophis*). University of California Publications in Zoology 44(1):1-150.

Fitch. H.S. 1941. The feeding habits of California garter snakes. California Fish and Game 27(2):1-32.

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

Gibbons, J.W., and J.L. Greene. 1979. X-ray photography: A technique to determine reproductive patterns of freshwater turtles. Herpetologica 35:86-89.

Grinnell, J., and H.W. Grinnell. 1907. The reptiles of Los Angeles County. Throop Polytechnic Institute Bulletin (35):1-35.

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 20:490-509.

Hayes, M.P., and M.R. Jennings. 1988. 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* Management of amphibians, reptiles, and small mammals in North America, Proceedings of the Symposium, July 19-21, 1988 - Flagstaff, Arizona (Technical Coordinators: Szaro, R.E., Severson, K.E., and Patton, D.R.). U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report (RM-166):1-458.

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, California. 181 pp.

Irwin, J.F., and D.L. Soltz. 1984. The natural history of the tidewater goby, *Eucyclogobius newberryi*, in San Antonio and Shuman Creek system, Santa Barbara County, California. Unpublished report for the U.S. Fish and

Wildlife Service, Sacramento Endangered Species Office, under Contract Order (11310-0215-2):1-33.

Jennings, M. R. and M. P. Hayes. 1990. Status of the California red-legged frog *Rana aurora draytonii* in the Pescadero Marsh Natural Preserve. Contract Report prepared for California Department of Fish and Game, Resource Protection Division, Sacramento, California. Contract (4-823-9018):1-30.

Jones and Stokes, Associates. 1987. Sliding toward extinction: The state of California's natural heritage. Report prepared for The Nature Conservancy, San Francisco, California. 105 pp.

Leitritz, E., and R.C. Lewis. 1976. Trout and salmon culture (hatchery methods). California Department of Fish and Game, Fish Bulletin (164):1-197

Major, J. 1988. California climate in relation to vegetation. Pages 11 - 74 *in* Terrestrial vegetation of California (Eds: Barbour, M.G.; Major, J.) California Native Plant Society, Special Publication (9):1-1033.

Meehan, W.R., and W.S. Platts. 1978. Livestock grazing and the aquatic environment. Journal of Soil and Water Conservation 33:274-278.

Moyle, P.B. 1976. Fish introductions in California: history and impact on native fishes. Biological Conservation 9:101-118.

Moyle, P.B., J.E. Williams, and E.D. Wikramanayake. 1989. Fish species of special concern of California. Final report submitted to the California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, California, under contract (7337):ii + 222 pp.

Platts, W.S., W.F. Megahan, and G.W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. U.S. Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report (INT-138):1-70.

Rathbun, G.B., N. Siepel, and D. Holland. 1992. Nesting behavior and movements of western pond turtles, *Clemmys marmorata*. Southwestern Naturalist 37:319-324.

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

Sorensen, P., and L.J. Propp. 1992. Endangered and threatened wildlife and plants; 90-day finding and commencement of status reviews for a petition to list the western pond turtle and California red-legged frog. Federal Register 57(193):45761-45762. [5 October 1992].

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.

Swift, C.C., 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.

U.S. Fish and Wildlife Service. 1991. Animal candidate review for listing as endangered or threatened species. Federal Register 56(225):58804-58836. [21 November 1991].

Warner, R.E., and K.M. Hendrix (eds). 1984. California riparian systems; ecology, conservation, and productive management. University of California Press, Berkeley, California. 1035 pp.

Worcester, K.R. 1992. Habitat utilization in a central California coastal lagoon by the tidewater goby (*Eucyclogobius newberryi*). M.A. Thesis, California State Polytechnic University, San Luis Obispo, California. 218 pp.

Yates, E.B., and K.M. Van Konynenburg. 1990. Hydrology and water resources of the Cambria area, San Luis Obispo, California. Preliminary Version. U.S. Geological Survey, Water-resources Investigations Report [manuscript]. 189 pp.

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

## TABLES

**TABLE 1.** Status of some sensitive vertebrates occurring in coastal arroyos of central California.

| SPECIES | FEDERAL STATUS[1] | STATE STATUS |
|---|---|---|
| Steelhead[2] | BLM/USFS sensitive | spec. concern |
| Tidewater goby | USFWS candidate 1 | spec. concern |
| Calif. red-legged frog | USFWS candidate 1 | spec. concern |
| Foothill yellow-legged frog[3] | USFWS candidate 2 | spec. concern |
| Two-striped garter snake[4] | USFWS candidate 2 | none |
| Western pond turtle | USFWS candidate 1 | spec. concern |

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

2 Winter runs of this fish are declining in California from San Luis Obispo County, north. It has virtually disappeared south of San Luis Obispo County.

3 This frog has disappeared from much of its southern and central California range, and continues to decline in those few places where it still occurs in this region.

4 This snake is restricted to creeks in the inner and outer coastal ranges of central and southern California. It is disappearing in southern California due to habitat destruction.

**Table 2.** Number of tidewater gobies observed using various habitat types during visual surveys in San Simeon Creek from May 1992-April 1993. (Note: Lagoon = segments 11-29).

| Habitat | Juvenile (%) | Adult (%) | All Ages (%) |
|---|---|---|---|
| Lagoon | 7,824 (98.3%) | 1,094 (30.5%) | 8,918 (77.2%) |
| Pool | 135 ( 1.7%) | 2,456 (68.5%) | 2,591 (22.4%) |
| Riffle | 0 ( 0.0%) | 3 ( 0.1%) | 3 ( 0.0%) |
| Glide | 3 ( 0.0%) | 35 ( 0.9%) | 38 ( 0.3%) |
| TOTALS: | 7,962 (100.0) | 3,588 (100.0) | 11,550 (99.9%) |

**Table 3.** Number of tidewater gobies observed using various habitat types during visual surveys in Pico Creek from May 1992-April 1993 (Note: Lagoon = segments 1-13).

| Habitat | Juvenile (%) | Adult (%) | All Ages (%) |
|---|---|---|---|
| Lagoon | 11,262 (83.0%) | 1,997 (49.1%) | 13,259 (75.2%) |
| Pool | 163 ( 1.2%) | 581 (14.3%) | 744 ( 4.2%) |
| Riffle | 0 ( 0.0%) | 0 ( 0.0%) | 0 ( 0.0%) |
| Glide | 2,137 (15.8%) | 1,489 (36.6%) | 3,626 (20.6%) |
| TOTALS: | 13,562 (100.0) | 4,067 (100.0) | 17,629 (100.0) |

**Table 4.** Number of tidewater gobies observed during visual surveys over various substrate types in San Simeon Creek from May 1992-April 1993.

| Substrate | Juvenile (%) | Adult (%) | All Ages (%) |
|---|---|---|---|
| Boulder | 0 ( 0.0%) | 0 ( 0.0%) | 0 ( 0.0%) |
| Rock | 882 (11.1%) | 33 ( 0.9%) | 915 ( 7.9%) |
| Cobble | 27 ( 0.3%) | 347 ( 9.7%) | 374 ( 3.2%) |
| Gravel | 6 ( 0.0%) | 458 (12.8%) | 464 ( 4.0%) |
| Sand | 6,570 (82.5%) | 2,335 (65.1%) | 8,905 (77.1%) |
| Fines | 477 ( 6.0%) | 415 (11.6%) | 892 ( 7.7%) |
| TOTALS: | 7,962 (99.9%) | 3,588 (100.1) | 11,550 (99.9%) |

**Table 5.** Number of tidewater gobies observed during visual surveys over various substrate types in Pico Creek from May 1992-April 1993.

| Substrate | Juvenile (%) | Adult (%) | All Ages (%) |
|---|---|---|---|
| Boulder | 203 ( 1.9%) | 15 ( 0.4%) | 218 ( 1.5%) |
| Rock | 1,396 (12.7%) | 259 ( 6.5%) | 1,655 (11.1%) |
| Cobble | 1,012 ( 9.2%) | 549 (13.8%) | 1,561 (10.4%) |
| Gravel | 999 ( 9.1%) | 905 (22.7%) | 1,904 (12.7%) |
| Sand | 6,475 (59.0%) | 2,222 (55.7%) | 8,697 (58.1%) |
| Fines | 887 ( 8.1%) | 40 ( 1.0%) | 927 ( 6.2%) |
| TOTALS: | 10,972 (100.0) | 3,990 (100.1) | 14,962 (100.0) |

**Table 6.** Number of juvenile steelhead rainbow trout observed during visual surveys in various habitat types in Pico Creek from May 1992-April 1993 (Note: Lagoon = segments 1-13).

| Habitat | Number | (%) |
|---|---|---|
| Lagoon | 54 | (28.4%) |
| Pool | 31 | (16.3%) |
| Riffle | 19 | (10.0%) |
| Glide | 86 | (45.3%) |
| TOTALS: | 190 | (100.0%) |

**Table 7.** Number and age classes of all fish species observed during visual surveys in San Simeon and Pico Creeks, San Luis Obispo County, from May 1992-April 1993.

| Fish Species* | San Simeon Creek | | Pico Creek | |
|---|---|---|---|---|
| | Juveniles | Adults | Juveniles | Adults |
| Stickleback | 27,246 | 87,544 | 18,496 | 16,365 |
| Tidewater goby | 7,962 | 3,573 | 13,555 | 4,148 |
| Steelhead | 1 | 0 | 190 | 0 |
| Sculpins | 41 | 69 | 115 | 345 |
| Staghorn sculpin | 7 | 7 | 9 | 37 |
| Starry flounder | 0 | 1 | 3 | 2 |
| Brown bullhead | 2 | 6 | 0 | 0 |
| TOTALS: | 35,259 | 91,200 | 32,368 | 20,897 |

* See Introduction for scientific names of these fishes.

**Table 8.** Number of red-legged frogs sighted during visual surveys in three regions of lower San Simeon Creek during 1992. Lagoon = segments 11-29, slough = segments 1-10, creek = segments 30-49 (see Figure 5, top).

| Region | Small (%) | Large (%) | Total (%) |
|---|---|---|---|
| Lagoon | 10 (8.0%) | 42 (16.5%) | 52 (13.7%) |
| Slough | 86 (68.8%) | 72 (28.4%) | 158 (41.7%) |
| Creek | 29 (23.2%) | 140 (55.1%) | 169 (44.6%) |
| TOTALS: | 125 (100.0%) | 254 (100.0%) | 379 (100.0%) |

**Table 9.** Number of red-legged frogs sighted during visual surveys in two regions of lower Pico Creek during visual surveys during 1992. Lagoon = segments 1-13, creek = segments 14-35 (see Figure 5, bottom). There was no slough region in Pico Creek.

| Region | Small (%) | Large (%) | Total (%) |
|---|---|---|---|
| Lagoon | 12 (70.6%) | 72 (44.2%) | 84 (46.7%) |
| Creek | 5 (29.4%) | 91 (55.8%) | 96 (53.3%) |
| TOTALS: | 17 (100.0%) | 163 (100.0%) | 180 (100.0%) |

**Table 10.** Number of red-legged frogs sighted in four habitats during visual surveys in lower San Simeon and Pico Creeks during 1992. In Pico Creek, small and large frogs have been combined (= total) because of scarcity of small frog sightings. Land = > 50 cm from water, bank = within 50 cm of water, shore = in water within 50 cm of land, water = > 50 cm from land.

| | Pico Creek | San Simeon Creek | | |
|---|---|---|---|---|
| Habitat | Total (%) | Small (%) | Large (%) | Total (%) |
| Land | 0 (0%) | 0 (0%) | 4 (1.6%) | 4 (1.1%) |
| Bank | 22 (13.8%) | 6 (4.8%) | 30 (11.8%) | 36 (9.5%) |
| Shore | 50 (31.5%) | 25 (20.0%) | 64 (25.3%) | 89 (23.5%) |
| Water | 87 (54.7%) | 94 (75.2%) | 155 (61.3%) | 249 (65.9%) |
| TOTALS: | 159 (100.0%) | 125 (100.0%) | 253 (100.0%) | 378 (100.0%) |

**Table 11.** Number of red-legged frogs sighted during visual surveys in three creek habitat types in San Simeon and Pico Creeks during 1992 (see Platts, et al. 1983, for further definitions).

| Habitat | San Simeon Creek (%) | Pico Creek (%) |
|---|---|---|
| Pools | 336 (90.6%) | 142 (80.7%) |
| Glides | 33 (8.9%) | 32 (18.2%) |
| Riffles | 2 (0.5%) | 2 (1.1%) |
| TOTALS: | 371 (100.0%) | 176 (100.0%) |

**Table 12.** Number of red-legged frogs sighted during visual surveys in four vegetation types in lower San Simeon Creek during 1992. Type 1 = no vegetation, Type 2 = low vegetation, Type 3 = cattails, sedges, etc., and Type 4 = dense vegetation (see text for further details).

| Vegetation | Small (%) | Large (%) | Total (%) |
|---|---|---|---|
| Type 1 | 2 (1.7%) | 13 (6.0%) | 15 (4.5%) |
| Type 2 | 28 (23.5%) | 34 (15.7%) | 62 (18.5%) |
| Type 3 | 76 (63.9%) | 78 (35.9%) | 154 (45,8%) |
| Type 4 | 13 (10.9%) | 92 (42.4%) | 105 (31,2%) |
| TOTALS: | 119 (100.0%) | 217 (100.0%) | 336 (100.0%) |

**Table 13.** Number of red-legged frogs sighted during visual surveys in four types of vegetative cover in lower Pico Creek during 1992. Type 1 = no vegetation, Type 2 = low vegetation, Type 3 = cattails, sedges, etc., and Type 4 = dense vegetation (see text for further details).

| Vegetation | Small (%) | Large (%) | Total (%) |
|---|---|---|---|
| Type 1 | 2 (12.5%) | 7 (5.1%) | 9 (5.9%) |
| Type 2 | 3 (18.8%) | 7 (5.1%) | 10 (6.5%) |
| Type 3 | 7 (43.7%) | 40 (29.2%) | 47 (30.7%) |
| Type 4 | 4 (25.0%) | 83 (60.6%) | 87 (56.9%) |
| TOTALS: | 16 (100.0%) | 137 (100.0%) | 153 (100.0%) |

**Table 14.** Number of pond turtles sighted during visual surveys in three habitats types in lower San Simeon Creek during 1992. Bank = within 50 cm of water, Shore = in water within 50 cm of land, and water = > 50 cm from land.

| Habitat | Small (%) | Large (%) | Total (%) |
|---|---|---|---|
| Bank | 2 (13.3%) | 63 (22.3%) | 65 (21.8%) |
| Shore | 2 (13.3%) | 6 (2.1%) | 8 (2.7%) |
| Water | 11 (73.3%) | 214 (75.6%) | 225 (75.5%) |
| TOTALS: | 15 (100.0%) | 283 (100.0%) | 298 (100.0%) |

**Table 15.** Number of pond turtles sighted during visual surveys in four vegetative cover types in lower San Simeon Creek during 1992. Type 1 = no vegetation, Type 2 = low vegetation, Type 3 = cattails, sedges, etc., and Type 4 = dense vegetation (see text for further details).

| Vegetation | Small (%) | Large (%) | Total (%) |
|---|---|---|---|
| Type 1 | 0 (0.0%) | 8 (2.8%) | 8 (2.7%) |
| Type 2 | 11 (73.3%) | 191 (68.0%) | 202 (68.2%) |
| Type 3 | 2 (13.3%) | 49 (17.4%) | 51 (17.2%) |
| Type 4 | 2 (13.3%) | 33 (11.7%) | 35 (11.8%) |
| TOTALS: | 15 (100.0%) | 281 (100.0%) | 296 (100.0%) |

**Table 16.** Characteristics of upland sites used by pond turtles in lower San Simeon and Pico Creeks during 1992.

| ACTIVITY | NO. INDIV. | NO. SITES | $\bar{x}$ METERS TO H2O±SD; RANGE | $\bar{x}$ DAYS IN UPLAND±SD; RANGE |
|---|---|---|---|---|
| BASKING | 9 | 28 | 4.5±3.0; 0.5-12 | 1.3±1.3; 1-8 |
| DORMANT | 16 | 55 | 43.5±71.0; 2-450 | 22.3±31.5; 1-173 |
| NESTING ATTEMPTS | 6 | 13 | 56.3±51.2; 15-171 | 1.2±0.4; 1-2 |
| NEST/EGGS | 4 | 4 | 17.3±7.5; 9.5-27 | 1±0; 0 |

**Table 17.** Characteristics of pond turtle nest sites and attempted nest sites in lower San Simeon Creek during 1992. See Figure 39.

| SITE ID | TURTLE ID | DATE(S) 1992 | TERRESTRIAL TIME | BEHAVIOR |
|---|---|---|---|---|
| A | 6048 | 4-5 May | N/A | Inactive |
| B | 6048 | 6-8 May | N/A | Inactive |
| C | 6051 | 28 May | N/A | Inactive |
| D | 6051 | 29 May | N/A | Inactive |
| E | 6051 | 30 May | N/A | Inactive |
| F | 2281 | 5 June | ca.1700-ca.1830 | Hole |
| G | 2281 | 6 June | ca.0955-1135 | Wet Soil |
| H | 2281 | 8 June | ca.0800-0955 | Hole |
| H | 2281 | 8 June | ca.1645-ca.1730 | Inactive |
| I | 1B38 | 11 June | ca.1735-ca.1905 | Inactive |
| J | 1B38 | 14 June | ca.1630-ca.1830 | Eggs |
| K | 6048 | 13 June | ca.1600-1720 | Eggs |
| L | 6009 | 13 June | ca.1600-1855 | Eggs |
| M | 2285 | 12 June | N/A | Inactive |
| N | 2285 | 12-13 June | N/A | Inactive |

**Table 18.** Characteristics of two-striped garter snake home ranges in lower San Simeon Creek during 1992. See Figures 42 and 43.

| SNAKE ID & SEX | FIRST/LAST DATE WITH RADIO(S) | NO. DAYS W/RADIO | NO. TIMES LOCATED/ SEARCHED | NO. UNIQUE RADIO LOCATIONS | HOME RANGE ($m^2$) | $\bar{x}$ DAILY DISTANCE TO WATER (m) | $\bar{x}$ DISTANCE MOVED/DAY (m) |
|---|---|---|---|---|---|---|---|
| **SUMMER RANGES** | | | | | | | |
| 2318 F | 19 Aug - 24 Aug | 4 | 11/4 | 7 | 83 | 2.7 | 7.6 |
| 3707 F | 18 Aug - 18 Oct[1] | 29 | 62/28 | 24 | 1110 | 13.1 | 8.8 |
| 446A F | 16 Sep - 22 Sep | 7 | 12/7 | 5 | 244 | 4.6 | 5.7 |
| 471D F | 27 Jul - 19 Aug | 24 | 66/23 | 37 | 5269 | 5.1 | 20.7 |
| 5E69 F | 8 Sep - 11 Sep | 4 | 7/4 | 7 | 2448 | 5.9 | 41.4 |
| 6B0D F | 24 Sep - 9 Oct | 16 | 23/13 | 5 | 309 | 12.7 | 2.4 |
| 7729 F | 18 Aug - 29 Sep[2] | 18 | 46/18 | 10 | 1029 | 6.1 | 14.6 |
| Mean | | | | | 1498.9 | 7.2 | 14.5 |
| ± Standard Deviation | | | | | 1847.6 | 4.1 | 13.3 |
| **WINTER RANGES** | | | | | | | |
| 1B73 F | 23 Oct - 20 Nov | 29 | 29/25 | 10 | 52 | 61.0 | 1.9 |
| 2024 M | 23 Oct - 20 Nov | 30 | 32/27 | 12 | 1235 | 53.6 | 4.0 |
| 3707 F | 19 Oct - 14 Dec[2] | 57 | 68/52 | 20 | 8900 | 181.7 | 4.9 |
| Mean | | | | | 3395.7 | 98.8 | 3.6 |
| ± Standard Deviation | | | | | 4803.5 | 71.3 | 1.5 |

1 = Radio-tagged 3 times
2 = Radio-tagged 2 times

**FIGURE 1**
Location of San Simeon Creek and Pico Creek in northwestern San Luis Obispo County, California. Urbanized areas of San Simeon Acres, Cambria, Cayucos, and Morro Bay (north to south) are illustrated by parallel hatching.

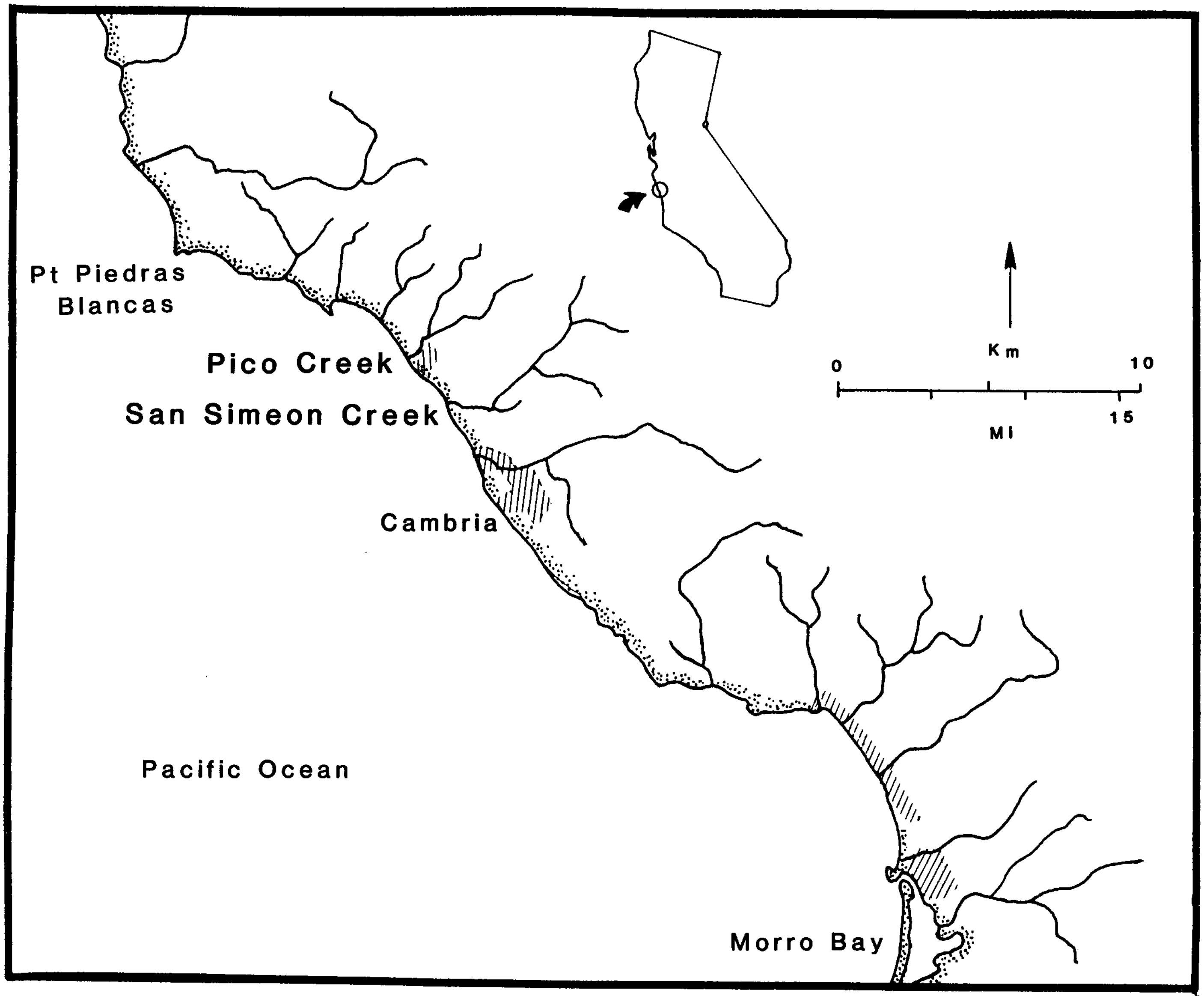


**FIGURE 2**

California red-legged frog, southwestern pond turtle, and two-striped garter snake (from top to bottom). Methods of radio-transmitter attachment are illustrated for each species. See text for details.

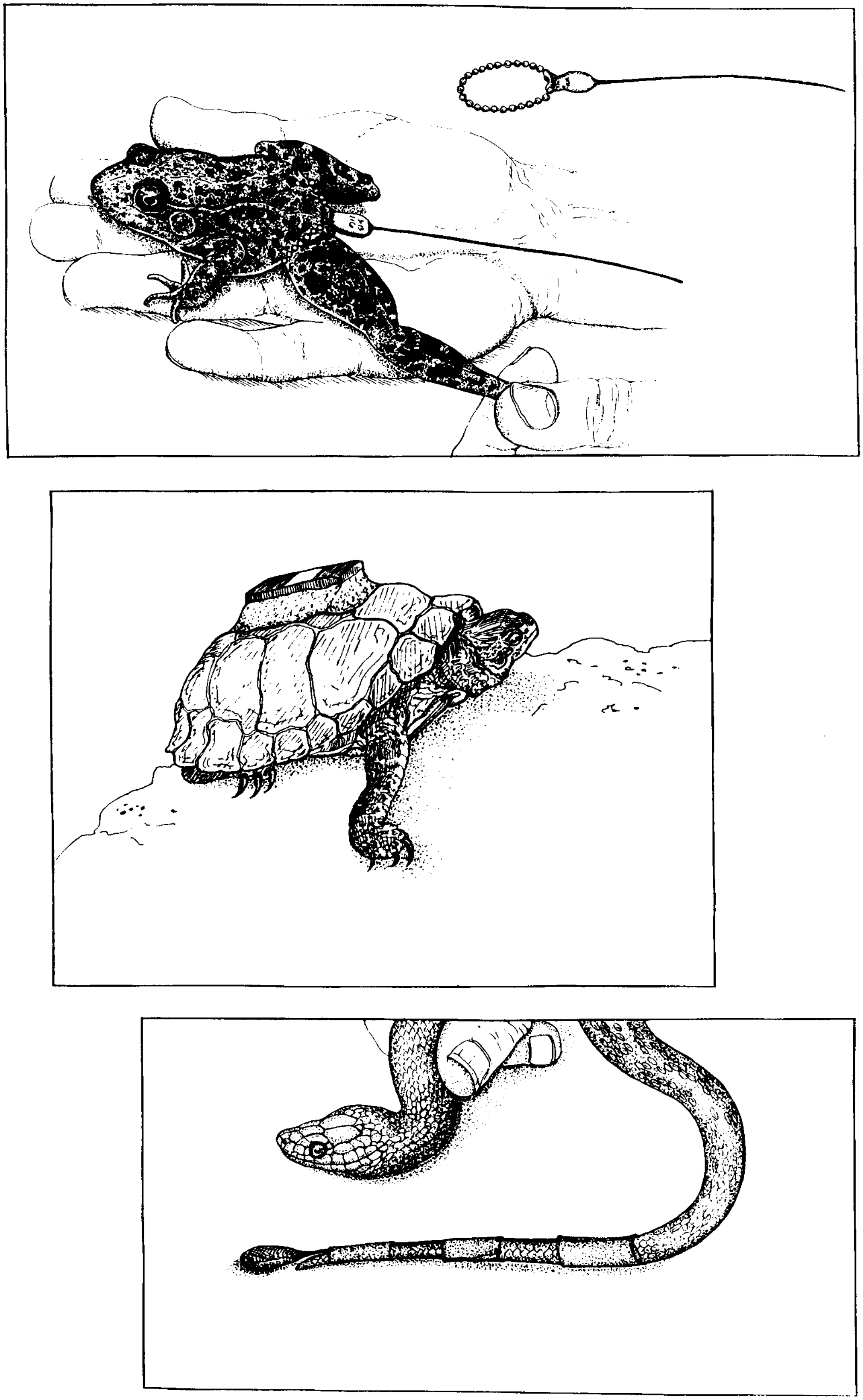


**FIGURE 3**

San Simeon Creek study area. Shaded areas along creek represent closed-canopy riparian forest. Shaded areas away from creek are largely Monterey pine forest. Solid areas are buildings. See Figure 5 (top) for additional information.

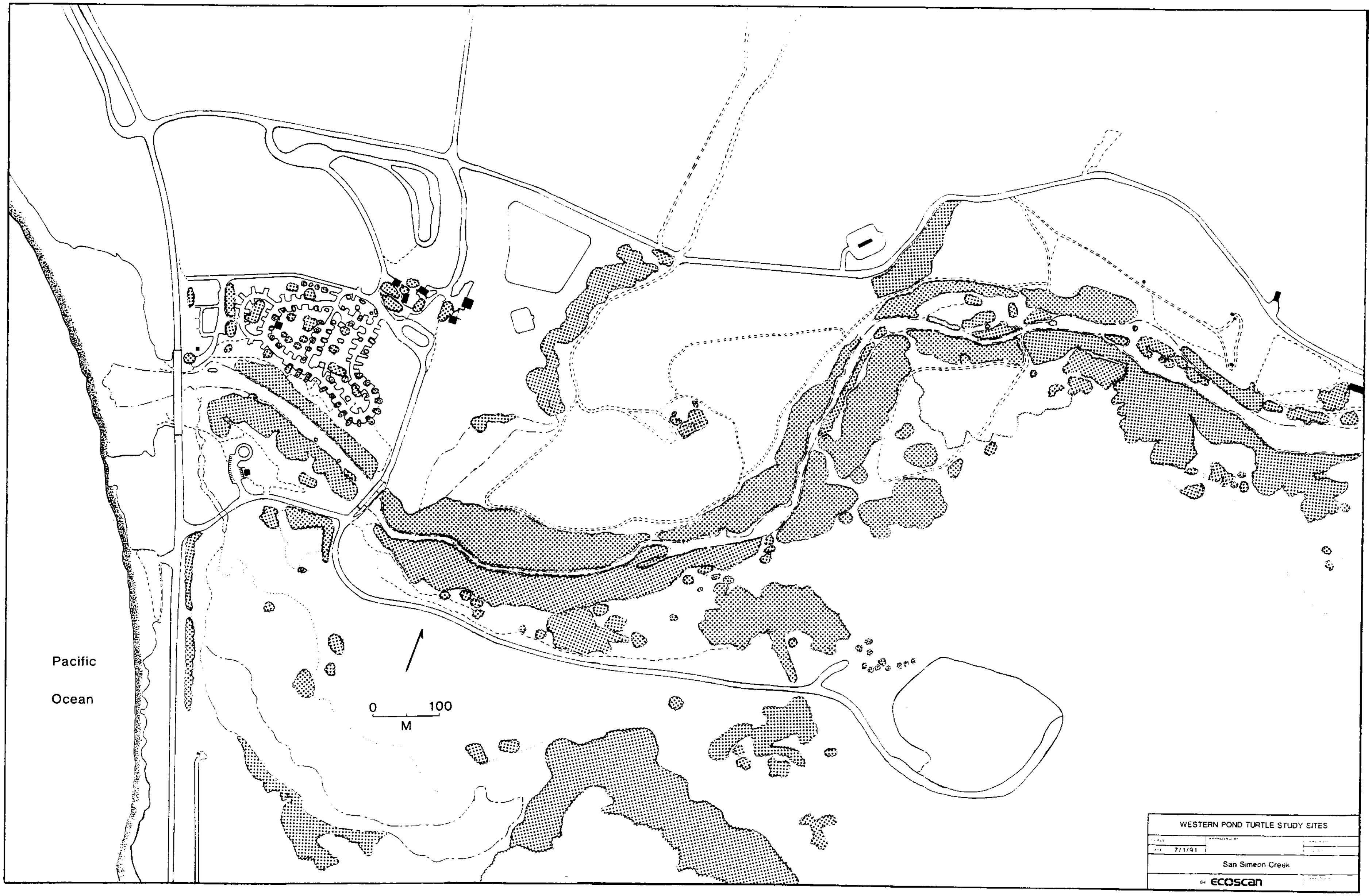


**FIGURE 4**

Pico Creek study area. Shaded areas represent closed-canopy riparian forest. Solid areas are buildings in San Simeon Acres. See Figure 5 (bottom) for additional information.

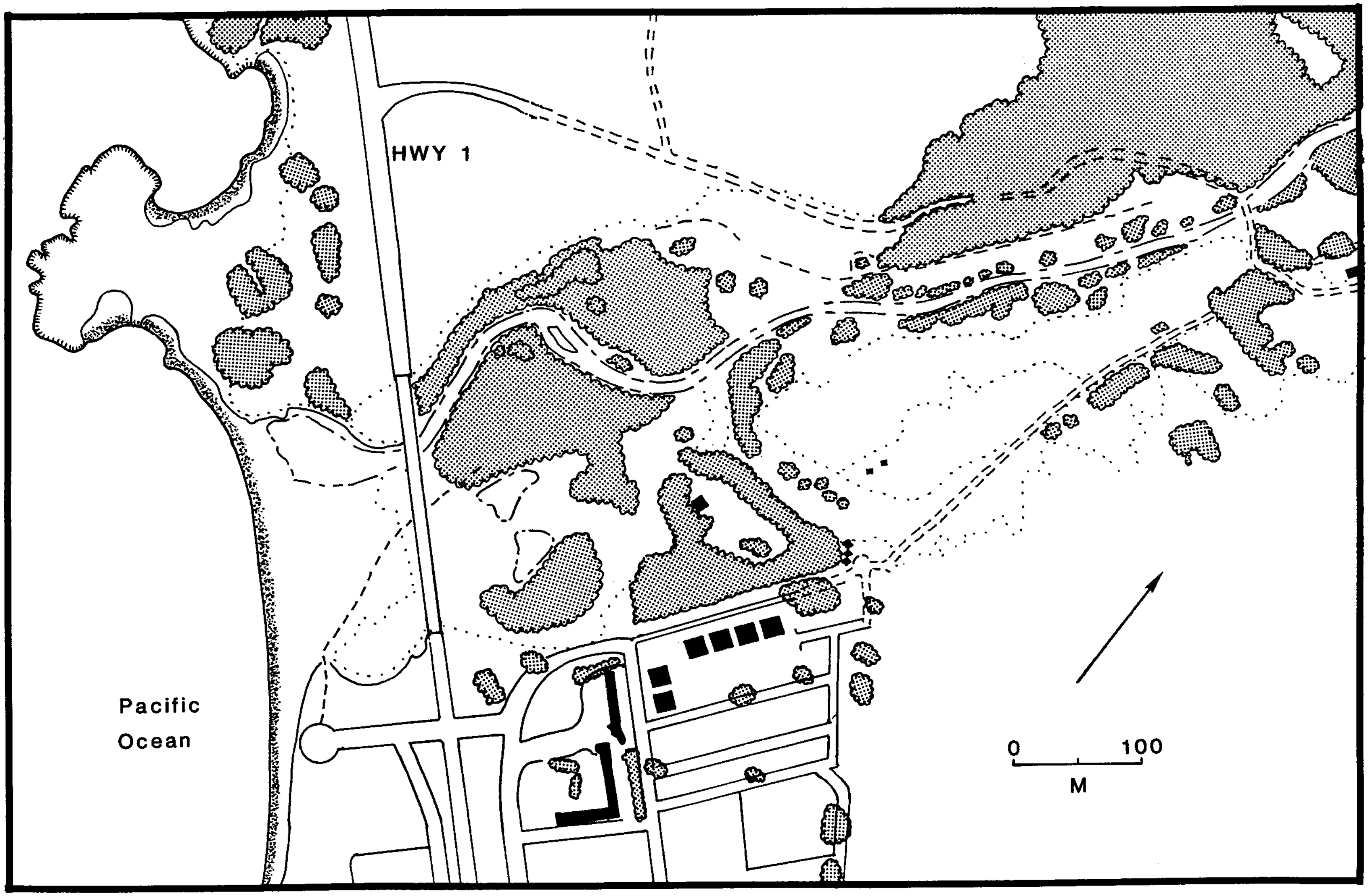
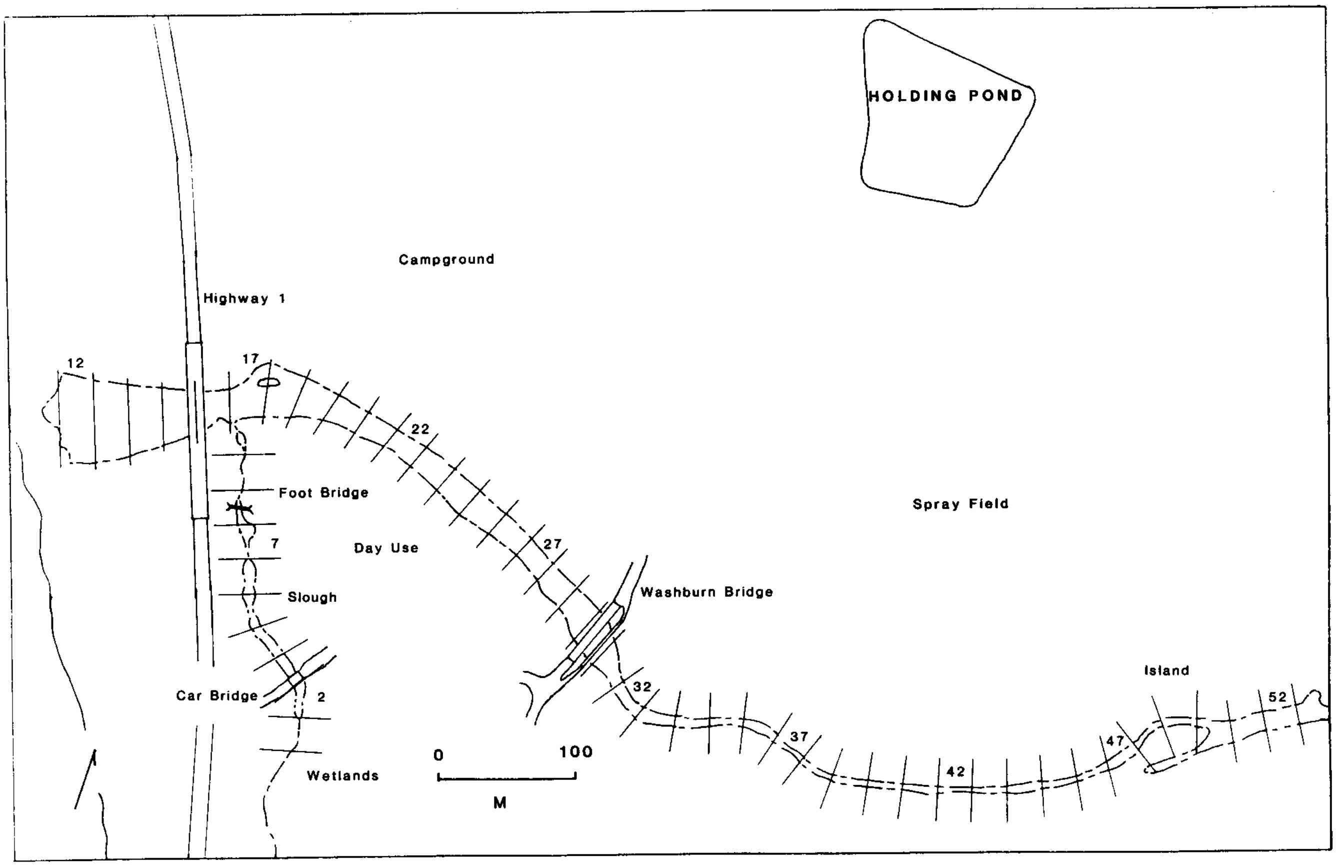


**FIGURE 5**
San Simeon Creek study area (top) and Pico Creek study area (bottom) with locations of 25-m-long segments up stream beds. Important features are also identified. See Figures 3 and 4.



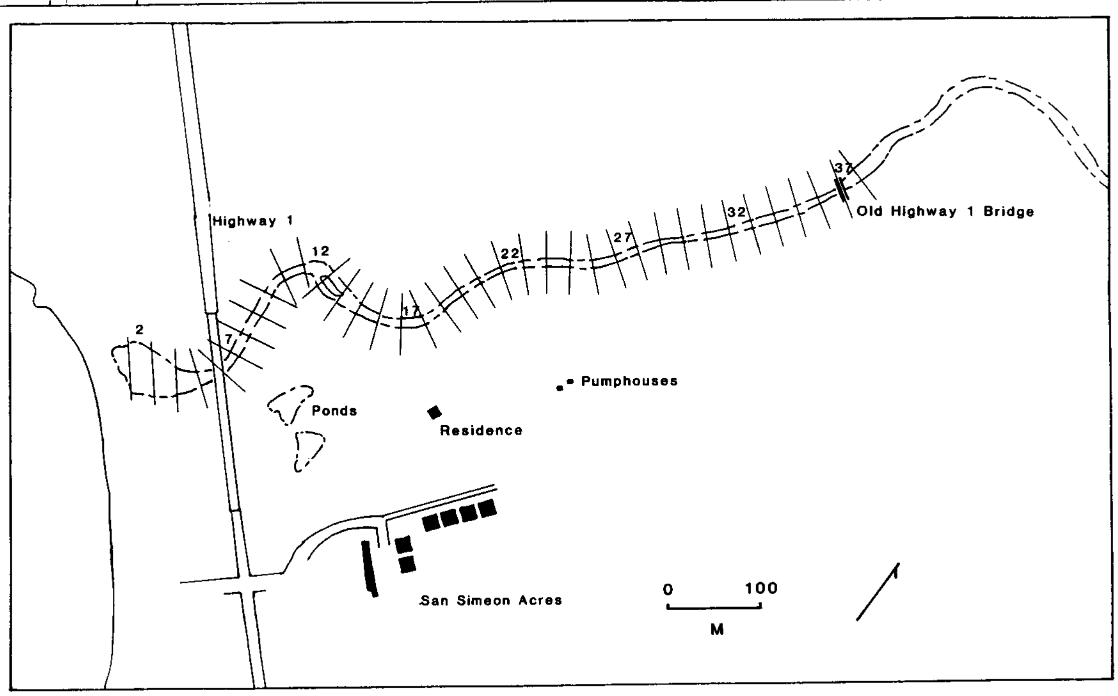



FIGURE 6. Total weekly rainfall at the Cambria Community Services District (CCSD) waste water treatment plant near the mouth of Santa Rosa Creek, Cambria. Dates define beginning of week. Data courtesy of CCSD.

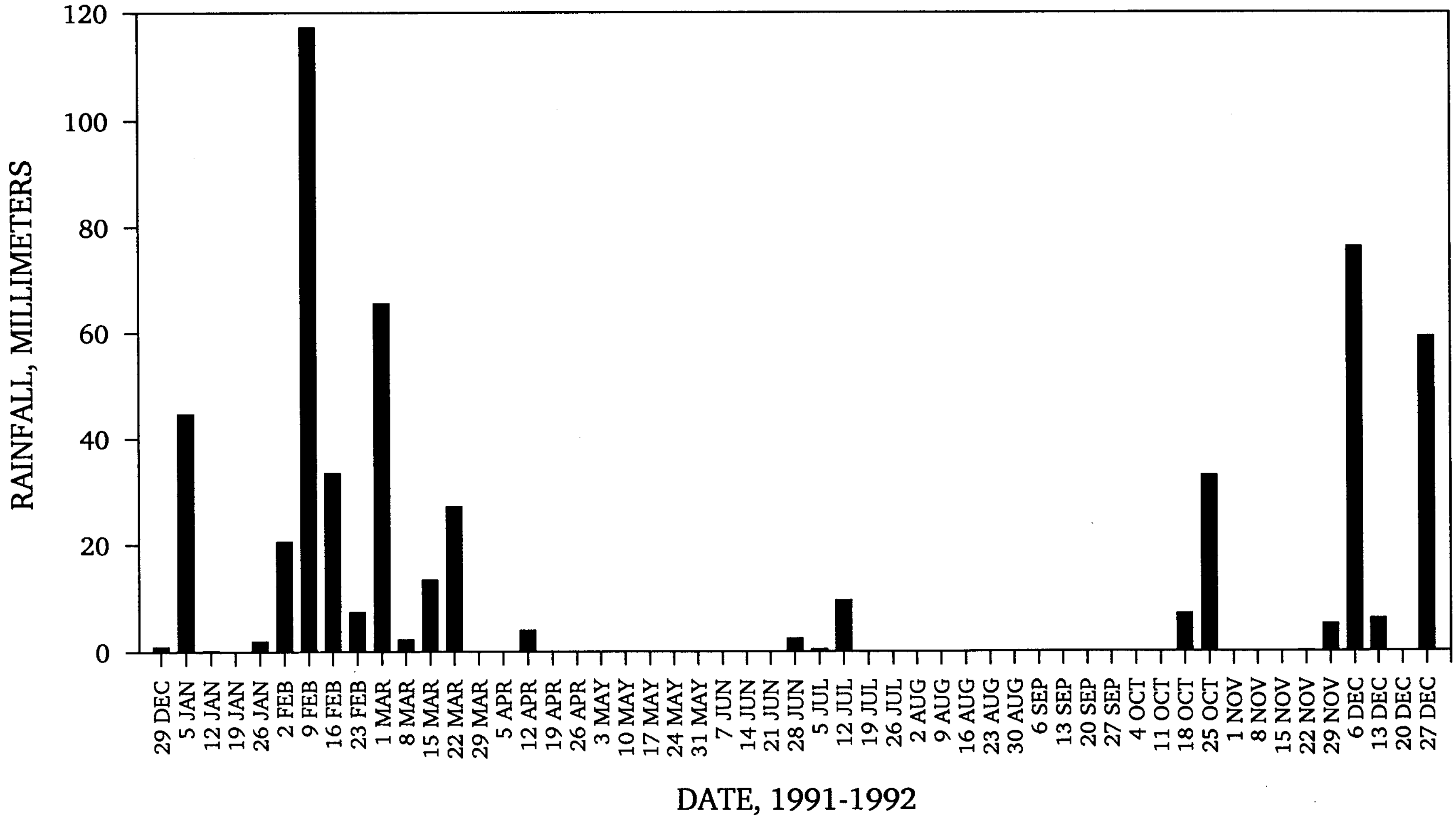


FIGURE 7. Instantaneous stream flow on San Simeon Creek. Measurements were taken weekly at segment 49 from January through May, 1992, and at segment 32 from June through December, 1992.

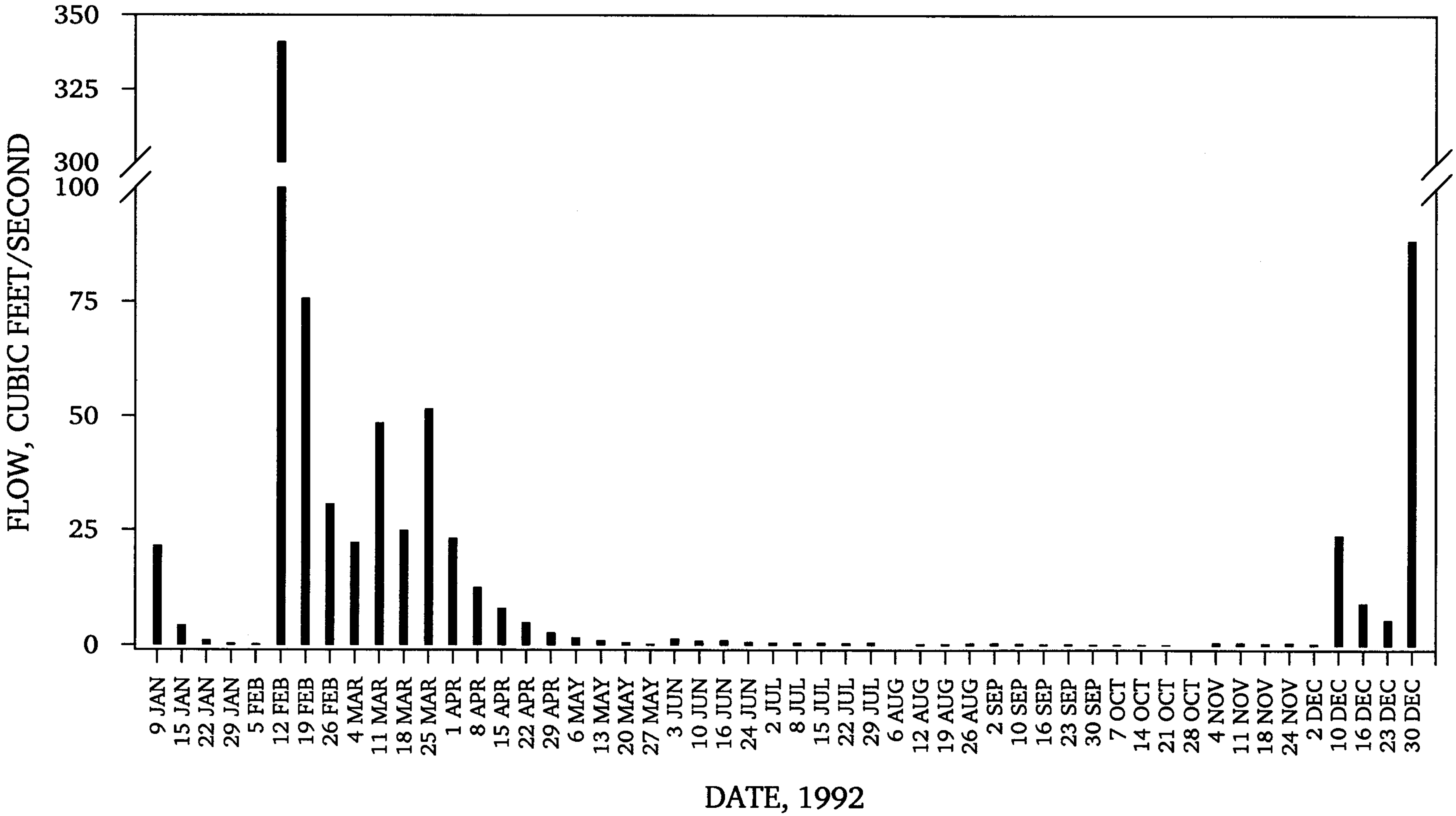


FIGURE 8. Instantaneous stream flow on Pico Creek. Measurements were taken weekly at segments 24 through 28, depending on stream flow conditions.

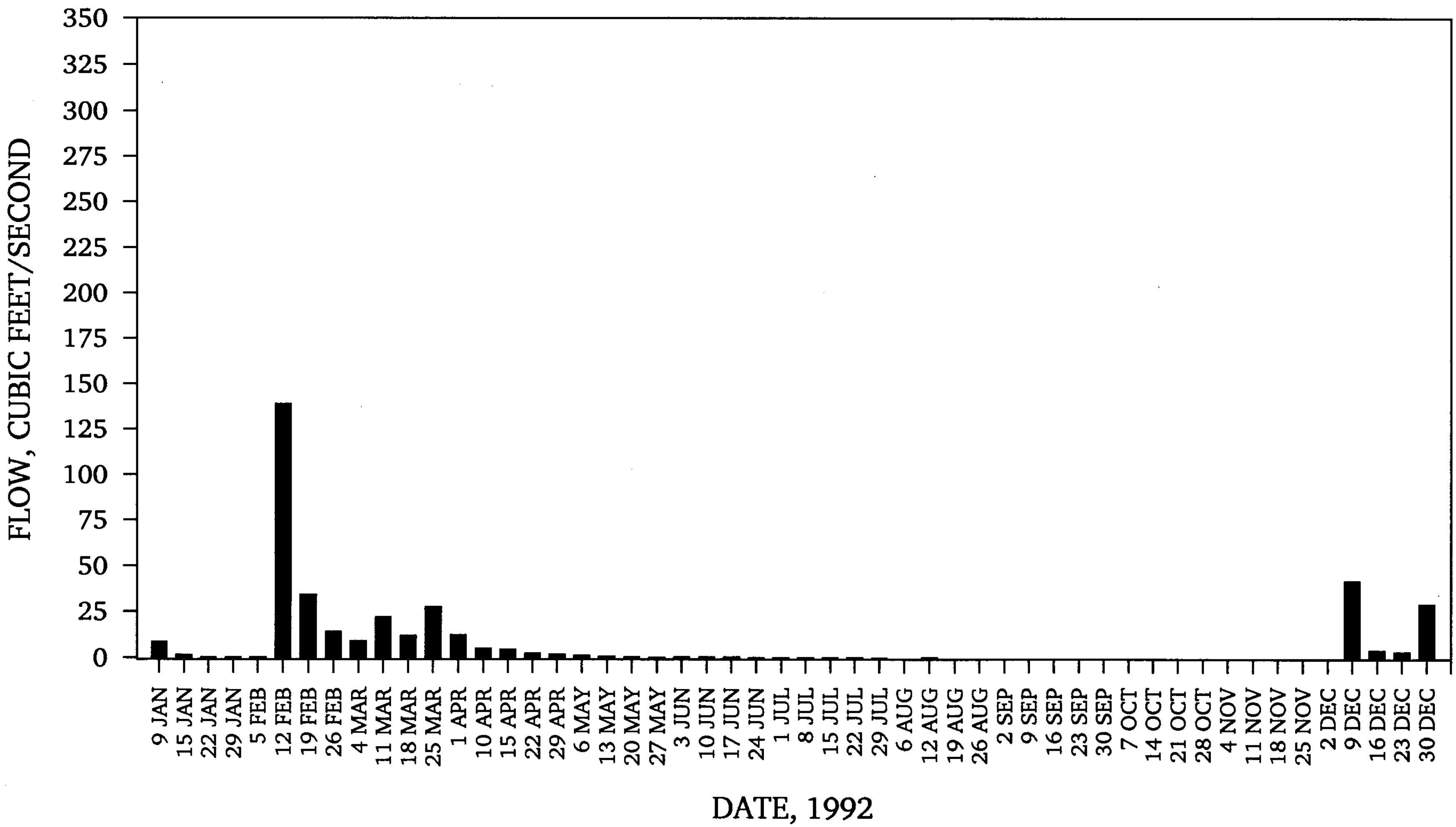


FIGURE 9. Instantaneous stream flow at segment 72 on San Simeon Creek. Data were recorded hourly by automatic gage, which was maintained by the Engineering Department, San Luis Obispo County.

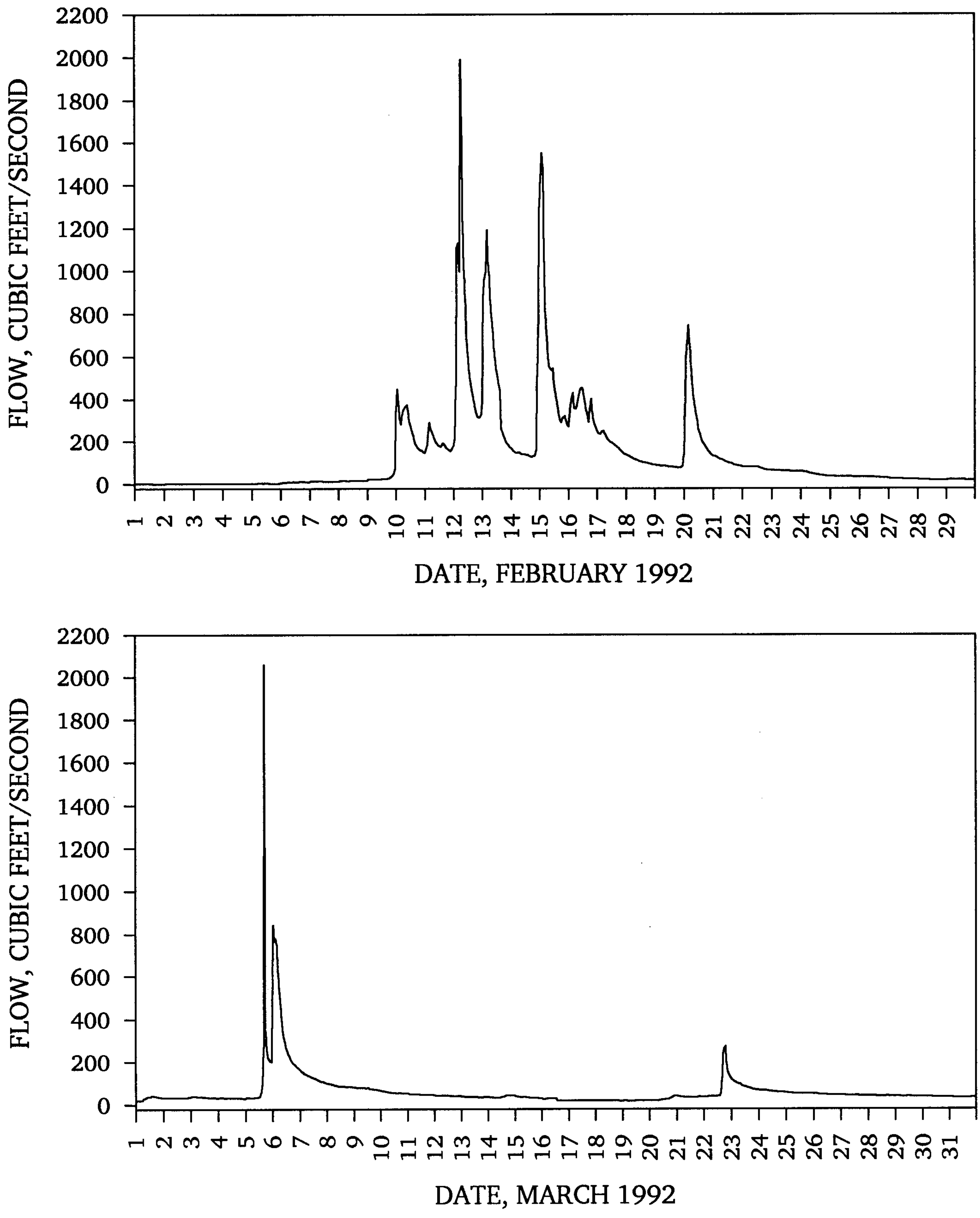


FIGURE 10. Mean, maximum, and minimum water salinity at segment 17 (lagoon) on San Simeon Creek. Data are derived from weekly measurements taken every 20 cm, from bottom to surface. The means are connected with lines.

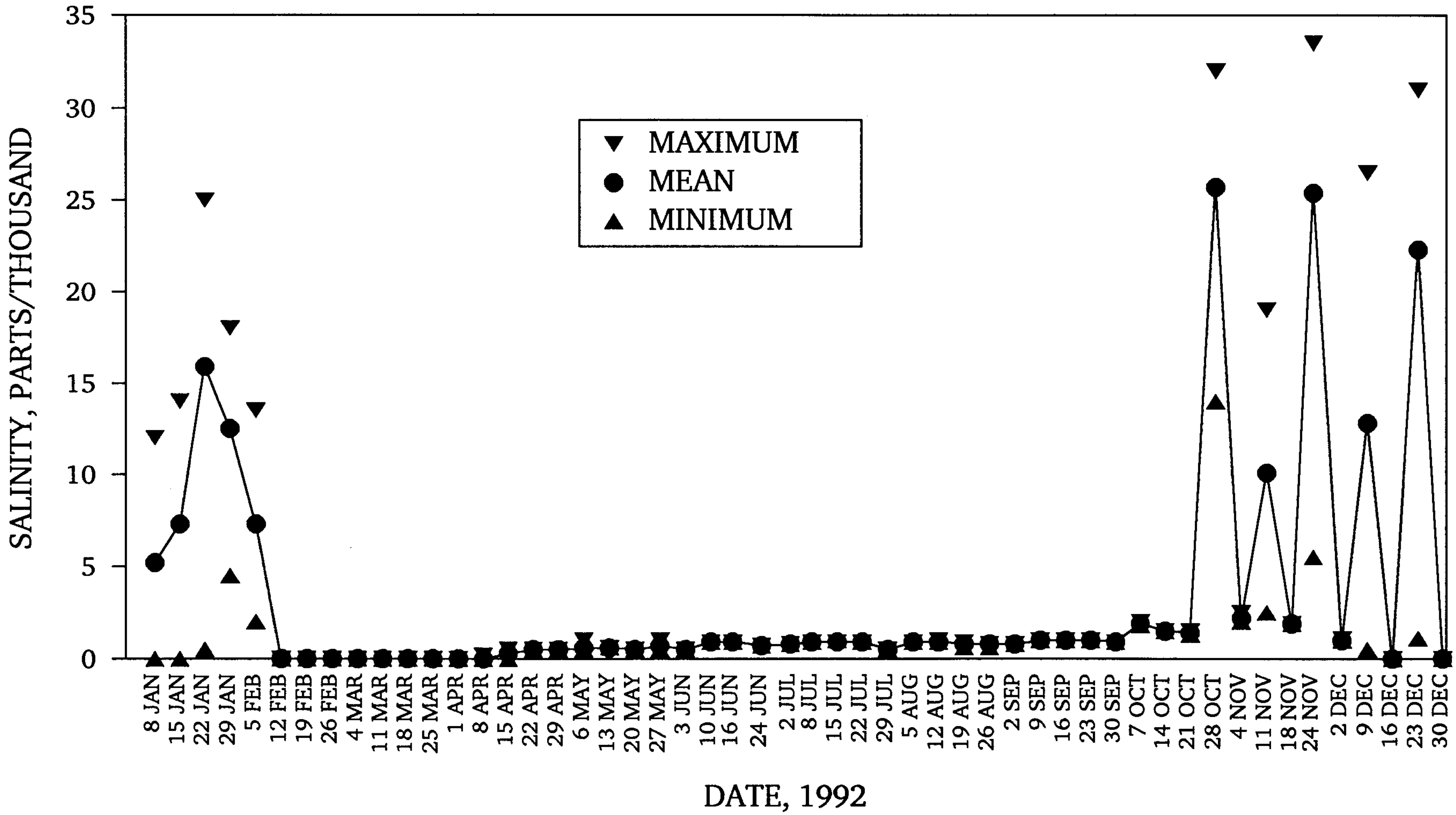


FIGURE 11. Mean, maximum, and minimum water salinity at segment 6 (lagoon) on Pico Creek. Data are derived from weekly measurements taken every 20 cm, from surface to bottom. The means are connected with lines.

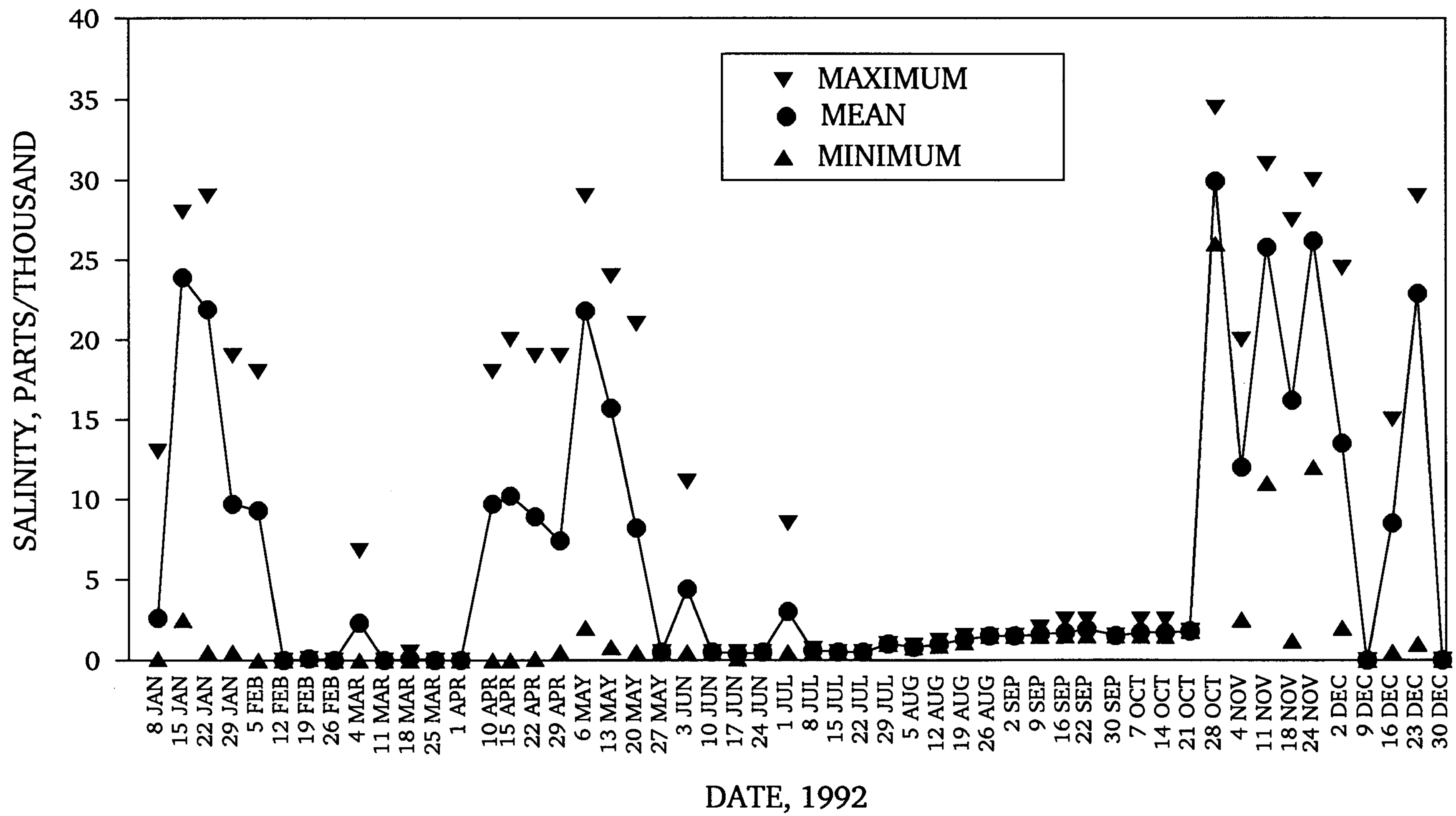


FIGURE 12. A. Surface elevation of San Simeon Lagoon above mean sea level. Data were taken weekly at the southern piling of the Highway 1 bridge.
B. Depth of water in San Simeon Lagoon from surface. Area below the dotted line represents lagoon water with a salinity of 6 parts/thousand or greater, as determined by weekly measurements taken at segment 17 (lagoon) every 20 cm, from surface to bottom.

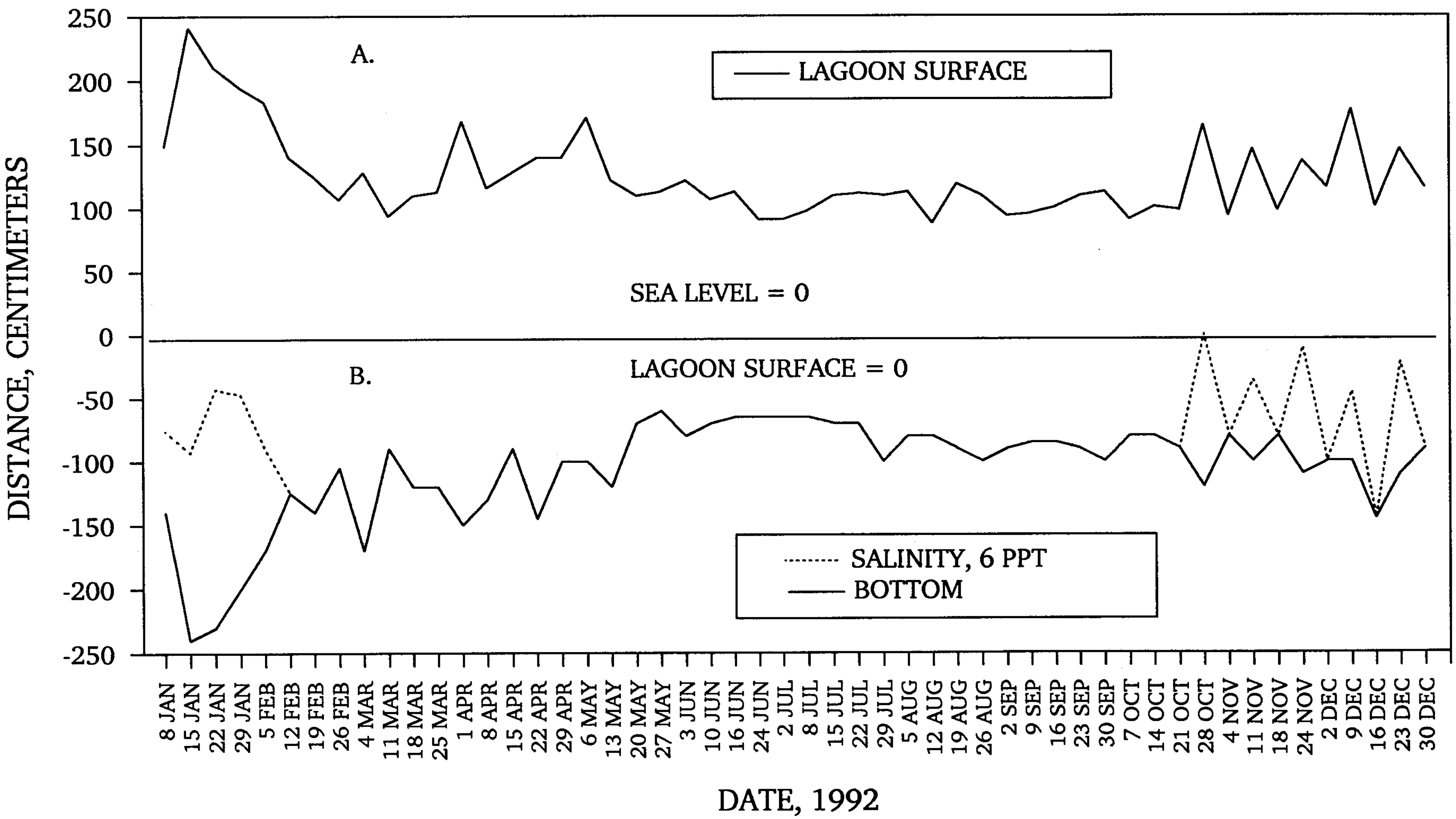


FIGURE 13. A. Surface elevation of Pico Lagoon above mean sea level. Data were taken weekly at the mid-stream piling of the Highway 1 bridge.
B. Depth of water in Pico Lagoon from surface. Area below the dotted line represents lagoon water with a salinity of 6 parts/thousand or greater, as determined by weekly measurements taken at segment 6 (lagoon) every 20 cm, from surface to bottom.

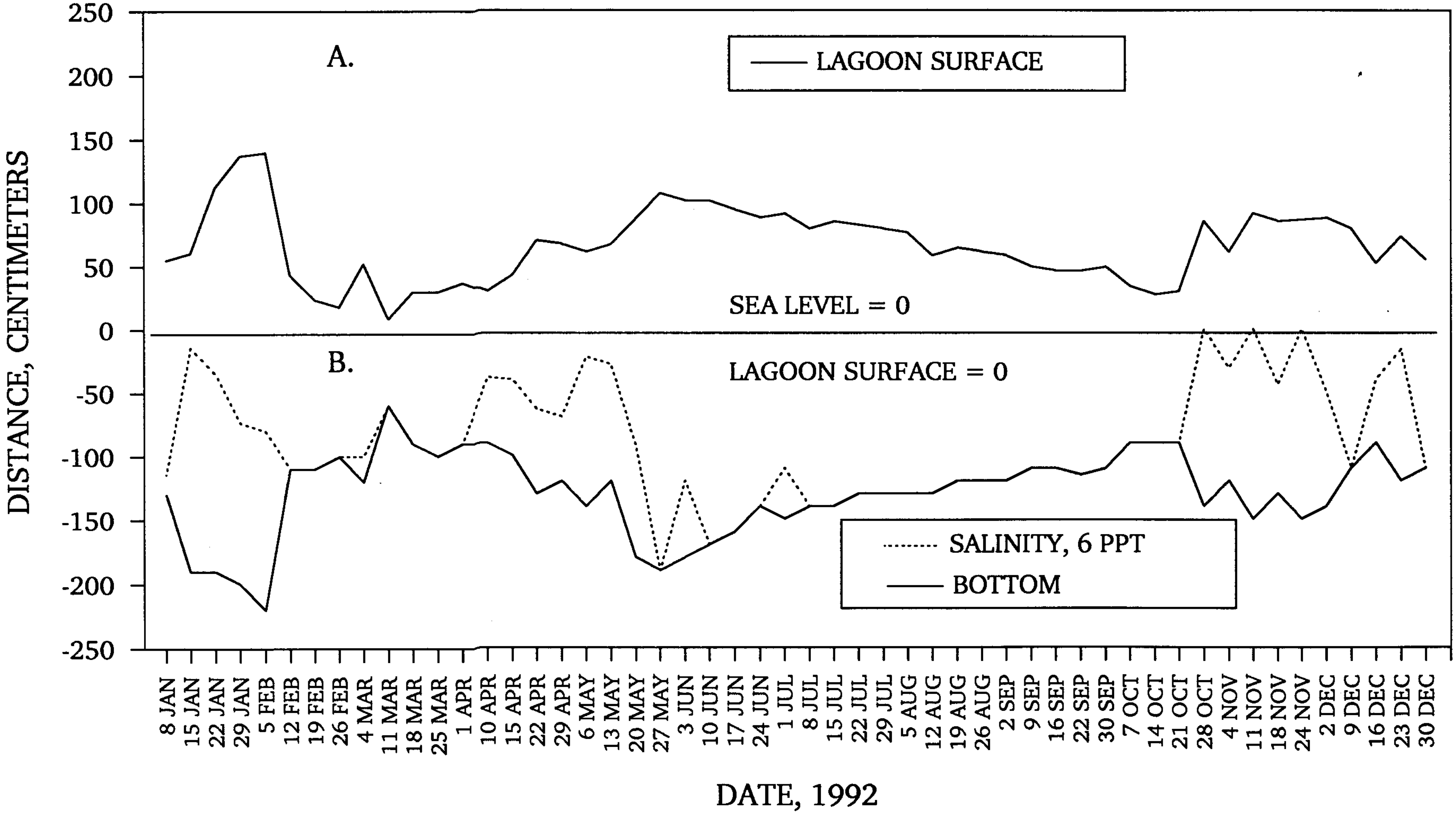


FIGURE 14. Water salinity measured at five sites on San Simeon Creek in winter (February), summer (June), and fall (November). Data were taken about 10 cm below the surface and about 5 cm above the bottom. Segment 17 and 25 = lagoon, 31-40 = creek.

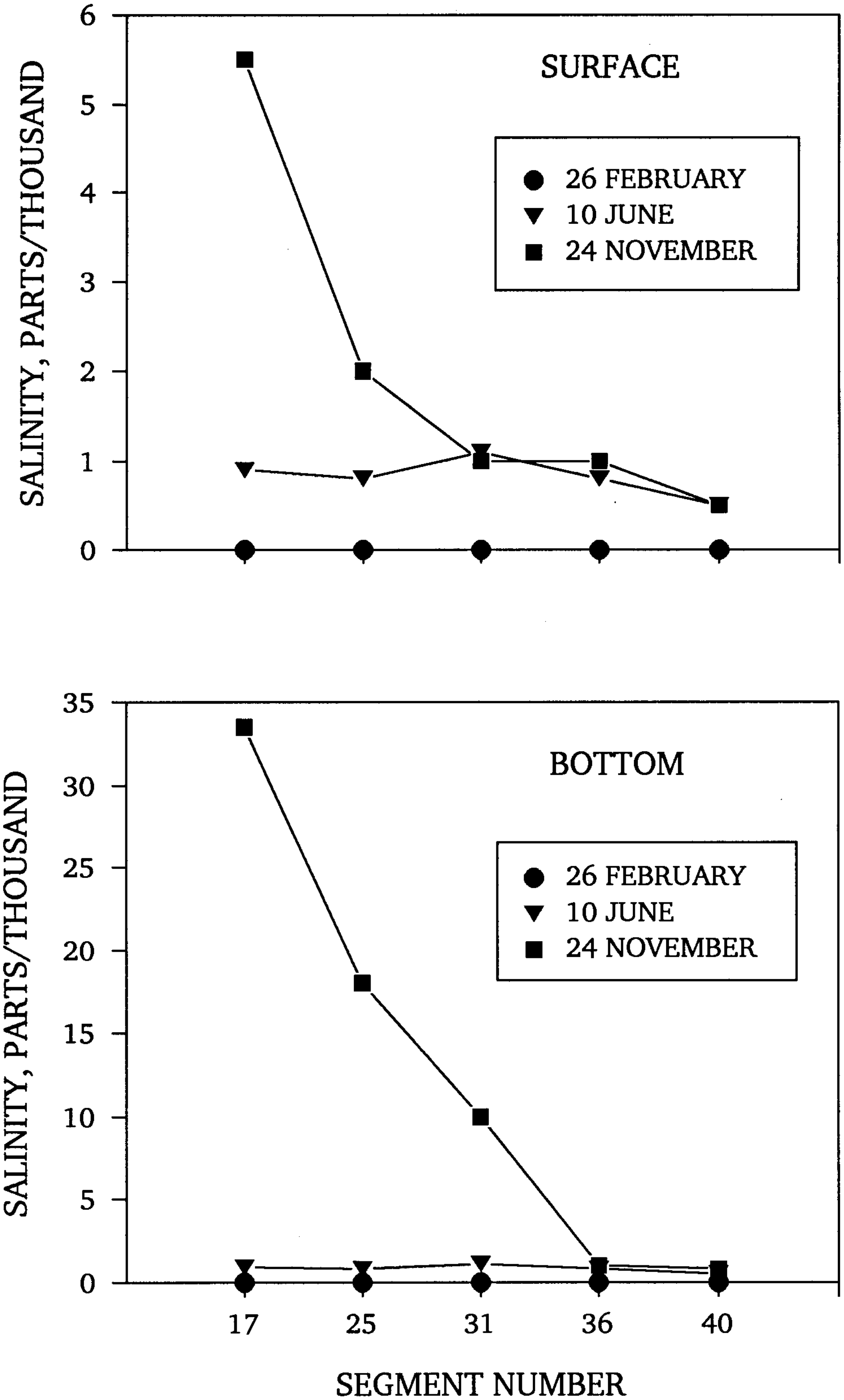


FIGURE 15. Water salinity measured at five sites on Pico Creek in winter (February), summer (June), and fall (November). Data were taken about 10 cm below the surface, and about 5 cm above the bottom. Segment 6 and 10 = lagoon, 17-28 = creek.

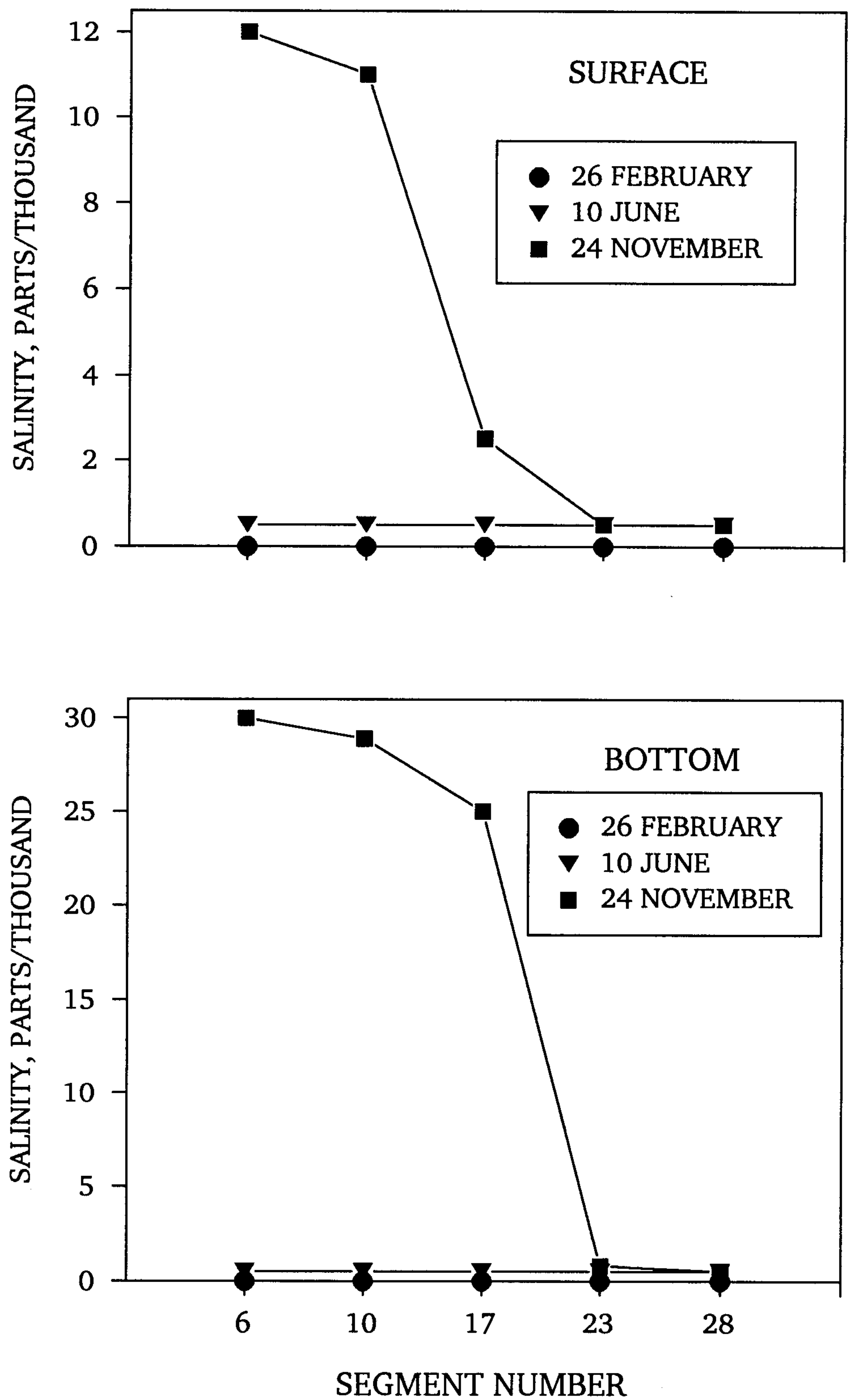


FIGURE 16. Mean, maximum, and minimum water salinities in the slough at San Simeon Creek, calculated from weekly data taken near mouth (segment 8) and upstream (segment 2). Data were taken about 10 cm below the surface and about 5 cm above the bottom.

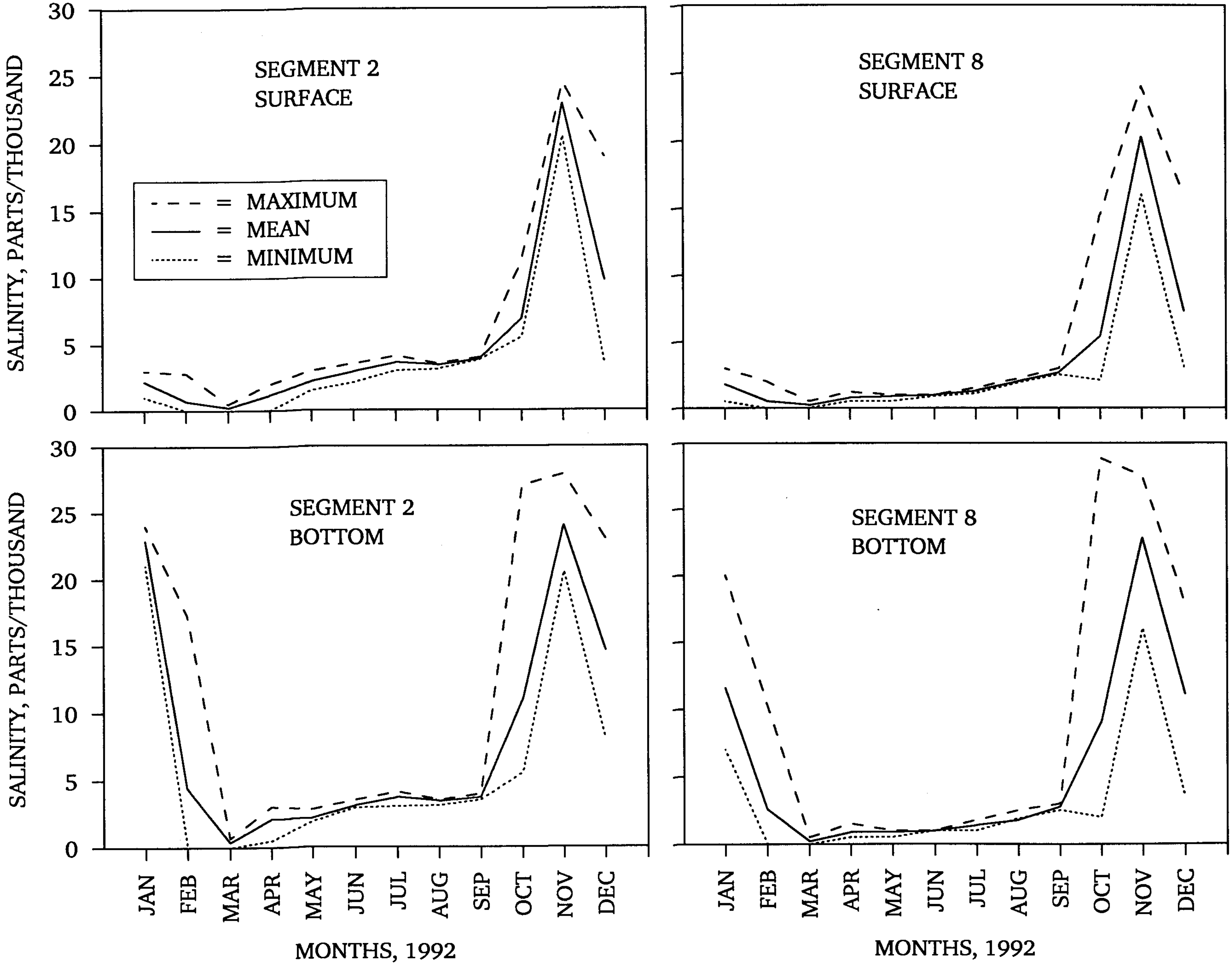


FIGURE 17. Water temperatures measured at five sites in San Simeon Creek during winter (February), summer (June), and fall (November). Data were taken about 10 cm below surface, and about 5 cm above bottom. Segments 17 and 25 = lagoon, 31-40=creek.

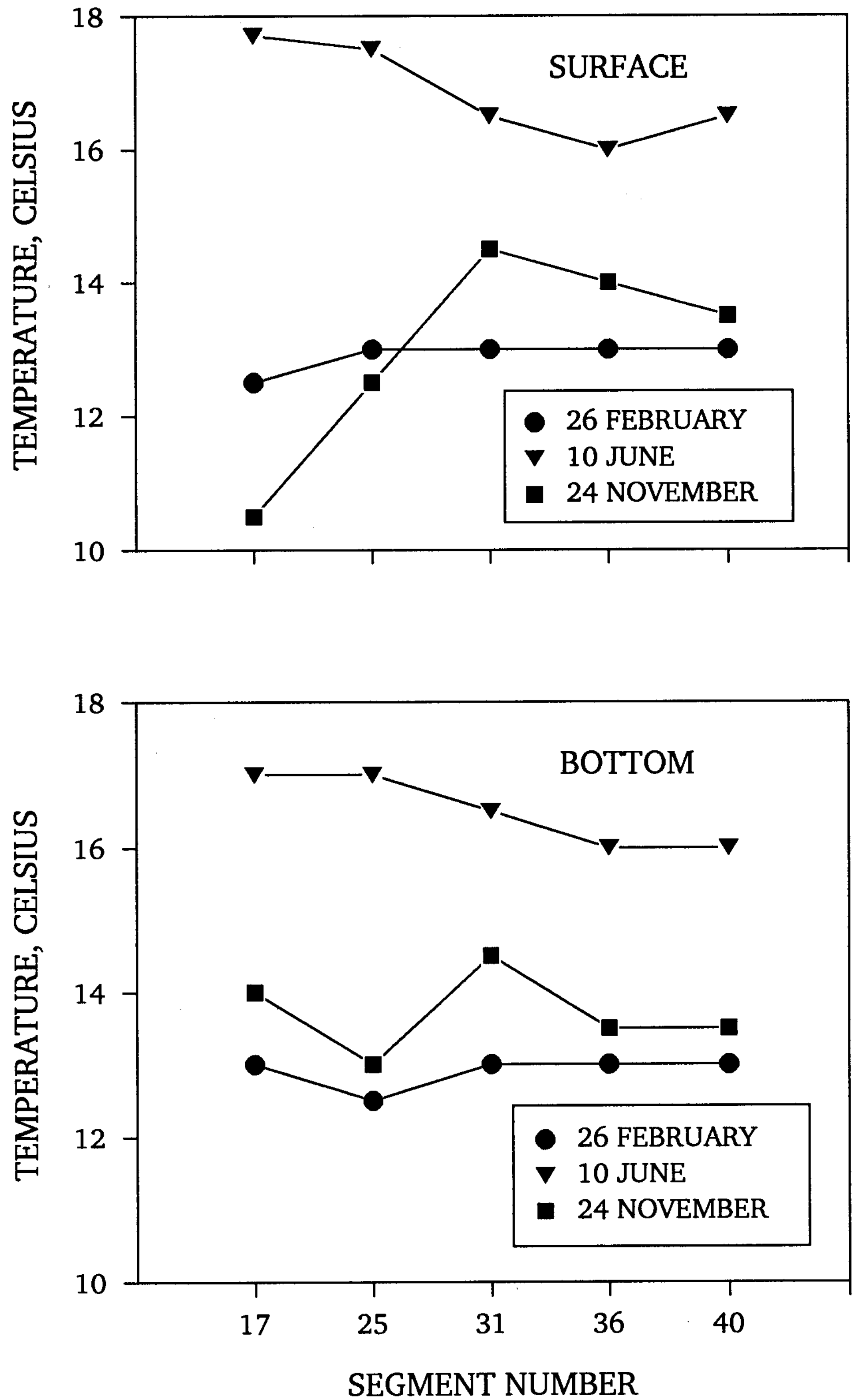


FIGURE 18. Water temperature measured at five sites in Pico Creek during winter (February), summer (June), and fall (November). Data were taken about 10 cm below surface, and 5 cm above bottom. Segments 6 and 10 = lagoon, 17-28 = creek.

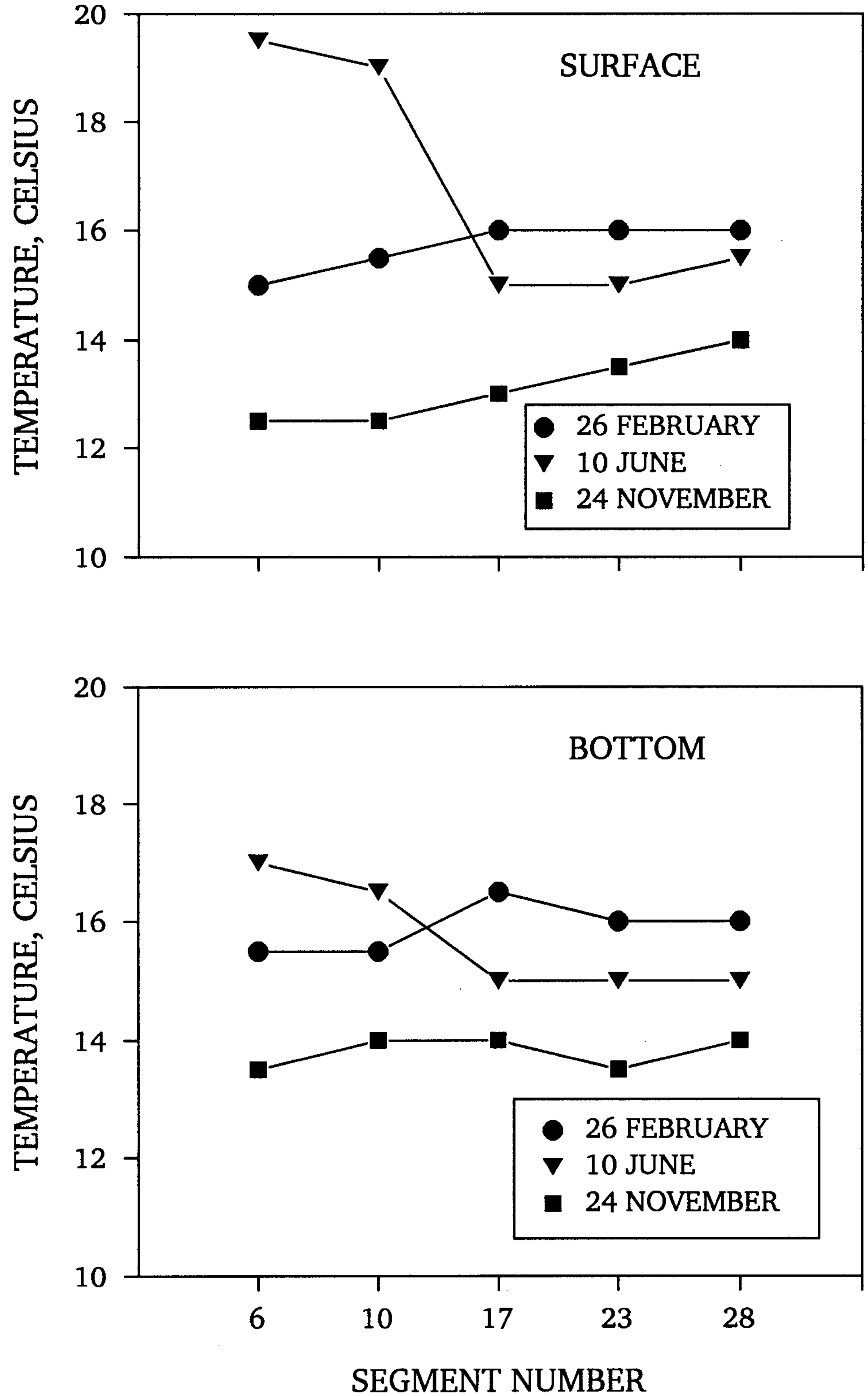


FIGURE 19. Mean water temperatures at four sites in San Simeon Creek (top) and three sites in Pico Creek (bottom). Data were calculated from weekly measurements taken about 5 cm above the bottom. Break in line represents no data taken.

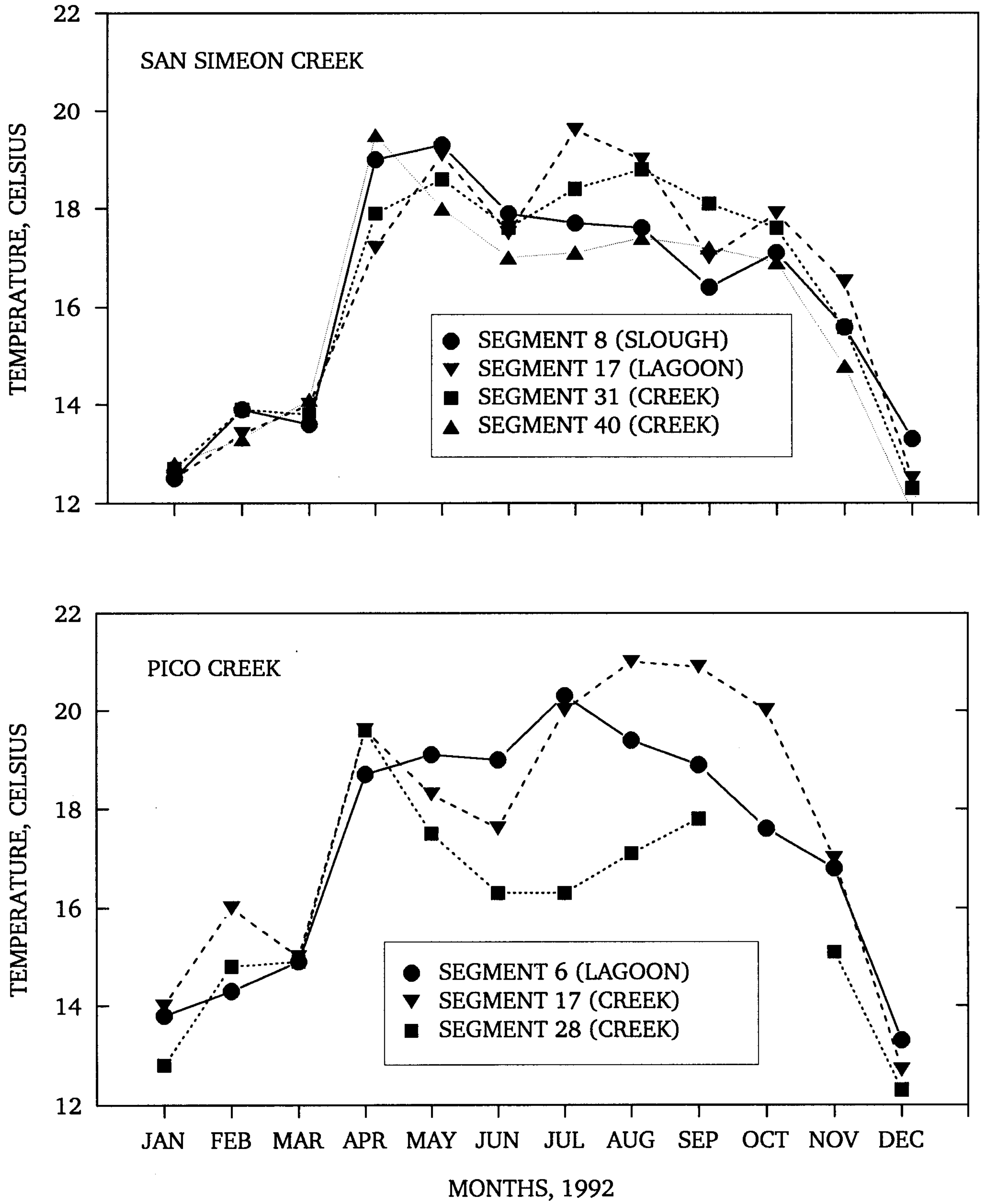


FIGURE 20. Dissolved oxygen levels in water at segments 17 (lagoon) and 30 (creek) in San Simeon Creek. Weekly data were taken about 5 cm below the surface, and about 5 cm above the bottom.

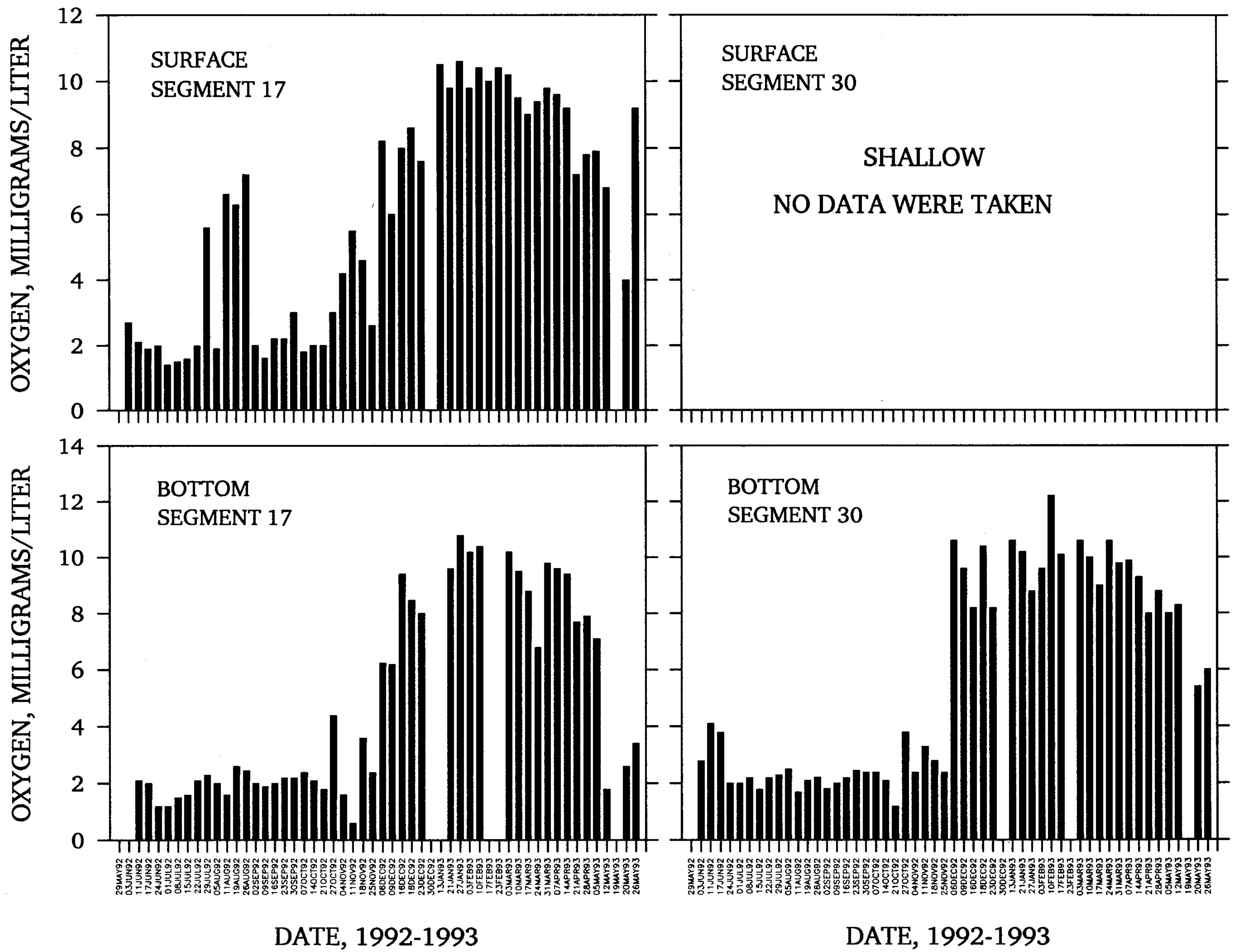


FIGURE 21. Dissolved oxygen levels in water at segments 6 (lagoon) and 32 (creek) in Pico Creek. Weekly data were taken about 5 cm below the surface, and about 5 cm above the bottom.

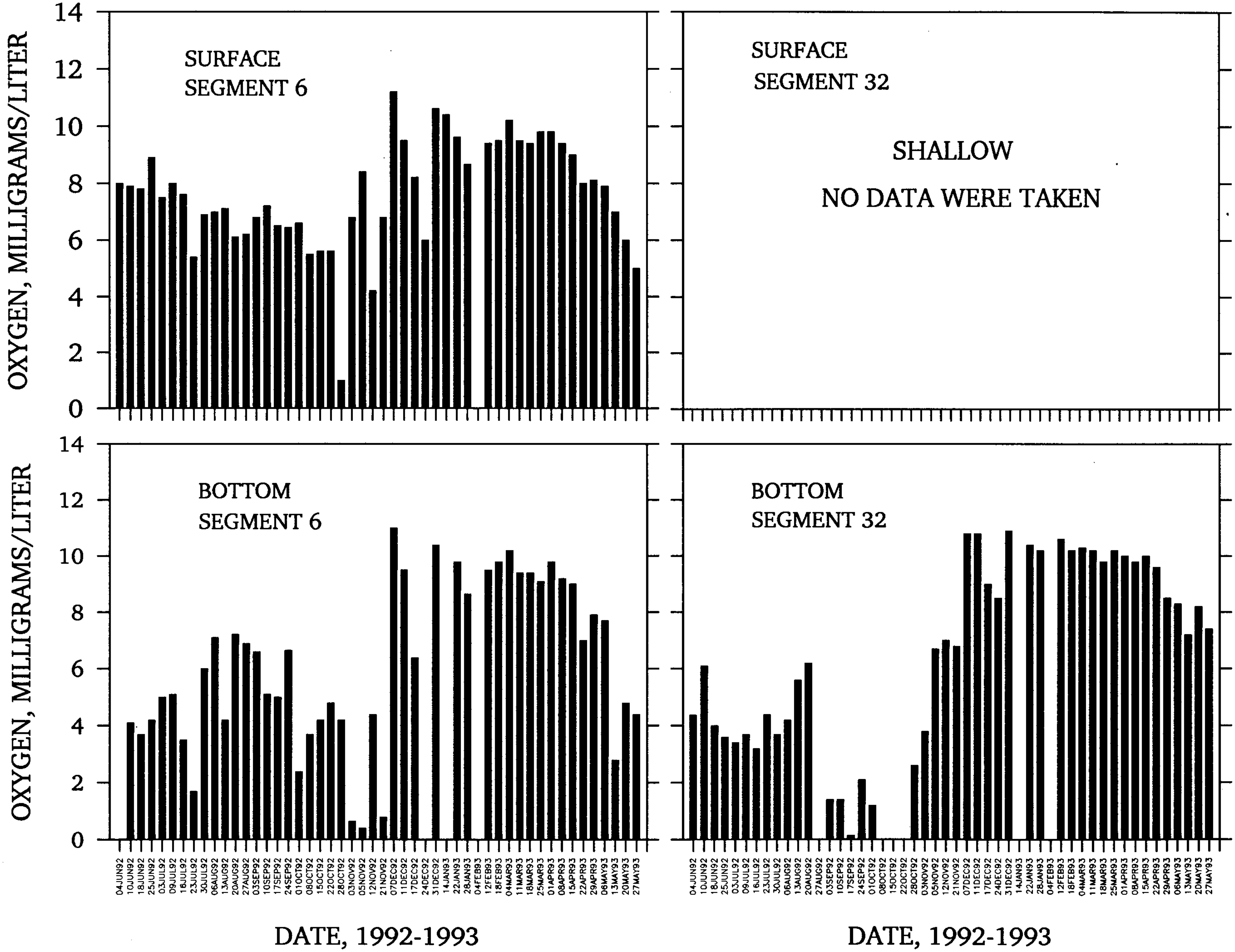


FIGURE 22. Mean number of adult tidewater gobies sighted during monthly visual surveys in San Simeon Creek (top) and Pico Creek (bottom). Surveys were completed from May 1992 through April 1993. Adult fish were equal to or greater than 40 mm total length.

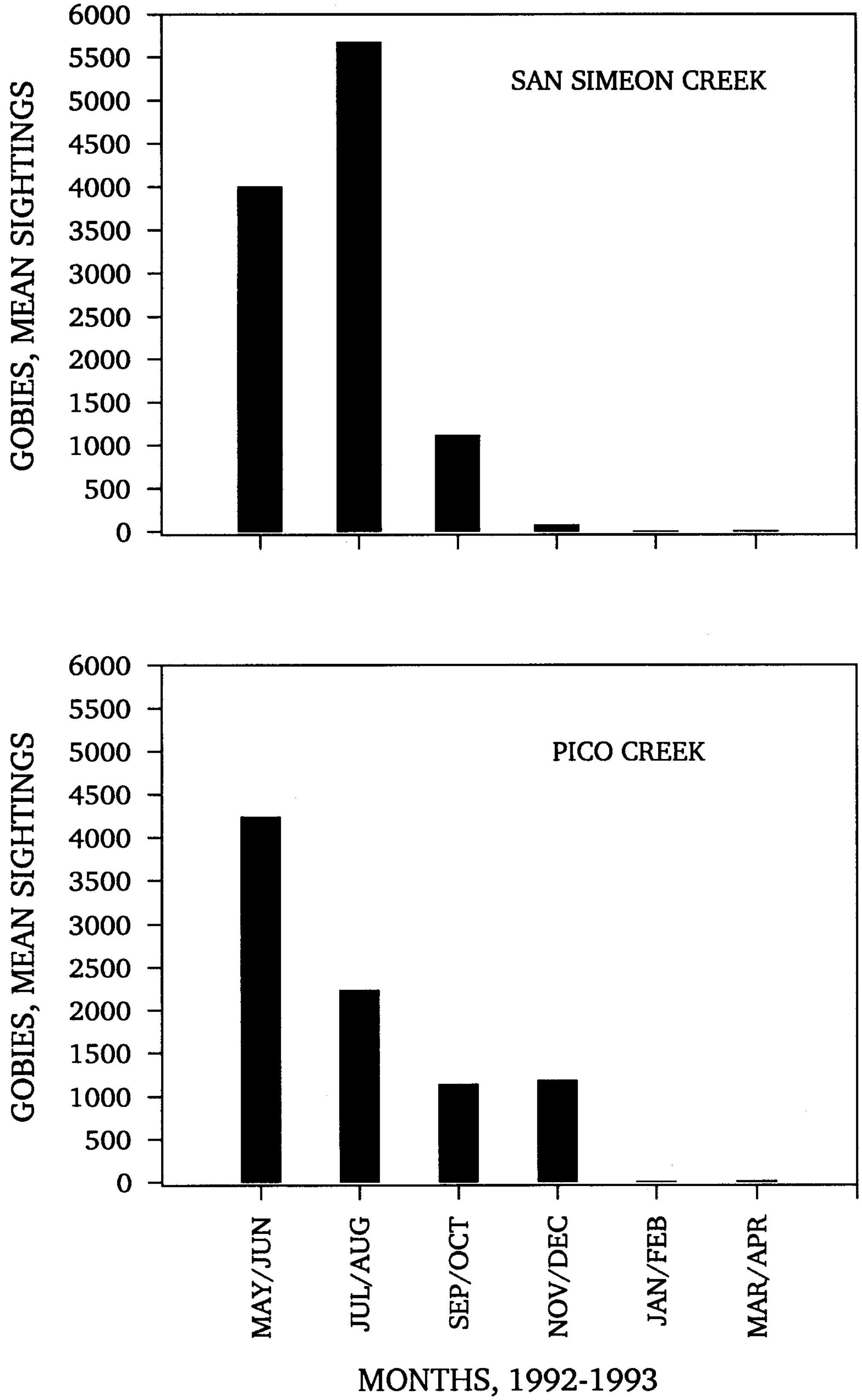


FIGURE 23. Total number of tidewater gobies sighted in 25-m-long segments in San Simeon Creek (not including slough). Lagoon = segments 11-29, creek = 30-49. Observations were made during 12 monthly visual surveys completed from May 1992 through April 1993. Adult fish were equal to or greater than 40 mm total length.

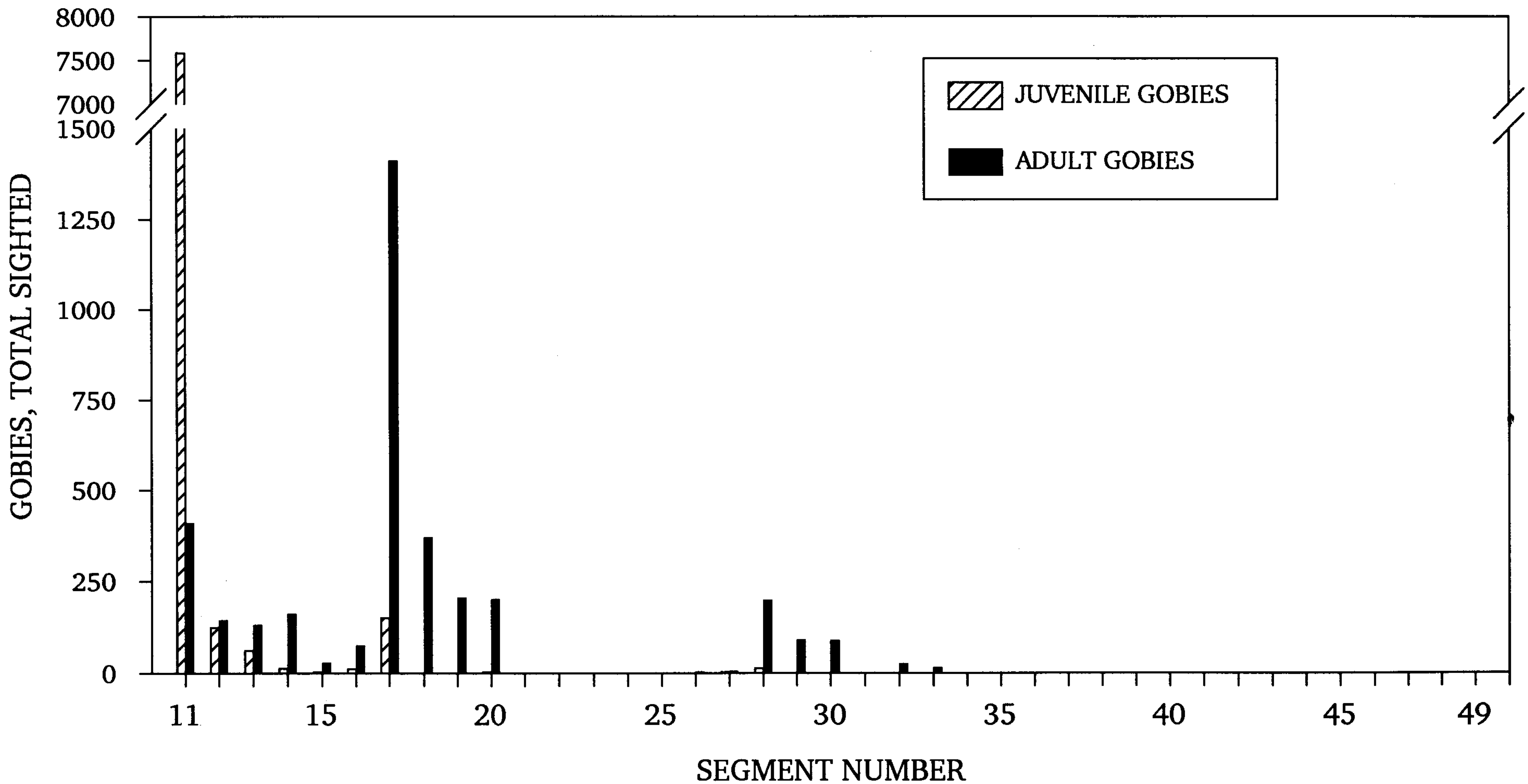


FIGURE 24. Total number of tidewater gobies sighted in 25-m-long segments in Pico Creek. Lagoon = segments 1-13, creek = 14-36. Observations were made during 12 monthly visual surveys completed from May 1992 through April 1993. Adult fish were equal to or greater than 40 mm total length.

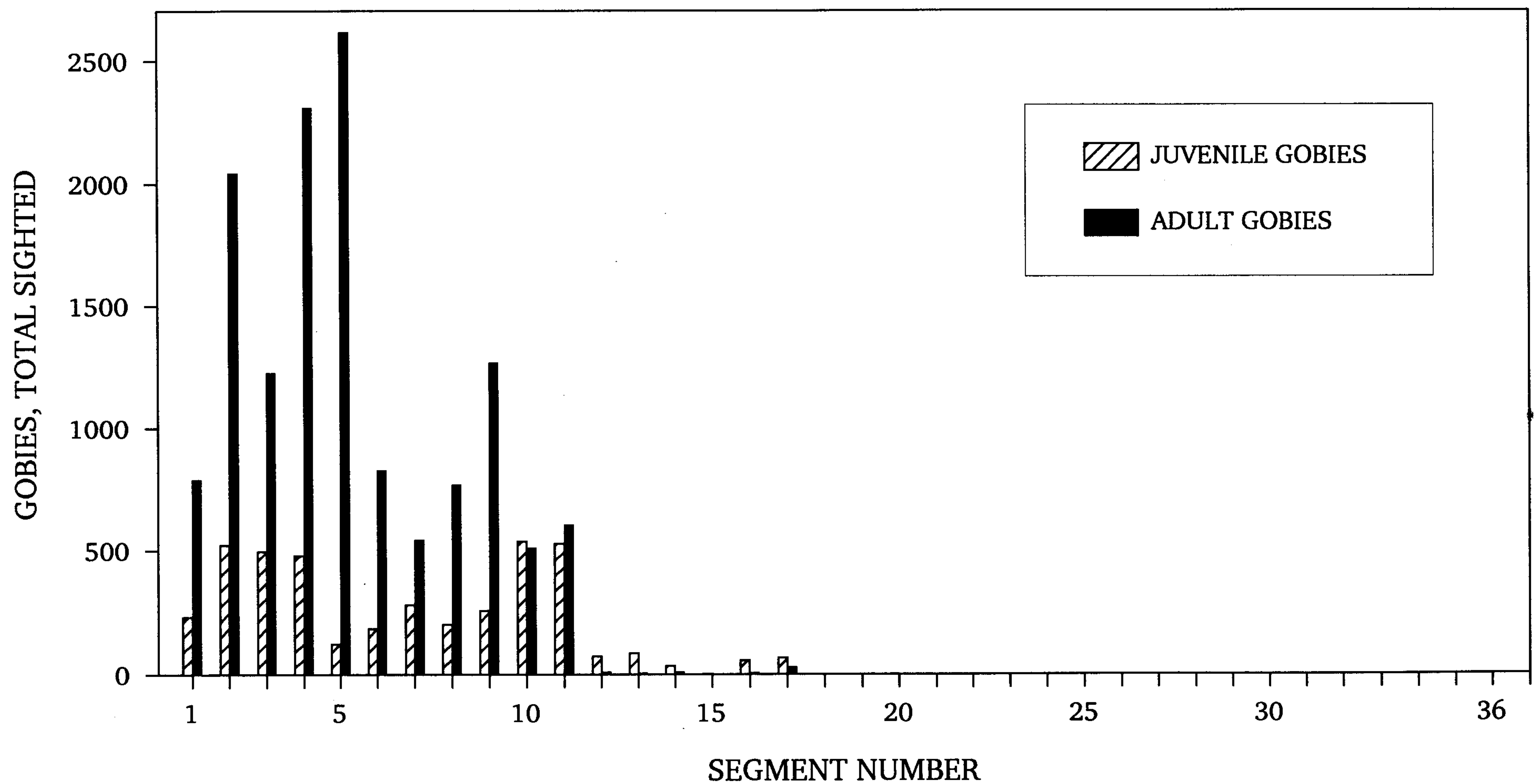


FIGURE 25. Total number of California red-legged frogs sighted in 25-m-long segments in San Simeon Creek. Slough = segments 1-10, lagoon = 11-29, creek = 30-49. Small frogs were < 60 mm in snout/urostyle length. Observations were made during 25 visual surveys completed about every two weeks during 1992.

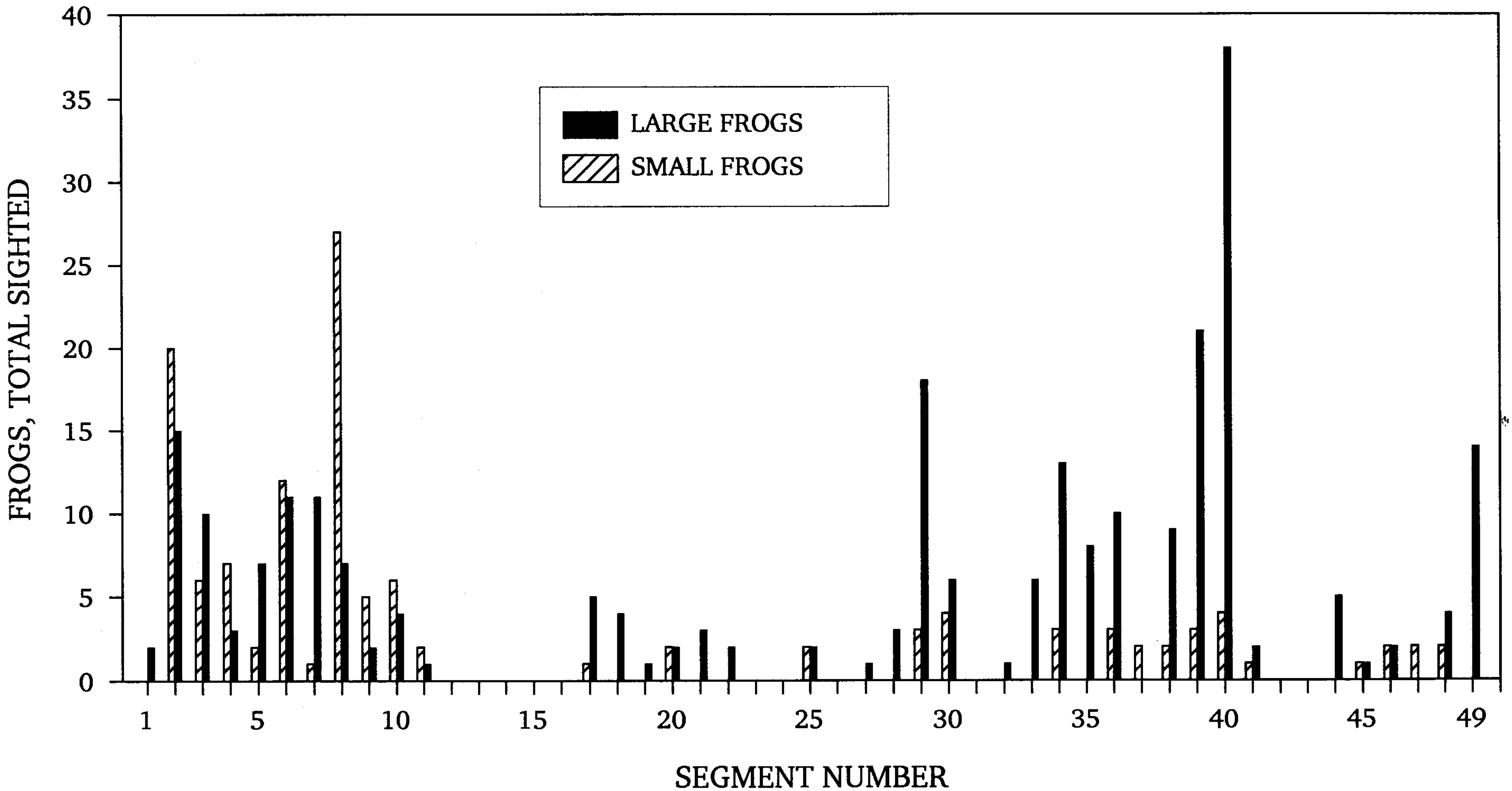


FIGURE 26. Total number of California red-legged frogs sighted in 25-m-long segments in Pico Creek. Lagoon = segments 1-13, creek = 14-36. Small frogs were < 60 mm snout/urostyle length. Observations were made during 25 visual surveys completed about every two weeks during 1992.

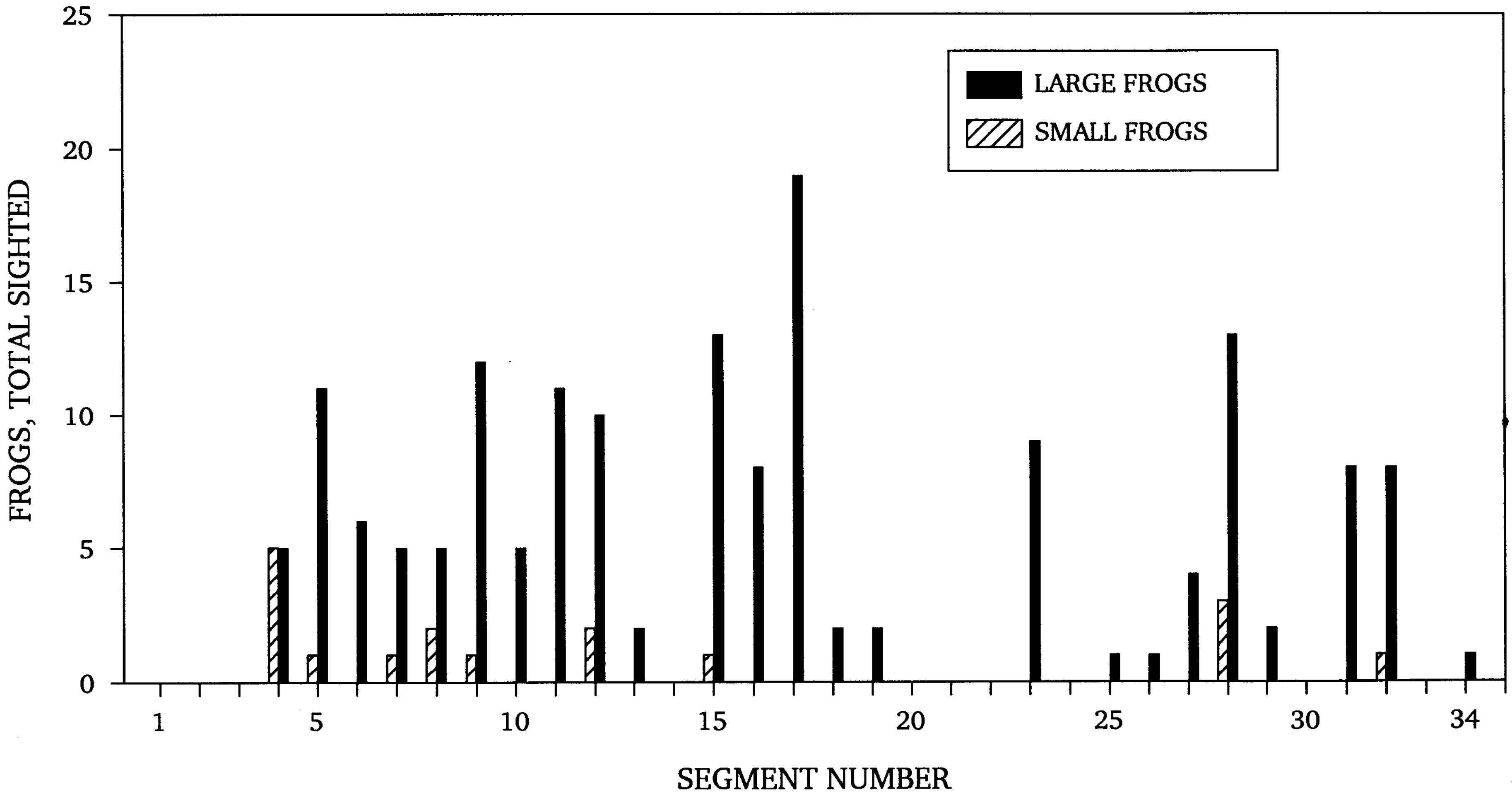


FIGURE 27. Mean number and range (filled circles and open triangles) of red-legged frogs sighted during visual surveys (N on top of ranges) in San Simeon Creek during 1992. Large frogs (top) were equal to or greater than 60 mm snout/urostyle length, and small frogs (bottom) were < 60 mm long.

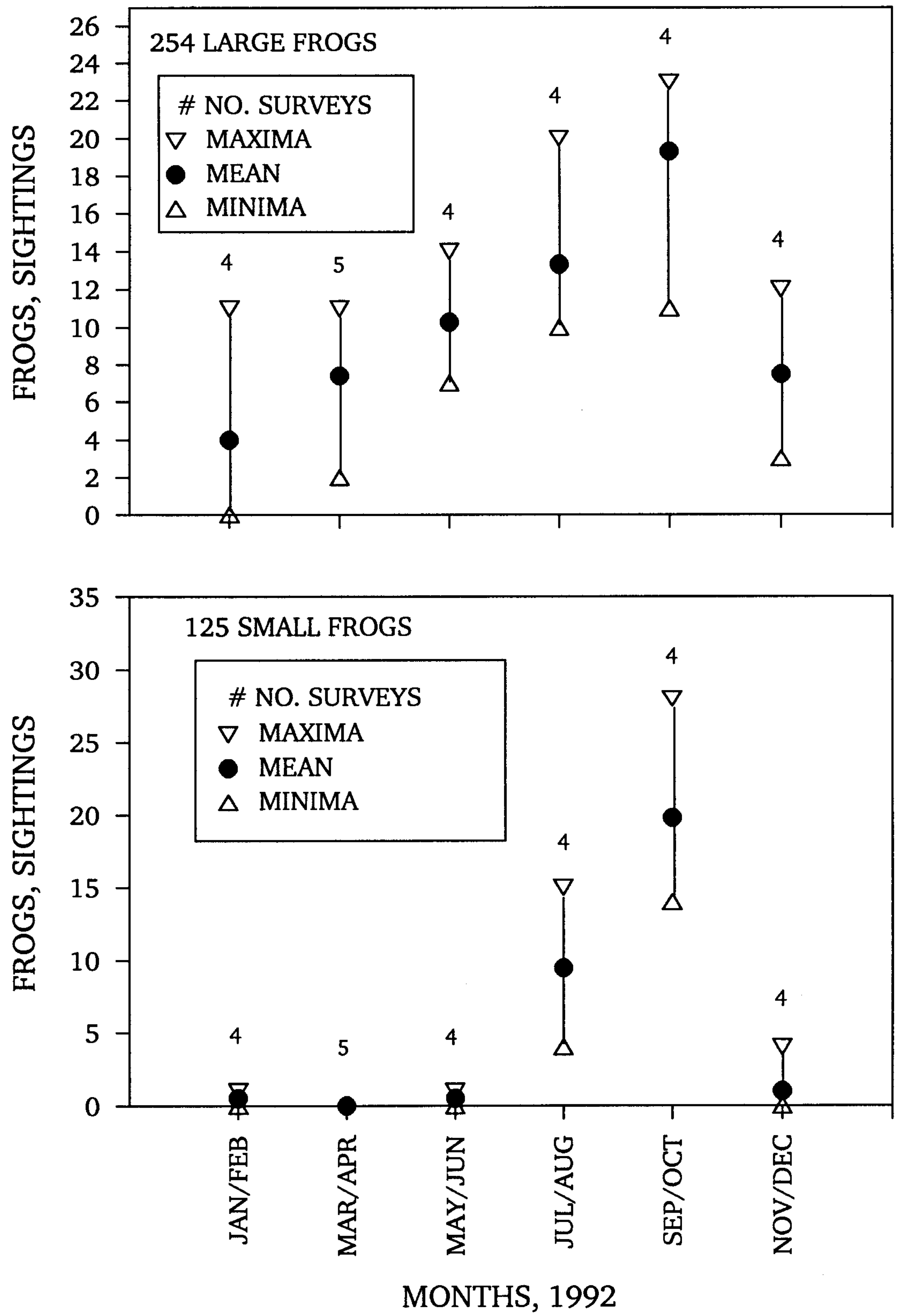


FIGURE 28 Mean number and range (filled circles and open triangles) of red-legged frogs sighted during visual surveys (N on top of range) in Pico Creek during 1992. Large frogs (top) were equal to or greater than 60 mm snout/urostyle length, and small frogs (bottom) were < 60 mm long.

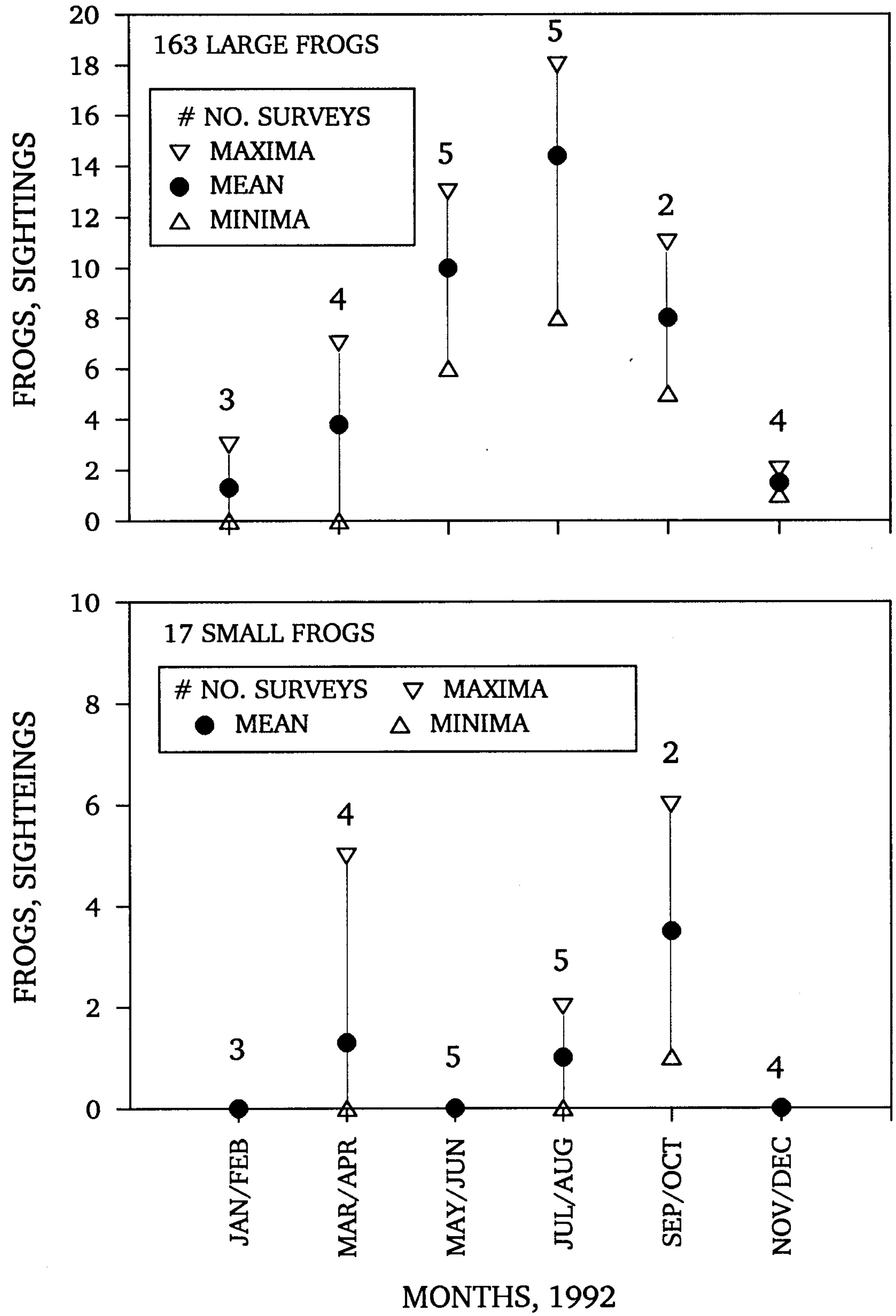


FIGURE 29. Total number of pond turtles sighted in 25-m-long segments in San Simeon Creek. Slough = segments 1-10, lagoon = 11-29, creek = 30-49. Small turtles were < 100 mm carapace length. Observations were made during 21 visual surveys completed about every two weeks during 1992.

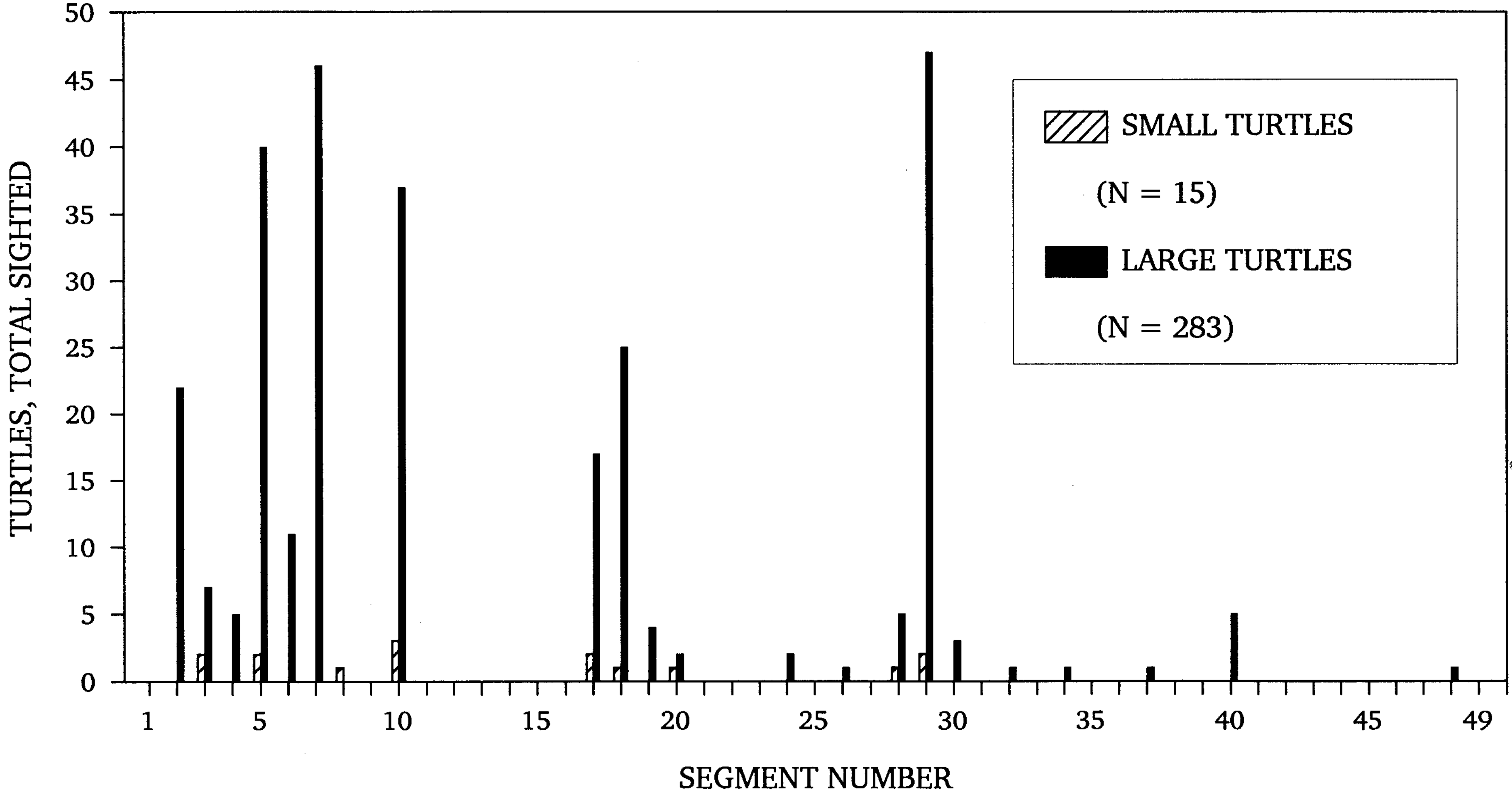


FIGURE 30. Frequency distribution of pond turtle group size based on sightings of 325 turtles during 21 surveys in San Simeon Creek during 1992. Turtles in a group were within 30 cm of each other.

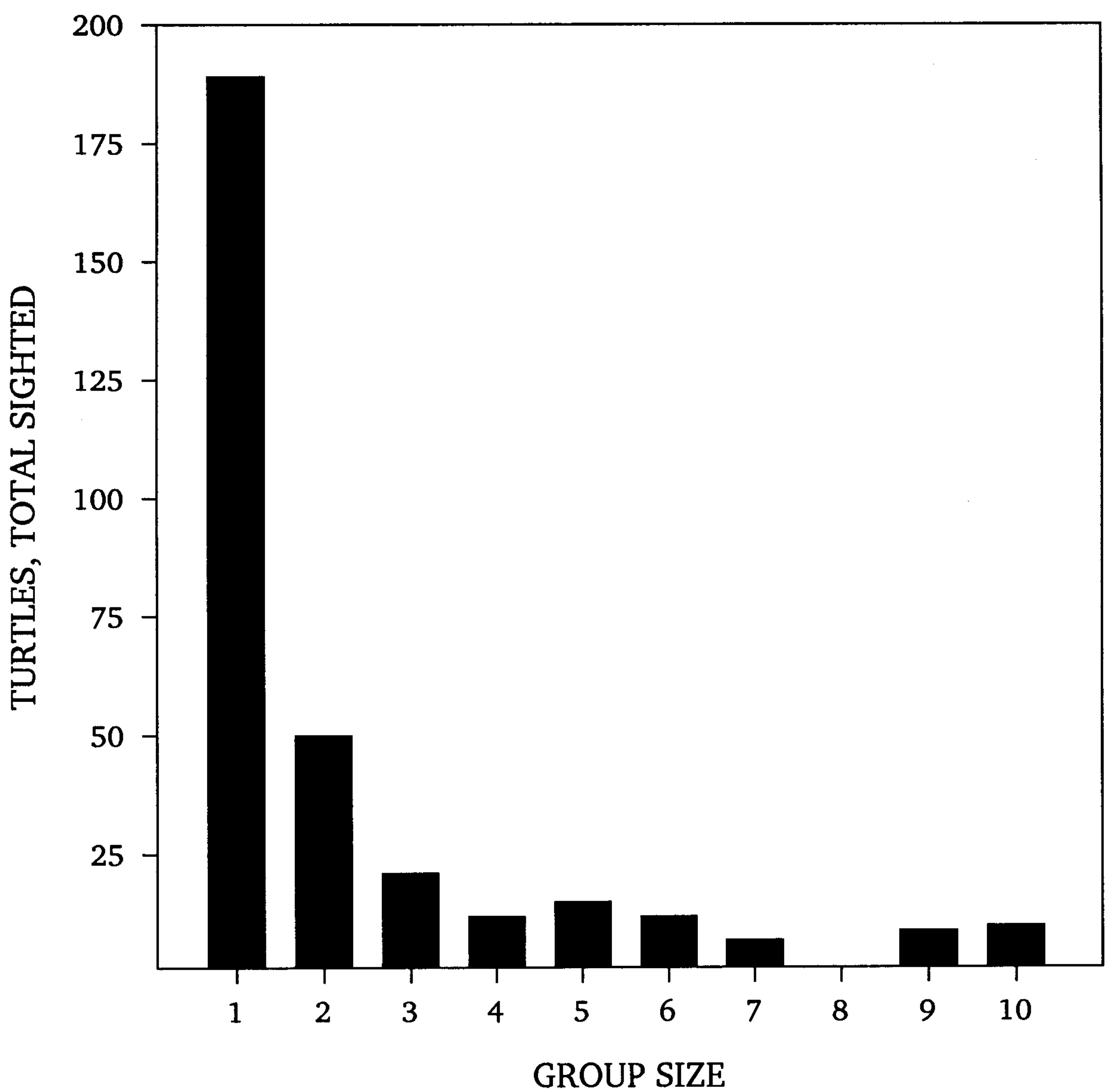


FIGURE 31. Mean number and range (filled circles and open triangles) of pond turtles sighted during visual surveys (N on top of range) in San Simeon Creek during 1992. Large turtles (top) were equal to or greater than 100 mm carapace length, and small turtles were < 100 mm long.

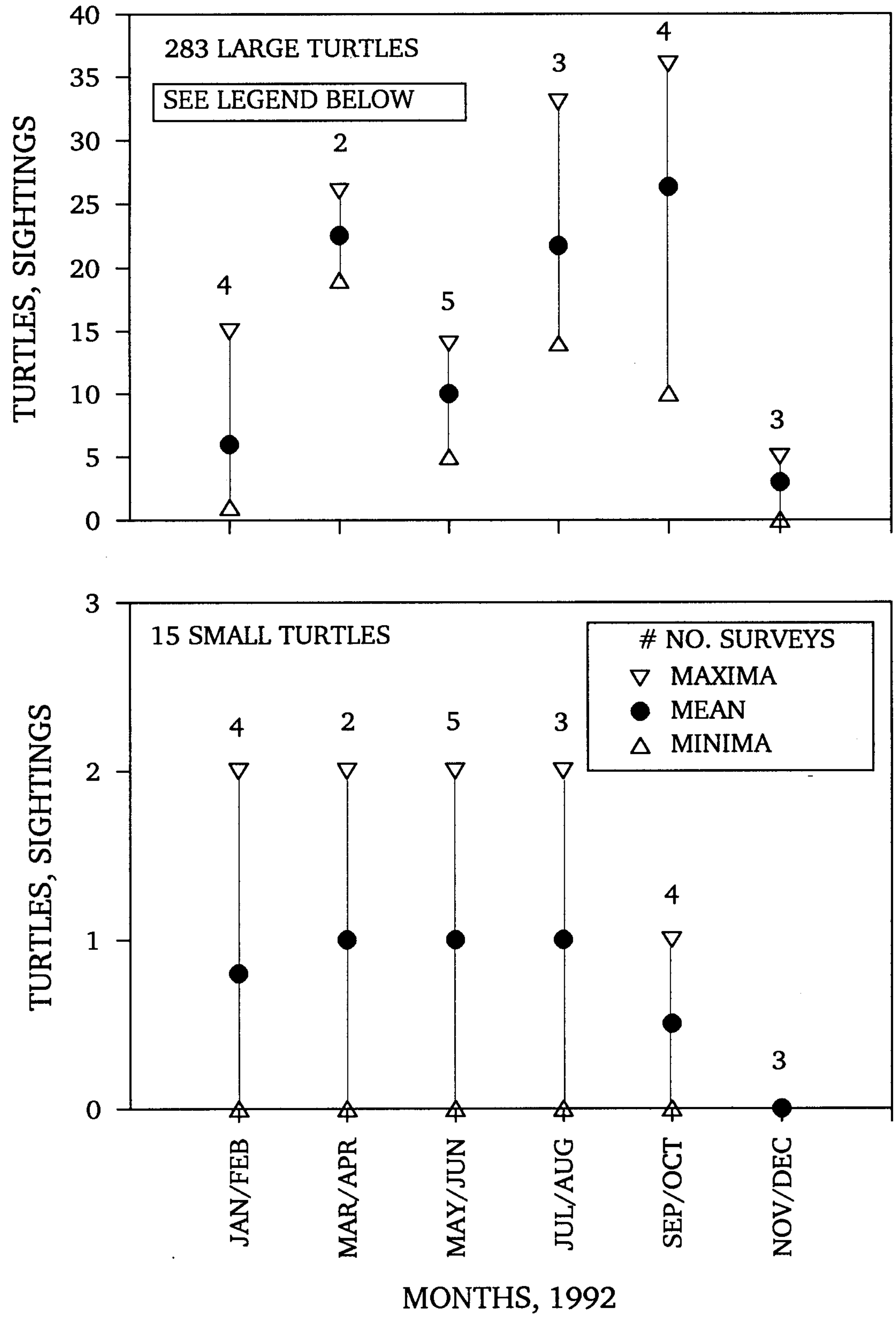


FIGURE 32. Terrestrial activity by male pond turtle 0311 in Pico Ponds. Data based on daily radio-locations. Vertical lines indicate distance to nearest creek or pond water. Lines < zero indicate turtle was in water. Blanks indicate turtle was not located. Note lack of terrestrial activity.

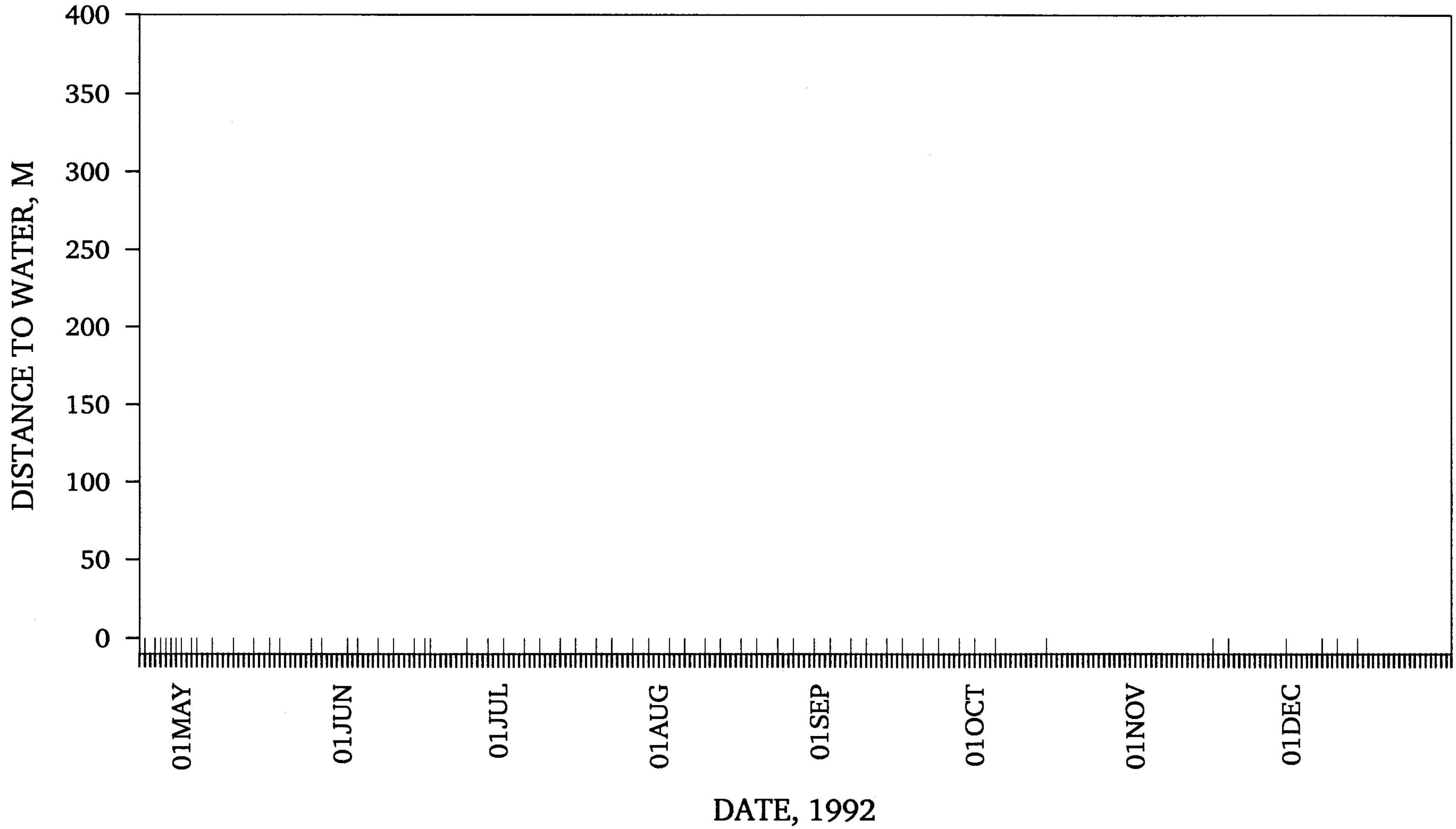


FIGURE 33. Terrestrial activity by female pond turtle 6034 in Pico Creek. Data based on daily radio-locations. Vertical lines indicate distance to nearest creek or pond water. Line < zero indicate turtle was in water. Blanks indicate turtle was not located. Note terrestrial basking activity in April/May, and terrestrial dormancy in late August-December.

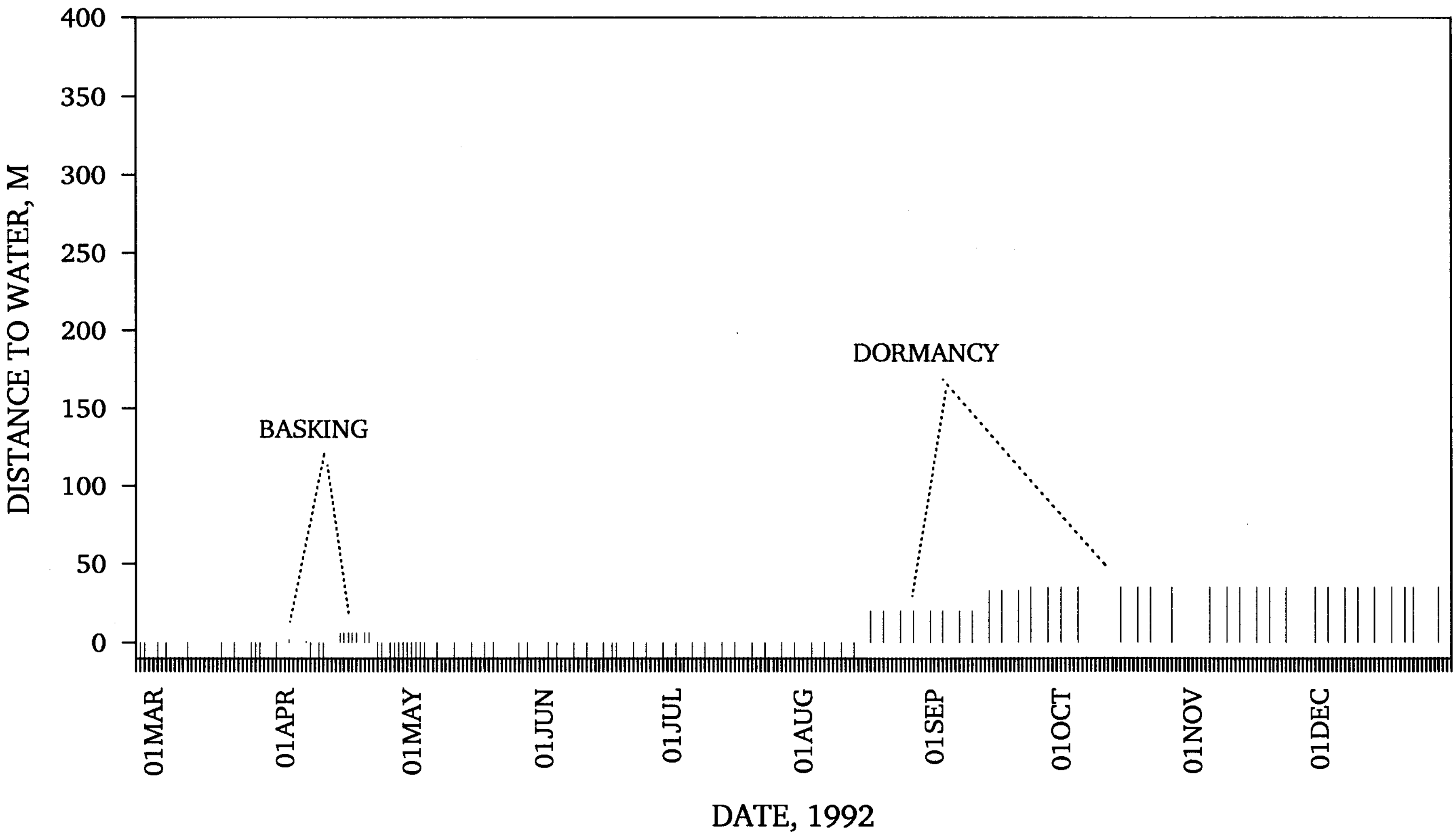


FIGURE 34. Terrestrial activity by female pond turtle 6048 in San Simeon Creek. Data based on daily radio-locations. Vertical lines indicate distance to nearest creek water. Lines < zero indicate turtle was in water. Blanks indicate turtle was not located. Note terrestrial nesting activity in May, basking in June, and dormancy in late October-December.

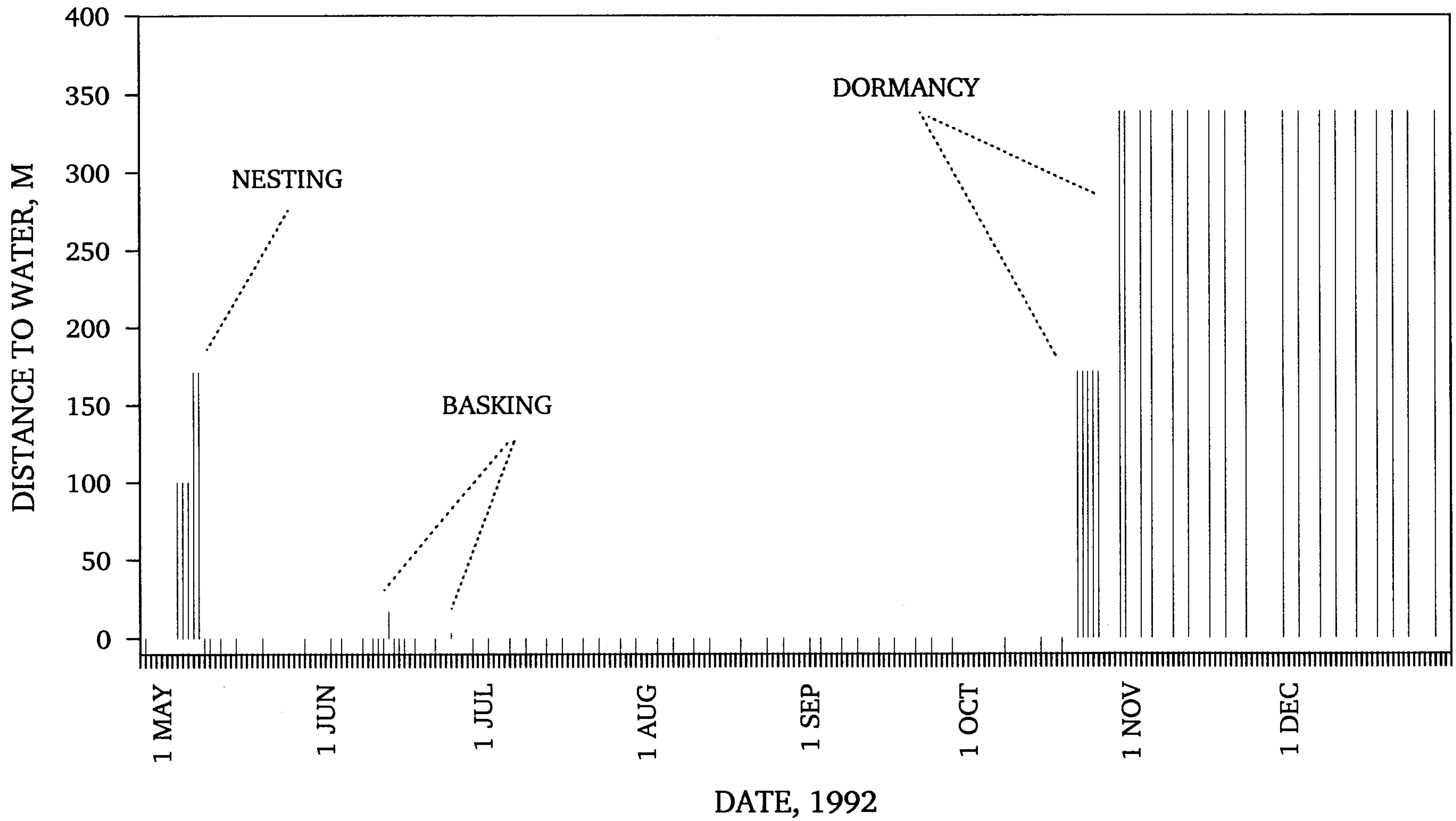


**FIGURE 35**
Locations of radio-tagged pond turtles in San Simeon Creek on a summer day (stars, 16 July 1992) and a winter day (circled stars, 7 December 1992). Four turtles were located at most southerly star in slough.

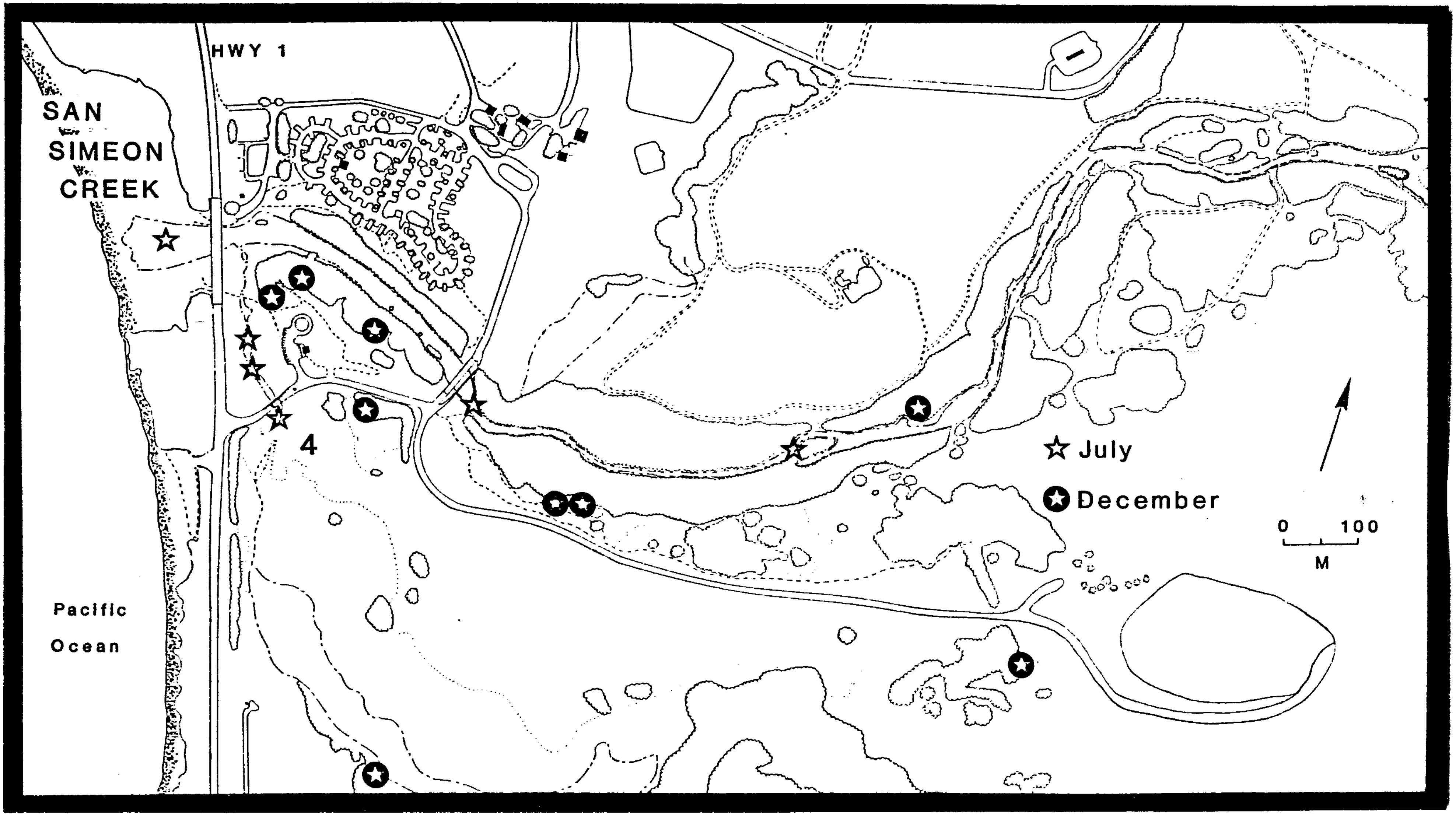


**FIGURE 36**
Locations of radio-tagged pond turtles in Pico Creek on a summer day (stars, 27 July 1992) and a winter day (circled stars, 16 November 1992). Numbers next to stars in pond indicate number of turtles. Note terrestrial basking in March/April, and summer dormancy in August - December.

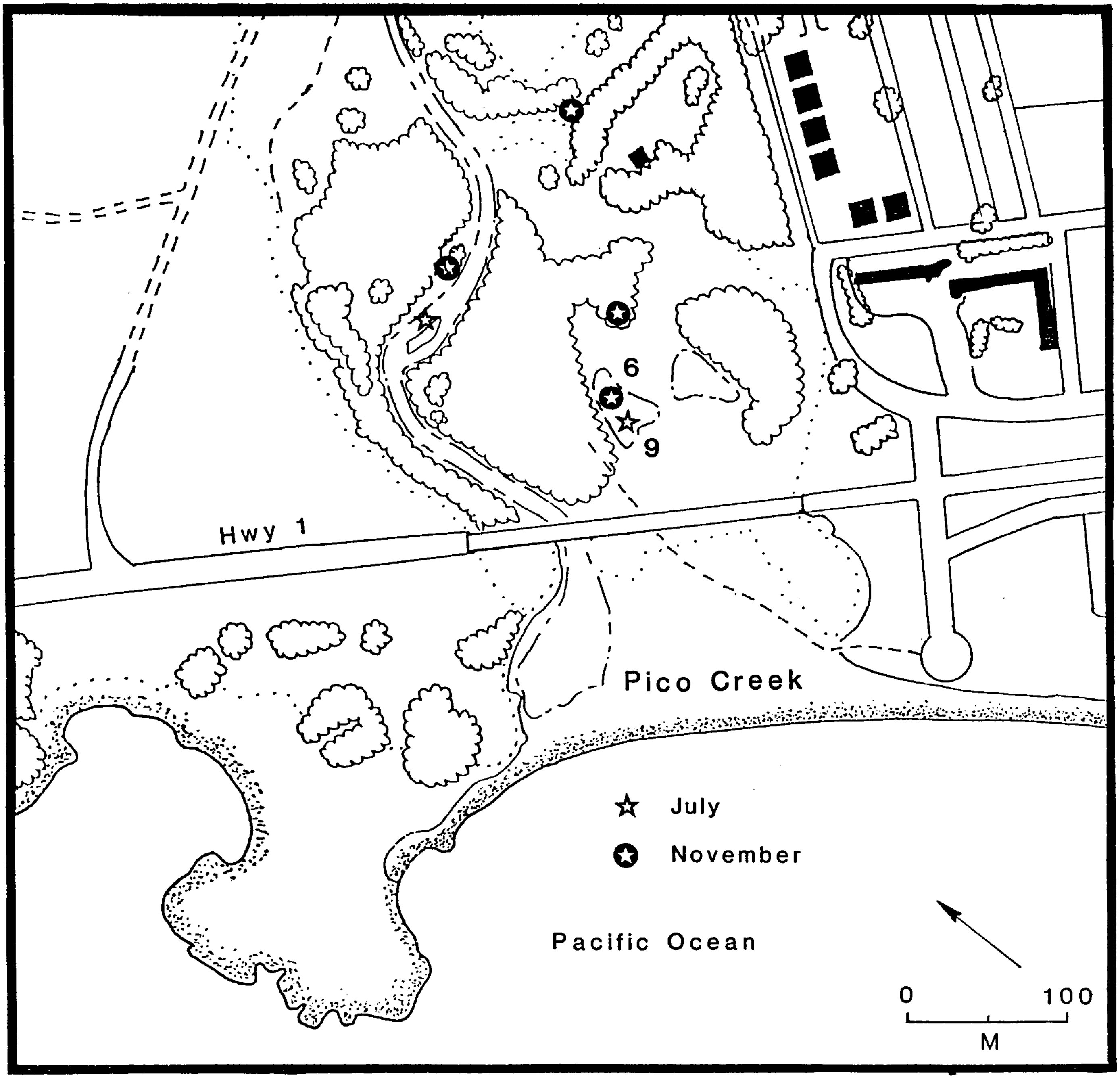


FIGURE 37. Terrestrial activity by male pond turtle 6133 in San Simeon Creek. Data based on daily radio-locations. Vertical lines indicate distance to nearest creek water. Lines < zero indicate turtle was in water. Blanks indicate turtle was not located. Note terrestrial basking in April-July, and summer/winter dormancy in August-December.

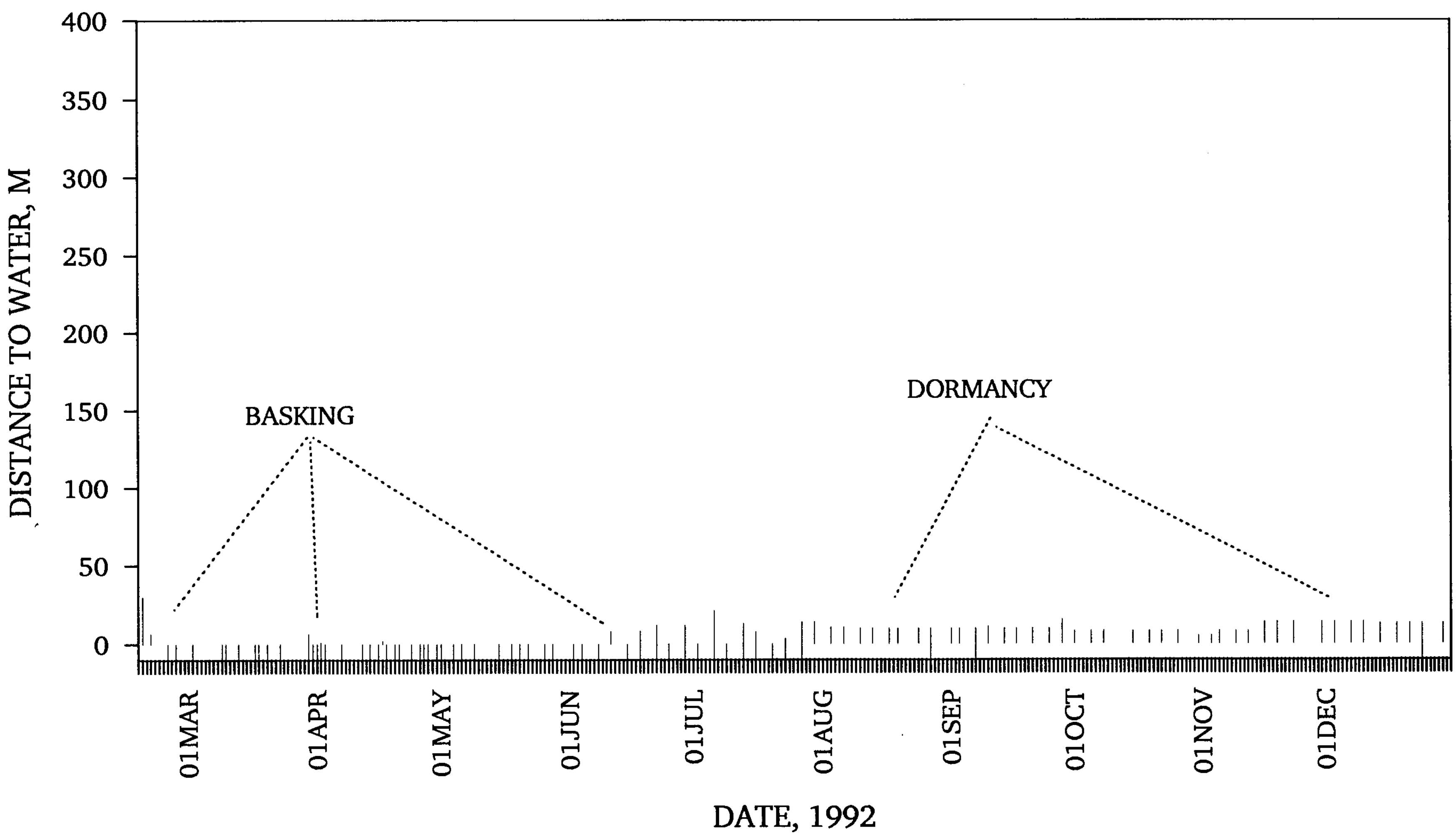


FIGURE 38. Terrestrial activity by male pond turtle 6022 in San Simeon Creek. Data based on daily radio-locations. Vertical lines indicate distance to nearest creek water. Lines < zero indicate turtle was in water. Blanks indicate turtle was not located. Note terrestrial basking activity in April, May, June, and July; dormancy in August-December.

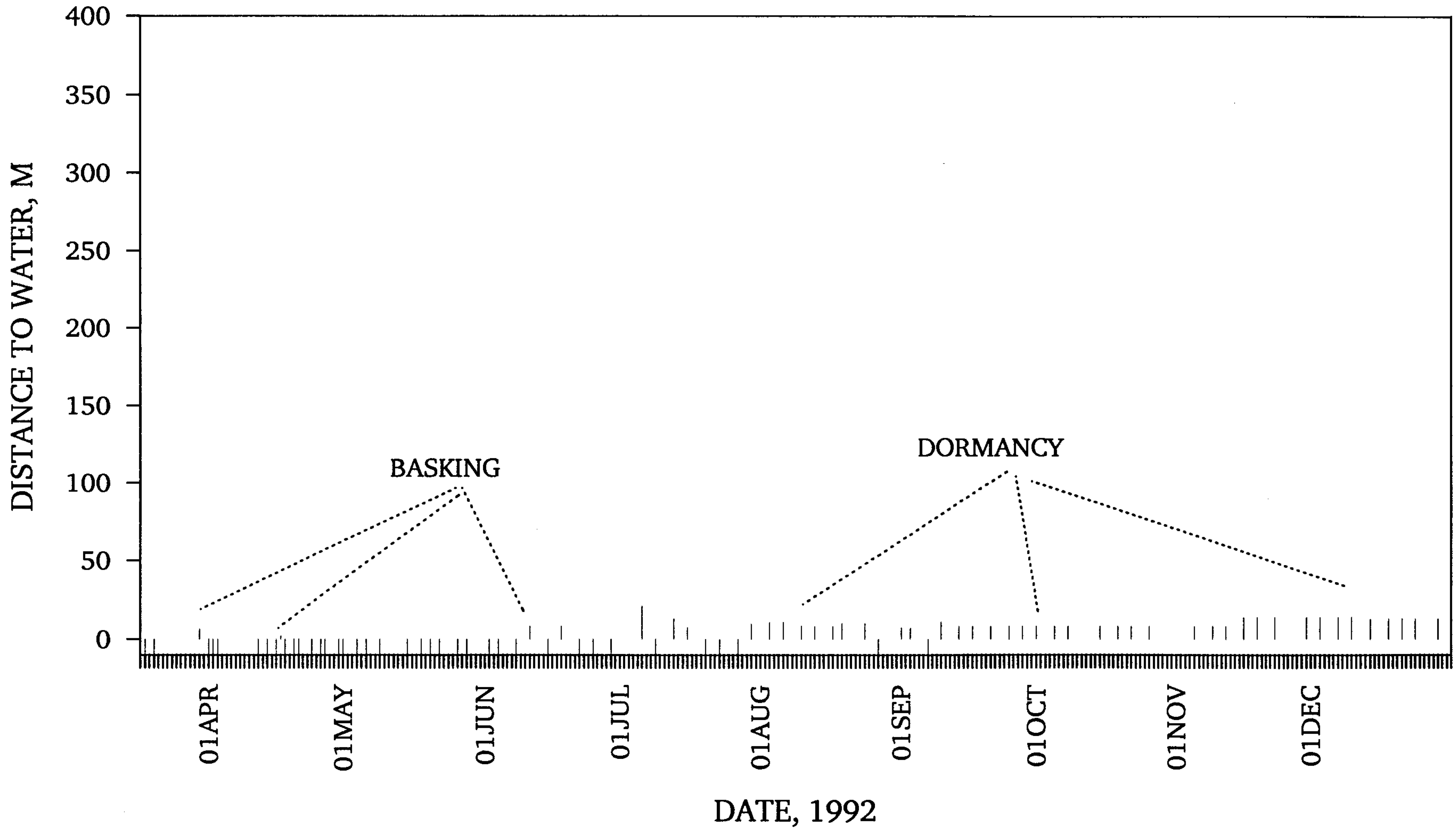


**FIGURE 39**
Locations (circled stars) of pond turtle nests, and attempted nests, in lower San Simeon Creek. Letters refer to summary data in Table 17.

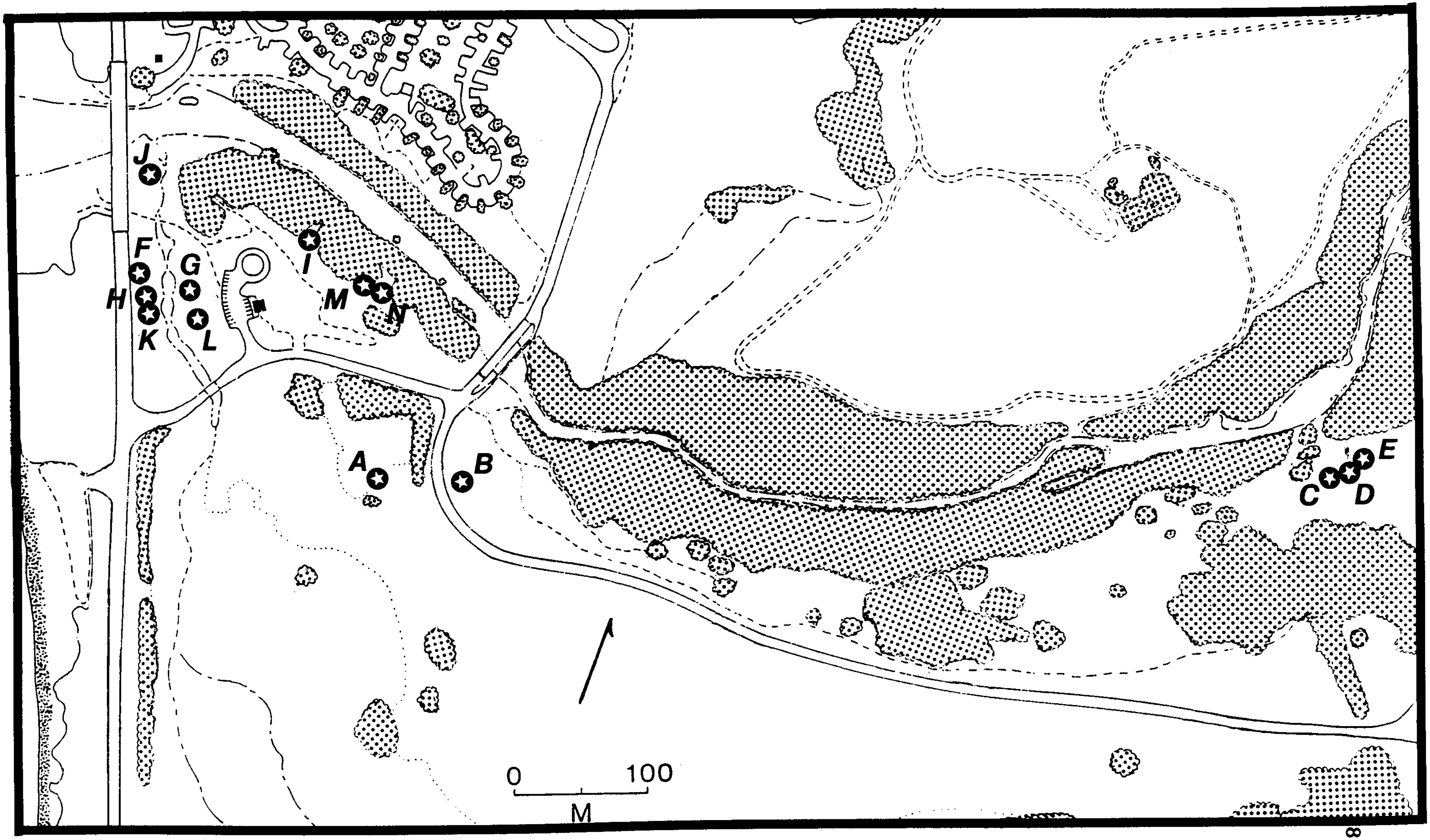


FIGURE 40. Total number of two-striped garter snakes sighted in 25-m-long segments in San Simeon Creek. Slough = segments 1-10, lagoon = 11-29, and creek = 30-49. Small snakes were 30 cm snout/vent length. Observations were made during 20 visual surveys completed about every two weeks during 1992.

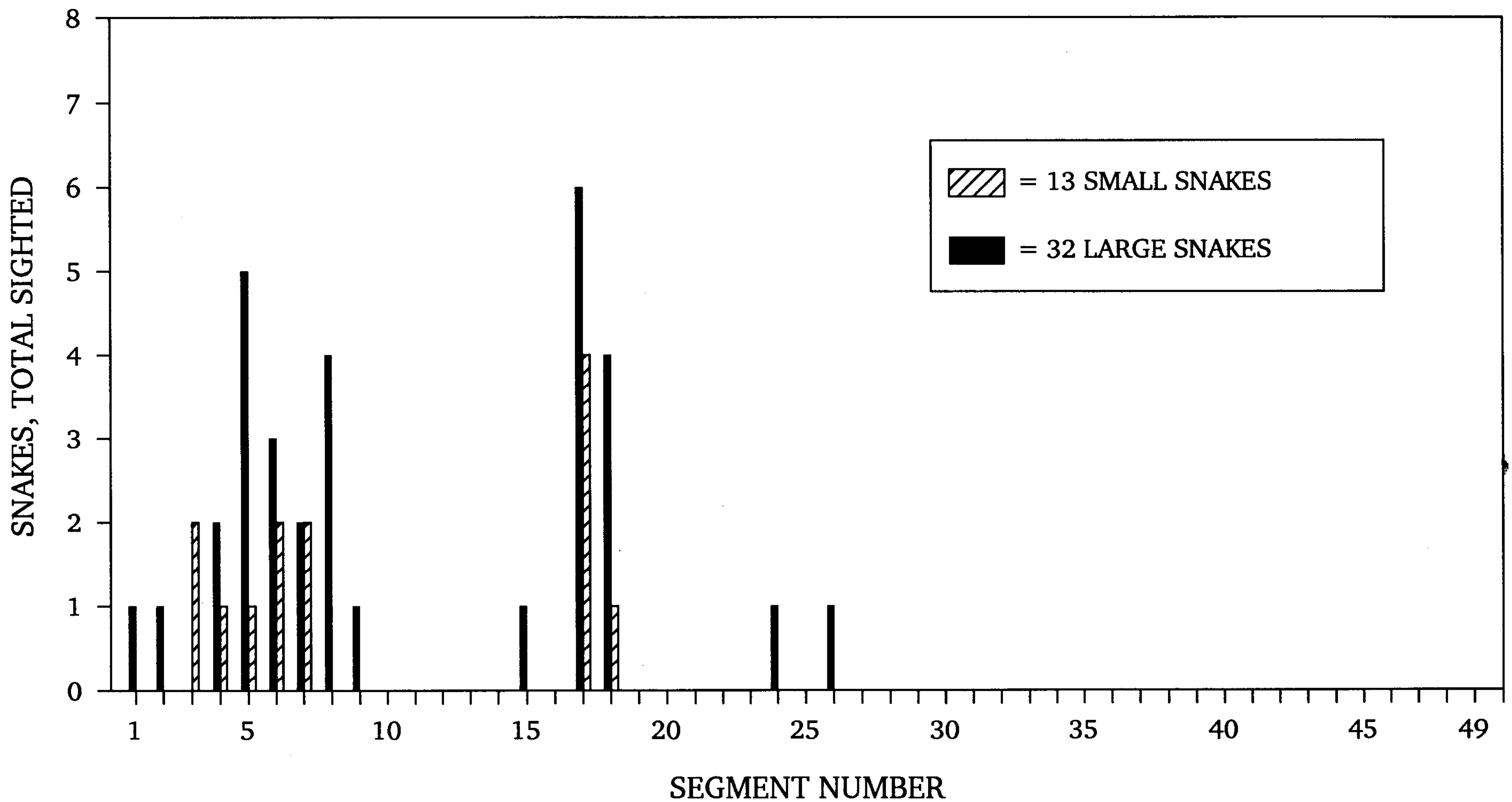


FIGURE 41. Mean number and range (filled circles and open triangles) of two-striped garter snakes sighted during visual surveys (N on top of range) in San Simeon Creek during 1992. Large snakes (top) were equal to or greater than 30 cm snout/vent length, and small snakes (bottom) were < 30 cm long.

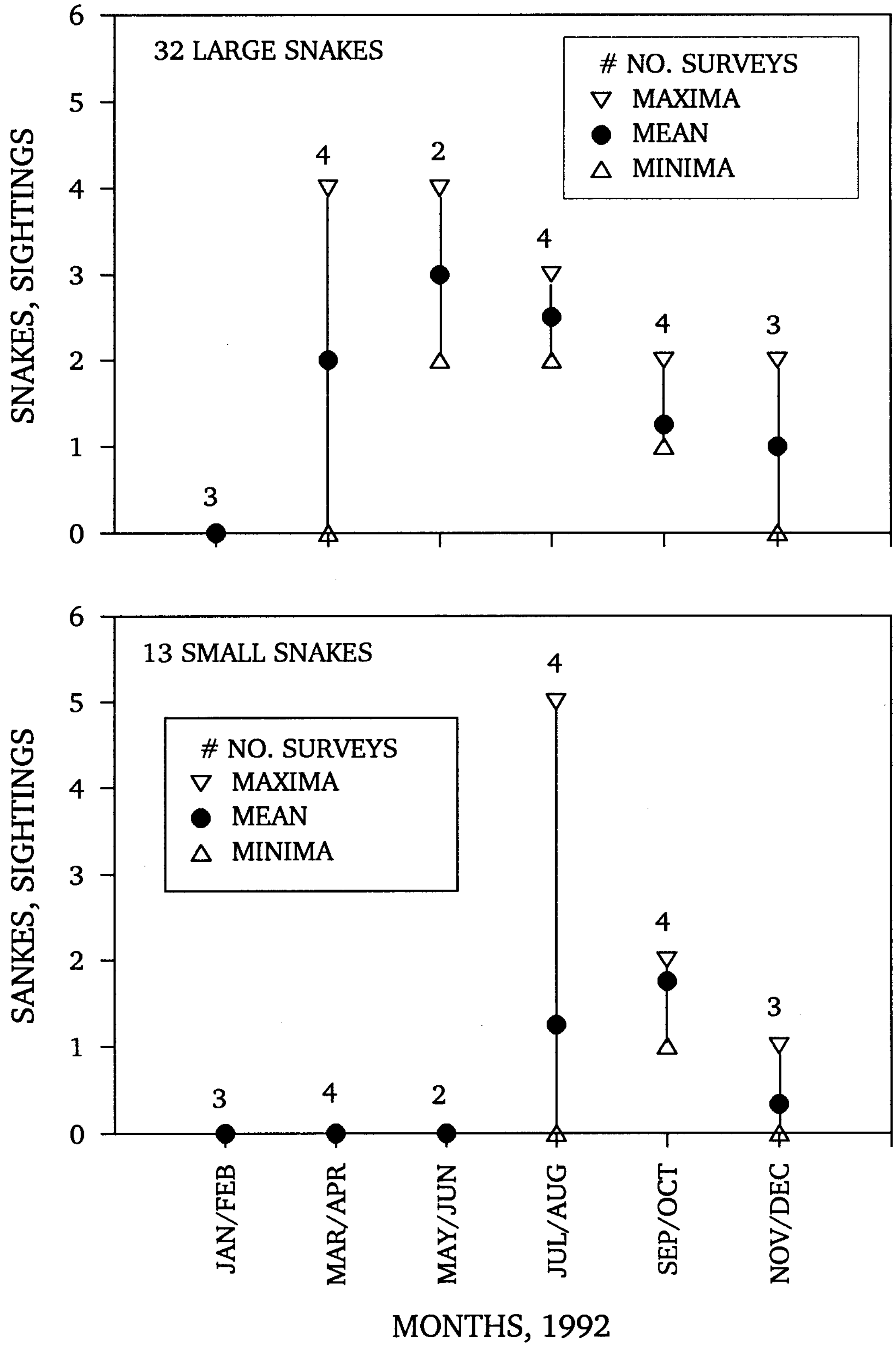


**FIGURE 42**
Home ranges (convex polygon method) for 7 radio-located two-striped garter snakes at San Simeon Creek during summer months (August through September, 1992). Snake identification numbers identify each home range. Characteristics of each home range are summarized in Table 18.

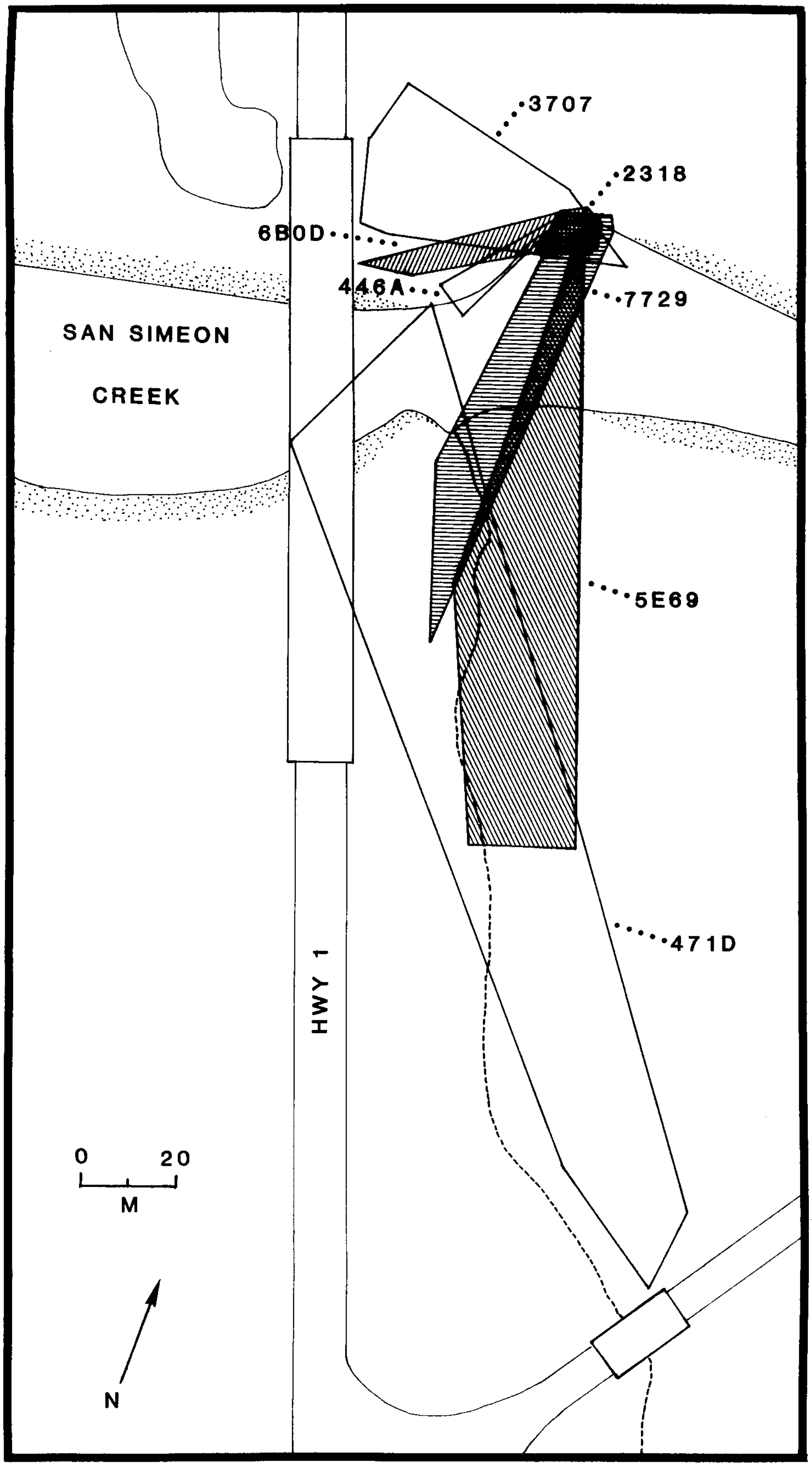
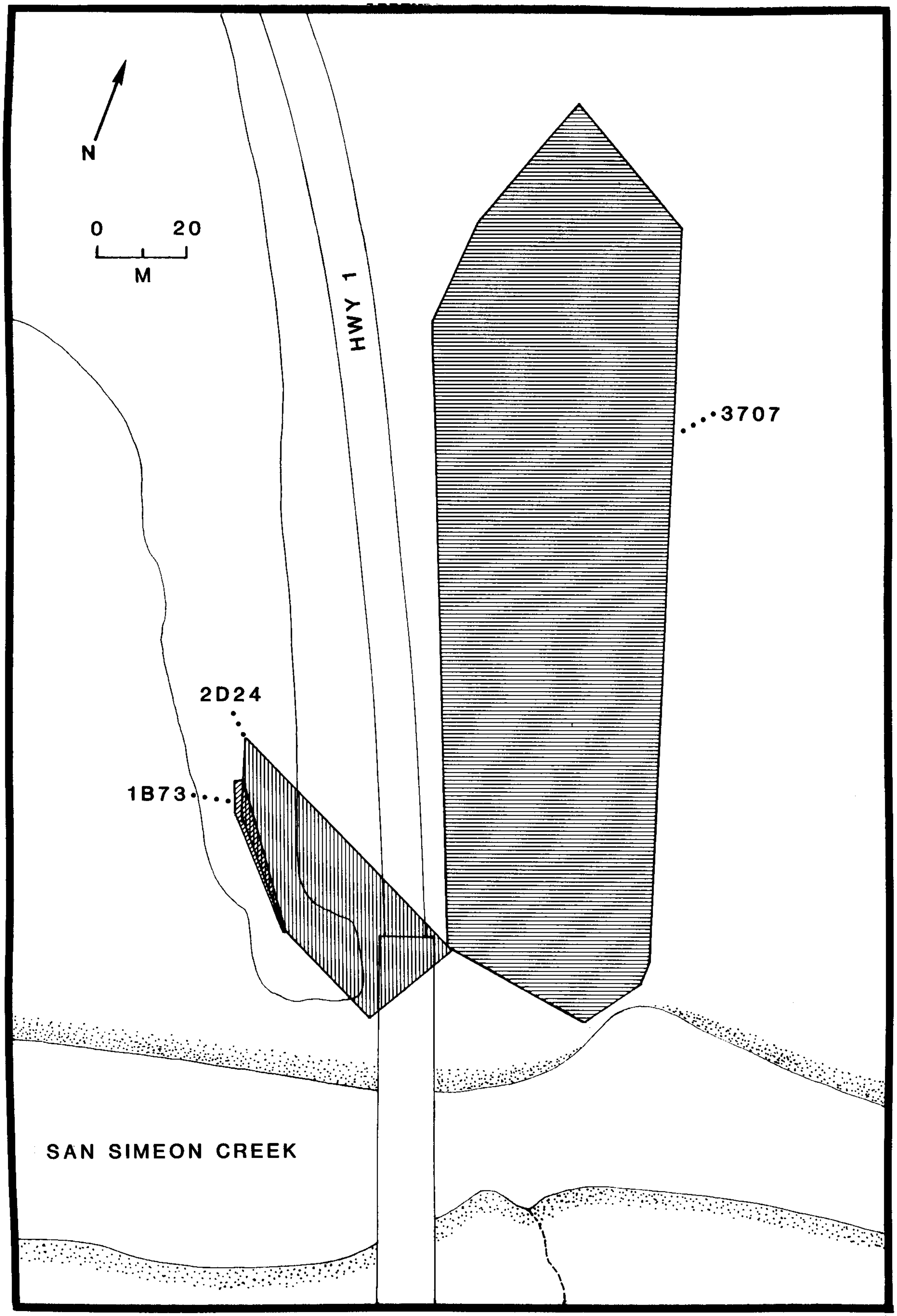


**FIGURE 43**
Home ranges (convex polygon method) for 3 radio-located two-striped garter snakes at San Simeon Creek during winter months (October through December, 1992). Snake identification numbers identify each home range. Characteristics of each home range are summarized in Table 18.



## APPENDIX 1. DATA SHEET FOR FISHES.

FISH SURVEY

Page __ of __

| DATE | TIME | SPECIES | GROUP | SIZE | SEGMENT | SEARCH | SIGHTING | HABITAT | BEHAVIOR | STREAM WIDTH | BED WIDTH | DEPTH | FLOW | SUBSTRATE | VEGETATION | WATER TEMP. | AIR TEMP. | CLOUD COVER | WIND | NOTES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |

DATE: SURVEY START: FINISH: OBSERVERS:

NOTES:

APPENDIX 2. DATA SHEET FOR REPTILES AND AMPHIBIANS.

| DATE | TIME | SPECIES | IDENTIFICATION | SEX | SIZE | SEGMENT | SEARCH | SIGHTING | HABITAT | GROUP | BEHAVIOR | STREAM WIDTH | BED WIDTH | DEPTH | FLOW | BANK ANGLE | SUBSTRATE | VEGETATION | WATER TEMP. | AIR TEMP. | SALINITY | CLOUD COVER | WIND | NOTES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |

DATE: SURVEY START: FINISH: OBSERVERS:

NOTES:

APPENDIX 3. CAPTURE SHEET FOR REPTILES AND AMPHIBIANS.

__ _______ ___/___
Sp ID Sex Cr

**ARROYO PROJECT CAPTURE DATA**

Observer:_____ __________ *

CAPTURE DATE: Day, month, year:________________ *

CAPTURE TIME: 24-hour clock: __________________ *

DRAINAGE: Two-letter code for arroyo or creek (? = UU):______ *

LOCATION: Two-digit segment number (? = UU):_____ *

LOCATION DESCRIPTION:

SPECIES: One letter code for binomial:____ *

IDENTIFICATION NUMBER: Last 4 digits of PIT or sequentially assigned number:__________ *

NATURAL MARKS: Circle one, also locate on sketch: Yes No *

RECAPTURE: Circle one: Yes No *

SEX: Circle one (U = undetermined): U Female Male *

TOTAL LENGTH: In millimeters (? = 999.99):___________ *

TAIL LENGTH: In millimeters (? = 999.99):___________ *

WEIGHT: In grams (? = 999.99):___________ *

GRAVID: Circle one (U = undetermined): U Male Yes No *

NUMBER EGGS/EMBRYOS (U or males = 99): ______ *

FREQUENCY (0 = none): RADIO ____________ *

PIT ______________ *

LOCATION (IP = intraperitoneal, SC = subcutaneous, LS = locate on sketch, NN = none): RADIO ____________ *

PIT ____________ *

RELEASE DATE: Day, month, year (? = blank): _________ *

RELEASE TIME: 24-hour clock (? = U): _____________ *

RELEASE DRAINAGE: Two-letter code for arroyo or creek:______ *

RELEASE SEGMENT (UU = undetermined): Two-digit number:_______ *

NOTES:

[U.S. Fish and Wildlife Service, Piedras Blancas Research Station. San Simeon. CA: 8 Mav 921

# A NEW RADIO-TRANSMITTER ATTACHMENT FOR LARGE RANID FROGS

## Preliminary Results

We have successfully used a ball or beaded chain belt to attach a mini-micro radio-transmitter to adult California red-legged frogs (Rana aurora draytonii). With the increasing awareness of declining amphibians, biologists have become more interested in gathering information on the behavioral ecology of frogs. Preliminary results suggest that our attachment technique shows promise in providing this type of information. Biologists have experimented with various methods of attaching radio transmitters to frogs. Many of these methods involve some form of harness around the "waist" and rear legs, using materials as diverse as plastic (Tygon) tubing, rubber (latex) bands, and fabrics (Spandex). Some of these techniques resulted in unacceptable abrasion to the frogs' skin and are sometimes too complicated to easily use under field conditions.

### How the Chain Belt Works

Our method of attaching radios is adapted from a technique used to collar small mammals, such as bats and squirrels. The method involves a ball or bead chain belt (Ball Chain Manufacturing Co., 741 S. Fulton Ave., Mt. Vernon, NY 10550; telephone 914/664-7500 or Bead Industries, 110 Mt. Grove St., Bridgeport, CN 06605; telephone 203/334-4124) fitted around the "waist" of the frog. The belt supports the radio transmitter. The chain lacks sharp edges, is very flexible, and easily rolls or slides over the skin, thus conforming to the contour of the frog with minimal abrasion. When a transmitter needs replacing, a new belt and transmitter unit are placed on the frog.

We have used #3 size chain, which is the smallest supplied with connectors. We use Devcon 2-ton epoxy to cement a bead or ball chain connector to the tip of a Holohil (Holohil Systems Ltd., 3387 Stonecrest Rd., Woodlawn, Ontario, Canada KOA 3MO; telephone 613/832-3649) BD-2 transmitter (pulse rate about 40/minute for an estimated life of about 70 days, 10 cm whip antenna, weight about 1.2 grams without attachment). The connector has an opening in the middle ("type B coupling"), which allows the epoxy to flow through the hole and form a strong bond with the transmitter.

On adult California red-legged frogs, a perfect fit of the belt is attained by cutting the chain length so that the belt/transmitter unit slides snugly over the extended legs. The belt should lightly compress the upper leg muscles as it slips onto the waist.

Optimal Components of the Belt

We have been experimenting with different chain and connector combinations. Brass chain has worked well because it results in minimal skin irritation and it tarnishes to nearly the same dorsal color of the frog. However, there are two major problems with brass: it is essentially permanent (the corrosion is too slow to release the belt from the frog) and it is relatively heavy (a brass belt weighs about the same as the transmitter). IF a radio fails prematurely, and the frog can not be recaptured, the radio-tag will potentially remain on the animal for life. In order to solve this problem, we have experimented with chain belts made of different metals, which fail (and drop off) due to electrolytic corrosion of dissimilar materials.

In one case, we radio-tagged a frog with a belt made from a brass connector and aluminum chain. Corrosion of dissimilar metals caused a ball of the chain to fail at the connector (thus releasing the unit from the frog) after 54 days. This combination of materials may consistently disintegrate too soon, resulting in belt failure before the transmitter battery is exhausted or the frog is recaptured. Aluminum chain is made with aluminum balls and brass posts between the balls. This combination may corrode more slowly. We are now trying an aluminum connector and chain, with the hope that this combination will consistently last at least as long as the 70-day life of the transmitter batteries. Another metal that might be experimented with in combination with aluminum or brass is carbon steel.

Another advantage of aluminum chain over brass is that it weighs less. However, aluminum remains bright and shiny, which may attract predators to tagged frogs. We have been spraying the chain black with a good quality enamel paint. It might also be possible to get anodized chain (such as is used by the military for "dog chains"), but the corrosive properties of the aluminum may be affected by this coating.

Radio-tag Has Minimal Effects

We have restricted our tagging to large (greater than 95 mm snout-vent length) male frogs. We tagged three individuals with six radios for a cumulative period of 167 days. Results have been encouraging. We observed virtually no skin abrasion on all frogs, and only one radio was shed after 13 days of tracking. Transmitters seem to ride mostly on the dorsum, but some have slid around to the ventrum. In either case, the whip antenna trails behind the frog. Based on opportunistic observations of both captive and free-ranging frogs, we found no discernable effect on their behavior.

The range of the signal from the transmitter under ideal field conditions is about 100 meters. In relatively clear, fresh water we received the signal from a distance of about three meters from a radio-tagged frog that was about a meter underwater.

Although our samples are small, our preliminary data are encouraging. We suggest that biologists experiment with this attachment method to further define and refine its application.

**APPENDIX 5.** **Water chemistry values taken at about weekly intervals at two sites in San Simeon Creek and Pico Creek. Abbreviations and Units: S = measurement taken about 5 cm below surface; B = measurement taken about 5 cm above bottom; Water Temp. = Temperature in °C; Conductivity = micromoles; Salinity = Parts/thousand; Oxygen = Milligrams/liter (mg/l); $CO_2$ = Carbon dioxide in mg/l; $NO_2$ = Nitrite in mg/l; $NH_4$ = Ammonia in mg/l; CL = Free Chlorine in mg/l; TOTL CL = Total Chlorine in mg/l. Missing values are indicated by a series of nines (9999...).**

APPENDIX 5A: WATER CHEMISTRY VALUES AT SEGMENT 17. SAN SIMEON CREEK

| DATE | TIME | | WATER TEMP. | | CONDUCTIVITY | | SALINITY | | OXYGEN | | CO2 | | NO2 | | NH4 | | PH | | CL | | TOTL CL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B |
| 29-May-92 | 1620 | 9999 | 20.9 | 99.9 | 900.00 | 99999.99 | 0.5 | 99.9 | 99.99 | 99.99 | 87.7 | 999.9 | 0.00 | 9.99 | 0.60 | 9.99 | 8.50 | 9.99 | 0.0 | 9.9 | 0.0 | 9.9 |
| 03-Jun-92 | 0920 | 9999 | 28.0 | 99.9 | 99999.99 | 99999.99 | 99.9 | 99.9 | 2.70 | 99.99 | 5.2 | 999.9 | 0.16 | 9.99 | 0.40 | 9.99 | 8.00 | 9.99 | 0.0 | 9.9 | 0.0 | 9.9 |
| 11-Jun-92 | 0611 | 0611 | 14.6 | 14.4 | 910.00 | 900.00 | 0.8 | 0.8 | 2.10 | 2.10 | 67.0 | 62.0 | 0.13 | 0.10 | 0.30 | 0.20 | 7.80 | 8.00 | 0.0 | 0.0 | 0.0 | 0.0 |
| 17-Jun-92 | 0630 | 0630 | 14.5 | 14.2 | 930.00 | 1100.00 | 0.8 | 0.8 | 1.90 | 2.00 | 70.0 | 8.1 | 0.16 | 0.16 | 0.40 | 0.50 | 7.41 | 7.42 | 0.0 | 0.0 | 0.0 | 0.0 |
| 24-Jun-92 | 0558 | 0558 | 17.0 | 16.9 | 1440.00 | 1100.00 | 1.0 | 0.8 | 2.00 | 1.20 | 76.4 | 81.2 | 0.20 | 0.15 | 0.40 | 0.50 | 7.51 | 7.55 | 0.0 | 0.0 | 0.0 | 0.0 |
| 01-Jul-92 | 0603 | 0603 | 16.0 | 16.8 | 1000.00 | 1120.00 | 0.8 | 1.0 | 1.40 | 1.20 | 63.6 | 63.2 | 0.25 | 0.20 | 0.50 | 0.60 | 7.73 | 7.73 | 0.0 | 0.0 | 0.0 | 0.0 |
| 08-Jul-92 | 0559 | 0559 | 16.0 | 16.0 | 1100.00 | 1210.00 | 0.9 | 1.0 | 1.50 | 1.50 | 109.3 | 72.2 | 0.20 | 0.18 | 0.30 | 0.40 | 7.69 | 7.63 | 0.0 | 0.0 | 0.0 | 0.0 |
| 15-Jul-92 | 0546 | 0546 | 18.0 | 18.0 | 1290.00 | 1130.00 | 1.0 | 0.9 | 1.60 | 1.60 | 62.0 | 66.4 | 0.19 | 0.21 | 0.40 | 0.50 | 7.58 | 7.53 | 0.0 | 0.0 | 0.0 | 0.0 |
| 22-Jul-92 | 0548 | 0548 | 15.0 | 15.1 | 1250.00 | 1240.00 | 1.0 | 1.0 | 2.00 | 2.10 | 65.8 | 63.8 | 0.14 | 0.14 | 0.50 | 0.30 | 7.61 | 7.56 | 0.0 | 0.0 | 0.0 | 0.0 |
| 29-Jul-92 | 0602 | 0600 | 18.0 | 16.8 | 1010.00 | 980.00 | 0.8 | 0.8 | 5.60 | 2.30 | 62.2 | 74.8 | 0.10 | 0.30 | 0.50 | 0.40 | 8.20 | 7.70 | 0.0 | 0.0 | 0.0 | 0.0 |
| 05-Aug-92 | 0606 | 0605 | 15.0 | 14.6 | 1100.00 | 1100.00 | 0.9 | 0.9 | 1.90 | 2.00 | 77.6 | 83.2 | 0.20 | 0.17 | 0.30 | 0.30 | 7.60 | 7.55 | 0.0 | 0.0 | 0.0 | 0.0 |
| 11-Aug-92 | 0618 | 0615 | 17.8 | 17.9 | 1210.00 | 1110.00 | 0.9 | 0.9 | 6.60 | 1.60 | 54.4 | 70.8 | 0.11 | 0.22 | 0.30 | 0.40 | 7.92 | 7.56 | 0.0 | 0.0 | 0.0 | 0.0 |
| 19-Aug-92 | 0630 | 0615 | 16.7 | 16.1 | 1180.00 | 1120.00 | 0.9 | 0.9 | 6.29 | 2.60 | 73.0 | 71.0 | 0.17 | 0.17 | 0.50 | 0.50 | 7.45 | 7.58 | 0.0 | 0.0 | 0.0 | 0.0 |
| 26-Aug-92 | 0634 | 0615 | 15.8 | 14.8 | 1010.00 | 1150.00 | 0.9 | 0.9 | 7.20 | 2.45 | 59.0 | 52.4 | 0.11 | 0.05 | 0.50 | 0.50 | 7.55 | 7.41 | 0.0 | 0.0 | 0.0 | 0.0 |
| 02-Sep-92 | 0627 | 0613 | 16.9 | 16.5 | 1100.00 | 1100.00 | 0.9 | 0.9 | 2.00 | 2.00 | 96.2 | 54.0 | 0.15 | 0.15 | 0.50 | 0.60 | 7.40 | 7.52 | 0.0 | 0.0 | 0.0 | 0.0 |
| 09-Sep-92 | 0634 | 0617 | 16.0 | 16.0 | 1300.00 | 1310.00 | 1.8 | 1.0 | 1.61 | 1.89 | 76.0 | 78.6 | 0.15 | 0.15 | 0.60 | 0.50 | 7.52 | 7.55 | 0.0 | 0.0 | 0.0 | 0.0 |
| 16-Sep-92 | 0637 | 0620 | 15.8 | 15.0 | 1590.00 | 1590.00 | 1.1 | 1.2 | 2.20 | 2.00 | 67.4 | 88.0 | 0.11 | 0.11 | 0.60 | 0.50 | 7.51 | 7.44 | 0.0 | 0.0 | 0.0 | 0.0 |
| 23-Sep-92 | 0628 | 0615 | 15.0 | 14.9 | 1100.00 | 1100.00 | 1.0 | 1.0 | 2.20 | 2.20 | 81.4 | 91.2 | 0.15 | 0.15 | 0.40 | 0.40 | 7.63 | 7.70 | 0.0 | 0.0 | 0.0 | 0.0 |
| 30-Sep-92 | 0712 | 0655 | 15.0 | 14.0 | 1090.00 | 1090.00 | 1.0 | 1.0 | 3.00 | 2.20 | 57.8 | 82.8 | 0.17 | 0.18 | 0.40 | 0.70 | 7.65 | 7.46 | 0.0 | 0.0 | 0.0 | 0.0 |
| 07-Oct-92 | 1707 | 1706 | 15.0 | 15.0 | 2030.00 | 2080.00 | 1.8 | 1.8 | 1.80 | 2.40 | 92.4 | 86.2 | 0.11 | 0.10 | 0.40 | 0.40 | 7.50 | 7.86 | 0.0 | 0.0 | 0.0 | 0.0 |

APPENDIX 5A: WATER CHEMISTRY VALUES AT SEGMENT 17, SAN SIMEON CREEK

| DATE | TIME | | WATER TEMP. | | CONDUCTIVITY | | SALINITY | | OXYGEN | | CO2 | | NO2 | | NH4 | | PH | | CL | | TOTL CL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B |
| 14-Oct-92 | 0721 | 0720 | 16.0 | 16.0 | 1800.00 | 1800.00 | 1.3 | 1.2 | 2.00 | 2.10 | 81.8 | 71.0 | 0.12 | 0.11 | 0.40 | 0.40 | 7.46 | 7.58 | 0.0 | 0.0 | 0.0 | 0.0 |
| 21-Oct-92 | 0745 | 0730 | 15.8 | 15.8 | 1690.00 | 1790.00 | 1.2 | 1.1 | 2.00 | 1.80 | 71.4 | 71.2 | 0.10 | 0.13 | 0.50 | 0.30 | 7.51 | 7.46 | 0.0 | 0.0 | 0.0 | 0.0 |
| 27-Oct-92 | 0730 | 0720 | 15.0 | 17.0 | 7210.00 | 39000.00 | 5.2 | 30.3 | 3.00 | 4.40 | 85.4 | 52.8 | 0.50 | 0.05 | 1.00 | 9.99 | 7.55 | 7.55 | 0.0 | 0.0 | 0.0 | 0.0 |
| 04-Nov-92 | 0730 | 0723 | 14.3 | 15.0 | 2880.00 | 3090.00 | 1.3 | 2.3 | 4.20 | 1.60 | 94.8 | 95.8 | 0.05 | 0.07 | 0.20 | 0.40 | 7.43 | 7.36 | 0.0 | 0.0 | 0.0 | 0.0 |
| 11-Nov-92 | 0654 | 0652 | 10.6 | 18.2 | 2220.00 | 28000.00 | 2.0 | 24.0 | 5.50 | 0.60 | 85.2 | 110.8 | 0.70 | 0.60 | 0.20 | 9.99 | 7.58 | 6.94 | 0.0 | 0.0 | 0.0 | 0.0 |
| 18-Nov-92 | 0730 | 0720 | 12.0 | 12.1 | 2110.00 | 2010.00 | 1.9 | 99.9 | 4.60 | 3.60 | 68.8 | 64.6 | 0.05 | 0.05 | 0.70 | 0.70 | 7.65 | 7.51 | 0.0 | 0.0 | 0.0 | 0.0 |
| 25-Nov-92 | 0800 | 0745 | 13.0 | 13.0 | 2300.00 | 31900.00 | 2.1 | 22.9 | 2.60 | 2.40 | 87.2 | 70.0 | 0.13 | 0.07 | 0.60 | 9.99 | 7.42 | 7.34 | 0.0 | 0.0 | 0.0 | 0.0 |
| 06-Dec-92 | 0732 | 0720 | 10.0 | 12.0 | 1200.00 | 23900.00 | 0.0 | 23.0 | 8.20 | 6.24 | 87.0 | 69.4 | 0.00 | 0.00 | 0.40 | 9.99 | 7.92 | 7.84 | 0.0 | 0.0 | 0.0 | 0.0 |
| 09-Dec-92 | 0901 | 0859 | 13.8 | 14.9 | 1410.00 | 33300.00 | 0.0 | 27.2 | 6.00 | 6.20 | 54.0 | 64.0 | 0.00 | 0.00 | 0.30 | 9.99 | 7.91 | 7.82 | 0.0 | 0.0 | 0.0 | 0.0 |
| 16-Dec-92 | 0735 | 0720 | 13.2 | 13.2 | 360.00 | 350.00 | 0.0 | 0.0 | 8.00 | 9.40 | 67.0 | 62.0 | 0.00 | 0.00 | 0.40 | 0.00 | 7.71 | 7.82 | 0.0 | 0.0 | 0.0 | 0.0 |
| 18-Dec-92 | 0738 | 0730 | 12.1 | 12.1 | 340.00 | 340.00 | 0.0 | 0.0 | 8.60 | 8.48 | 59.6 | 68.0 | 0.00 | 0.00 | 0.00 | 0.00 | 7.73 | 7.70 | 0.0 | 0.0 | 0.0 | 0.0 |
| 23-Dec-92 | 0735 | 0720 | 13.0 | 12.9 | 420.00 | 510.00 | 0.0 | 0.0 | 7.60 | 8.00 | 66.8 | 61.0 | 0.00 | 0.00 | 0.60 | 0.50 | 7.54 | 7.52 | 0.0 | 0.0 | 0.0 | 0.0 |
| 30-Dec-92 | 0735 | 0722 | 9.1 | 10.1 | 251.00 | 241.00 | 0.0 | 0.0 | 99.99 | 99.99 | 72.8 | 59.8 | 0.00 | 0.00 | 0.30 | 0.20 | 7.78 | 7.72 | 0.0 | 0.0 | 0.0 | 0.0 |
| 13-Jan-93 | 0856 | 9999 | 12.0 | 99.9 | 330.00 | 99999.99 | 0.0 | 99.9 | 10.50 | 99.99 | 999.9 | 999.9 | 0.00 | 9.99 | 0.00 | 9.99 | 7.94 | 9.99 | 0.0 | 9.9 | 0.0 | 9.9 |
| 21-Jan-93 | 0819 | 0817 | 13.0 | 13.0 | 230.00 | 230.00 | 0.0 | 0.0 | 9.80 | 9.60 | 45.8 | 44.8 | 0.00 | 0.00 | 0.30 | 0.40 | 7.80 | 7.85 | 0.0 | 0.0 | 0.0 | 0.0 |
| 27-Jan-93 | 0740 | 0720 | 10.0 | 10.0 | 361.00 | 311.00 | 0.0 | 0.0 | 10.60 | 10.80 | 64.4 | 60.6 | 0.00 | 0.00 | 0.60 | 0.30 | 7.85 | 7.83 | 0.0 | 0.0 | 0.0 | 0.0 |
| 03-Feb-93 | 0735 | 0720 | 10.2 | 10.5 | 418.00 | 412.00 | 0.0 | 0.0 | 9.80 | 10.20 | 55.8 | 49.4 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 10-Feb-93 | 0710 | 0705 | 9.9 | 9.9 | 281.00 | 281.00 | 0.1 | 0.1 | 10.40 | 10.40 | 73.0 | 63.0 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 17-Feb-93 | 0732 | 0730 | 11.0 | 11.0 | 400.00 | 392.00 | 0.0 | 0.0 | 10.00 | 99.99 | 49.2 | 999.9 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 23-Feb-93 | 0742 | 9999 | 12.0 | 99.9 | 99999.99 | 99999.99 | 99.9 | 99.9 | 10.40 | 99.99 | 999.9 | 999.9 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 03-Mar-93 | 0742 | 0741 | 10.8 | 10.8 | 398.00 | 390.00 | 0.1 | 0.1 | 10.20 | 10.20 | 38.2 | 48.8 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 10-Mar-93 | 0747 | 0746 | 12.1 | 12.1 | 474.00 | 460.00 | 0.0 | 0.0 | 9.50 | 9.50 | 54.2 | 43.6 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 17-Mar-93 | 0832 | 0831 | 14.6 | 14.2 | 580.00 | 580.00 | 0.2 | 0.2 | 9.00 | 8.80 | 61.6 | 62.6 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 24-Mar-93 | 0914 | 0913 | 14.2 | 14.1 | 500.00 | 38200.00 | 0.1 | 23.2 | 9.40 | 6.80 | 56.0 | 89.4 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 31-Mar-93 | 0657 | 0656 | 12.0 | 12.0 | 396.00 | 392.00 | 0.0 | 0.0 | 9.80 | 9.80 | 50.8 | 52.4 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 07-Apr-93 | 0747 | 0745 | 12.0 | 12.0 | 460.00 | 450.00 | 0.1 | 0.0 | 9.60 | 9.60 | 51.8 | 59.8 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 14-Apr-93 | 0720 | 0715 | 12.0 | 12.0 | 480.00 | 480.00 | 0.0 | 0.0 | 9.20 | 9.40 | 69.0 | 71.0 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 21-Apr-93 | 0713 | 0711 | 13.0 | 12.0 | 500.00 | 500.00 | 0.1 | 0.1 | 7.20 | 7.70 | 56.0 | 49.8 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 28-Apr-93 | 0728 | 0720 | 13.0 | 14.0 | 500.00 | 500.00 | 0.0 | 0.0 | 7.80 | 7.90 | 65.8 | 65.4 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 05-May-93 | 0702 | 0700 | 13.0 | 14.0 | 890.00 | 32000.00 | 0.5 | 26.5 | 7.90 | 7.10 | 53.4 | 77.4 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 12-May-93 | 0724 | 0718 | 13.0 | 19.0 | 490.00 | 2200.00 | 0.1 | 16.0 | 6.80 | 1.80 | 60.0 | 55.0 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 19-May-93 | 0637 | 0630 | 16.5 | 17.5 | 700.00 | 3100.00 | 0.1 | 23.5 | 99.99 | 99.99 | 73.8 | 75.8 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 20-May-93 | 0630 | 0623 | 18.0 | 19.0 | 690.00 | 29800.00 | 0.1 | 24.0 | 4.00 | 2.60 | 60.2 | 62.4 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 26-May-93 | 0640 | 0634 | 18.0 | 18.0 | 590.00 | 900.00 | 0.1 | 0.2 | 9.20 | 3.40 | 60.6 | 58.5 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |

APPENDIX 5B: WATER CHEMISTRY VALUES AT SEGMENT 30, SAN SIMEON CREEK

| DATE | TIME S | TIME B | WATER TEMP. S | WATER TEMP. B | CONDUCTIVITY S | CONDUCTIVITY B | SALINITY S | SALINITY B | OXYGEN S | OXYGEN B | CO2 S | CO2 B | NO2 S | NO2 B | NH4 S | NH4 B | PH S | PH B | CL S | CL B | TOTL CL S | TOTL CL B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 03-Jun-92 | | 0720 | | 17.0 | | 99999.99 | | 99.99 | | 2.80 | | 74.0 | | 0.00 | | 0.20 | | 7.50 | | 0.0 | | 0.0 |
| 11-Jun-92 | | 0703 | | 15.0 | | 700.00 | | 0.5 | | 4.10 | | 71.2 | | 0.20 | | 0.20 | | 7.80 | | 0.0 | | 0.0 |
| 17-Jun-92 | | 0719 | | 15.0 | | 800.00 | | 0.6 | | 3.80 | | 7.9 | | 0.20 | | 0.00 | | 7.40 | | 0.0 | | 0.0 |
| 24-Jun-92 | | 0636 | | 15.8 | | 810.00 | | 0.60 | | 2.00 | | 75.8 | | 0.04 | | 0.30 | | 7.50 | | 0.0 | | 0.0 |
| 01-Jul-92 | | 0635 | | 15.1 | | 820.00 | | 0.60 | | 2.00 | | 60.8 | | 0.04 | | 0.20 | | 7.55 | | 0.0 | | 0.0 |
| 08-Jul-92 | | 0640 | | 15.5 | | 880.00 | | 0.50 | | 2.20 | | 78.5 | | 0.05 | | 0.20 | | 7.59 | | 0.0 | | 0.0 |
| 15-Jul-92 | | 0617 | | 16.5 | | 870.00 | | 0.50 | | 1.80 | | 65.2 | | 0.04 | | 0.30 | | 7.44 | | 0.0 | | 0.0 |
| 22-Jul-92 | | 0617 | | 15.0 | | 900.00 | | 0.80 | | 2.20 | | 63.0 | | 0.05 | | 0.30 | | 7.52 | | 0.0 | | 0.0 |
| 29-Jul-92 | | 0626 | | 15.9 | | 900.00 | | 0.70 | | 2.30 | | 80.4 | | 0.05 | | 0.40 | | 7.50 | | 0.0 | | 0.0 |
| 05-Aug-92 | | 0638 | | 14.9 | | 900.00 | | 0.80 | | 2.50 | | 73.4 | | 0.05 | | 0.20 | | 7.45 | | 0.0 | | 0.0 |
| 11-Aug-92 | | 0655 | | 16.0 | | 950.00 | | 0.80 | | 1.70 | | 63.6 | | 0.52 | | 0.00 | | 7.45 | | 0.0 | | 0.0 |
| 19-Aug-92 | | 0753 | | 16.0 | | 820.00 | | 0.60 | | 2.10 | | 62.4 | | 0.07 | | 0.20 | | 7.25 | | 9.9 | | 9.9 |
| 20-Aug-92 | | 0721 | | 14.9 | | 500.00 | | 0.10 | | 6.20 | | 76.0 | | 0.00 | | 0.02 | | 7.25 | | 0.0 | | 0.0 |
| 26-Aug-92 | | 0658 | | 15.0 | | 920.00 | | 0.80 | | 2.21 | | 72.2 | | 0.06 | | 0.30 | | 7.03 | | 0.0 | | 0.0 |
| 02-Sep-92 | | 0645 | | 16.1 | | 980.00 | | 0.80 | | 1.81 | | 79.2 | | 0.05 | | 0.40 | | 7.33 | | 0.0 | | 0.0 |
| 09-Sep-92 | | 0716 | | 15.9 | | 940.00 | | 0.80 | | 2.00 | | 39.4 | | 0.08 | | 0.30 | | 7.39 | | 0.0 | | 0.0 |
| 16-Sep-92 | | 0710 | | 15.1 | | 1000.00 | | 0.80 | | 2.20 | | 89.2 | | 0.09 | | 9.99 | | 7.34 | | 0.0 | | 0.0 |
| 23-Sep-92 | | 0655 | | 15.0 | | 970.00 | | 0.80 | | 2.45 | | 84.4 | | 0.08 | | 0.60 | | 7.46 | | 0.0 | | 0.0 |
| 30-Sep-92 | | 0732 | | 15.1 | | 1000.00 | | 0.90 | | 2.40 | | 56.2 | | 0.08 | | 0.40 | | 7.41 | | 0.0 | | 0.0 |
| 07-Oct-92 | | 1735 | | 15.0 | | 1030.00 | | 1.00 | | 2.40 | | 83.4 | | 0.08 | | 0.30 | | 7.38 | | 0.0 | | 0.0 |
| 14-Oct-92 | | 0756 | | 15.8 | | 1020.00 | | 0.80 | | 2.10 | | 80.0 | | 0.07 | | 0.30 | | 7.37 | | 0.0 | | 0.0 |
| 21-Oct-92 | | 0805 | | 16.0 | | 1020.00 | | 1.00 | | 1.20 | | 84.0 | | 0.12 | | 0.40 | | 7.30 | | 0.0 | | 0.0 |
| 27-Oct-92 | | 0745 | | 16.9 | | 9200.00 | | 5.20 | | 3.80 | | 45.2 | | 0.23 | | 0.60 | | 7.66 | | 0.0 | | 0.0 |
| 04-Nov-92 | | 0745 | | 16.9 | | 1800.00 | | 1.10 | | 2.40 | | 78.6 | | 0.07 | | 0.30 | | 7.40 | | 0.0 | | 0.0 |
| 11-Nov-92 | | 0743 | | 14.0 | | 1150.00 | | 1.00 | | 3.30 | | 76.0 | | 0.30 | | 0.40 | | 7.45 | | 0.0 | | 0.0 |
| 18-Nov-92 | | 0745 | | 14.1 | | 1100.00 | | 0.90 | | 2.80 | | 67.0 | | 0.30 | | 0.60 | | 7.35 | | 0.0 | | 0.0 |
| 25-Nov-92 | | 0824 | | 14.2 | | 1130.00 | | 0.90 | | 2.40 | | 42.6 | | 0.00 | | 0.30 | | 7.37 | | 9.9 | | 9.9 |
| 06-Dec-92 | | 0800 | | 9.8 | | 378.00 | | 0.00 | | 10.60 | | 42.6 | | 0.00 | | 0.60 | | 7.71 | | 0.0 | | 0.0 |
| 09-Dec-92 | | 0925 | | 2.1 | | 330.00 | | 0.00 | | 9.60 | | 41.4 | | 0.00 | | 0.20 | | 7.92 | | 0.0 | | 0.0 |
| 16-Dec-92 | | 0800 | | 13.6 | | 399.00 | | 0.00 | | 8.20 | | 52.2 | | 0.00 | | 0.60 | | 7.62 | | 0.0 | | 0.0 |
| 18-Dec-92 | | 0804 | | 12.0 | | 310.00 | | 0.00 | | 10.40 | | 61.2 | | 0.00 | | 0.00 | | 7.72 | | 0.0 | | 0.0 |
| 23-Dec-92 | | 0756 | | 12.5 | | 360.00 | | 0.00 | | 8.20 | | 60.2 | | 0.00 | | 0.50 | | 7.43 | | 0.0 | | 0.0 |
| 30-Dec-92 | | 0759 | | 9.2 | | 249.00 | | 0.00 | | 99.99 | | 63.8 | | 0.00 | | 0.30 | | 7.73 | | 0.0 | | 0.0 |

APPENDIX 5B; WATER CHEMISTRY VALUES AT SEGMENT 30, SAN SIMEON CREEK

| DATE | TIME | | WATER TEMP. | | CONDUCTIVITY | | SALINITY | | OXYGEN | | CO2 | | NO2 | | NH4 | | PH | | CL | | TOTL CL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B |
| 13-Jan-93 | | 0912 | | 11.9 | | 300.00 | | 0.00 | | 10.60 | | 999.9 | | 0.00 | | 0.50 | | 8.00 | | 0.0 | | 0.0 |
| 21-Jan-93 | | 0844 | | 13.0 | | 215.00 | | 0.00 | | 10.20 | | 39.6 | | 0.00 | | 0.40 | | 7.87 | | 0.0 | | 0.0 |
| 27-Jan-93 | | 0755 | | 10.0 | | 290.00 | | 0.00 | | 8.80 | | 42.2 | | 0.00 | | 0.40 | | 7.78 | | 0.0 | | 0.0 |
| 03-Feb-93 | | 0748 | | 10.5 | | 416.00 | | 0.00 | | 9.60 | | 36.4 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 10-Feb-93 | | 0725 | | 9.8 | | 299.00 | | 0.10 | | 12.21 | | 71.0 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 17-Feb-93 | | 0748 | | 10.4 | | 378.00 | | 0.00 | | 10.10 | | 40.0 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 23-Feb-93 | | 9999 | | 99.9 | | 99999.99 | | 99.99 | | 99.99 | | 999.9 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 03-Mar-93 | | 0808 | | 11.0 | | 369.00 | | 0.00 | | 10.60 | | 48.0 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 10-Mar-93 | | 0812 | | 12.1 | | 415.00 | | 0.00 | | 10.00 | | 50.2 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 17-Mar-93 | | 0751 | | 14.5 | | 405.00 | | 0.00 | | 9.00 | | 47.6 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 24-Mar-93 | | 1009 | | 14.8 | | 479.00 | | 0.10 | | 10.60 | | 50.4 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 31-Mar-93 | | 0727 | | 12.0 | | 370.00 | | 0.00 | | 9.80 | | 48.4 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 07-Apr-93 | | 0813 | | 12.0 | | 440.00 | | 0.00 | | 9.90 | | 61.4 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 14-Apr-93 | | 0805 | | 11.5 | | 462.00 | | 0.00 | | 9.30 | | 45.0 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 21-Apr-93 | | 0742 | | 13.0 | | 492.00 | | 0.10 | | 8.00 | | 57.4 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 28-Apr-93 | | 0800 | | 13.0 | | 500.00 | | 0.10 | | 8.80 | | 68.2 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 05-May-93 | | 0715 | | 13.5 | | 520.00 | | 0.10 | | 8.00 | | 51.8 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 12-May-93 | | 0741 | | 12.5 | | 460.00 | | 0.00 | | 8.30 | | 50.0 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 19-May-93 | | 0707 | | 16.0 | | 700.00 | | 0.10 | | 99.99 | | 70.2 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 20-May-93 | | 0653 | | 17.0 | | 650.00 | | 0.20 | | 5.40 | | 63.0 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 26-May-93 | | 0707 | | 17.0 | | 550.00 | | 0.10 | | 6.00 | | 58.2 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |

APPENDIX 5C: WATER CHEMISTRY VALUES AT SEGMENT 6. PICO CREEK

| DATE | TIME S | TIME B | WATER TEMP. S | WATER TEMP. B | CONDUCTIVITY S | CONDUCTIVITY B | SALINITY S | SALINITY B | OXYGEN S | OXYGEN B | CO2 S | CO2 B | NO2 S | NO2 B | NH4 S | NH4 B | PH S | PH B | CL S | CL B | TOTL CL S | TOTL CL B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 04-Jun-92 | 0750 | 9999 | 20.0 | 99.9 | 780.00 | 99999.99 | 0.50 | 99.99 | 8.00 | 9.99 | 39.2 | 99.9 | 0.00 | 9.99 | 0.00 | 9.99 | 7.80 | 9.99 | 0.0 | 9.9 | 0.0 | 9.9 |
| 10-Jun-92 | 0810 | 1018 | 20.5 | 17.0 | 9999.99 | 99999.99 | 99.99 | 99.99 | 7.90 | 4.10 | 43.4 | 43.0 | 0.00 | 0.00 | 0.00 | 0.00 | 8.00 | 7.70 | 0.0 | 0.0 | 0.0 | 0.0 |
| 18-Jun-92 | 0659 | 0659 | 18.8 | 17.0 | 680.00 | 680.00 | 0.30 | 0.30 | 7.80 | 3.70 | 55.0 | 55.6 | 0.00 | 0.00 | 0.00 | 0.20 | 8.04 | 7.59 | 0.0 | 0.0 | 0.0 | 0.0 |
| 25-Jun-92 | 0608 | 0608 | 20.0 | 17.9 | 720.00 | 550.00 | 0.30 | 0.20 | 8.90 | 4.20 | 42.2 | 50.8 | 0.00 | 0.00 | 0.40 | 0.20 | 8.12 | 7.52 | 0.0 | 0.0 | 0.0 | 0.0 |
| 03-Jul-92 | 0615 | 0615 | 20.4 | 20.0 | 820.00 | 5000.00 | 0.40 | 3.20 | 7.50 | 5.00 | 65.2 | 88.1 | 0.00 | 0.00 | 0.30 | 0.00 | 8.22 | 7.70 | 0.0 | 0.0 | 0.0 | 0.0 |
| 09-Jul-92 | 0612 | 0612 | 19.0 | 17.8 | 720.00 | 800.00 | 0.30 | 0.40 | 8.00 | 5.10 | 50.2 | 77.5 | 0.00 | 0.00 | 0.20 | 0.30 | 8.27 | 7.72 | 0.0 | 0.0 | 0.0 | 0.0 |
| 16-Jul-92 | 0607 | 0607 | 21.0 | 19.9 | 800.00 | 760.00 | 0.20 | 0.30 | 7.60 | 3.50 | 51.0 | 51.2 | 0.00 | 0.00 | 0.40 | 0.30 | 7.95 | 7.45 | 0.0 | 0.0 | 0.0 | 0.0 |
| 23-Jul-92 | 0617 | 0613 | 19.0 | 18.0 | 1200.00 | 1700.00 | 0.90 | 1.00 | 5.40 | 1.70 | 54.6 | 60.2 | 0.00 | 0.00 | 0.40 | 0.40 | 8.10 | 7.72 | 0.0 | 0.0 | 0.0 | 0.0 |
| 30-Jul-92 | 0615 | 0610 | 20.0 | 20.0 | 1320.00 | 1280.00 | 0.70 | 0.40 | 6.90 | 6.00 | 42.5 | 43.4 | 0.00 | 0.00 | 0.30 | 0.30 | 8.25 | 8.10 | 0.0 | 0.0 | 0.0 | 0.0 |
| 06-Aug-92 | 0625 | 0622 | 19.3 | 19.0 | 1100.00 | 1090.00 | 0.60 | 0.70 | 7.00 | 7.10 | 48.8 | 53.6 | 0.00 | 0.00 | 0.30 | 0.30 | 8.33 | 8.21 | 0.0 | 0.0 | 0.0 | 0.0 |
| 13-Aug-92 | 0648 | 0638 | 20.1 | 19.9 | 1450.00 | 1670.00 | 1.00 | 1.00 | 7.10 | 4.20 | 45.4 | 57.0 | 0.00 | 0.00 | 0.30 | 0.50 | 8.14 | 7.72 | 0.0 | 0.0 | 0.0 | 0.0 |
| 20-Aug-92 | 0649 | 0634 | 19.1 | 18.8 | 1920.00 | 2280.00 | 1.20 | 1.50 | 6.10 | 7.21 | 56.0 | 66.4 | 0.02 | 0.02 | 0.60 | 0.30 | 7.75 | 7.72 | 0.0 | 0.0 | 0.0 | 0.0 |
| 27-Aug-92 | 0637 | 0623 | 19.9 | 19.0 | 2300.00 | 2490.00 | 1.60 | 1.60 | 6.20 | 6.89 | 60.4 | 63.2 | 0.00 | 0.00 | 0.40 | 0.50 | 7.86 | 7.92 | 0.0 | 0.0 | 0.0 | 0.0 |
| 03-Sep-92 | 0632 | 0619 | 21.0 | 19.0 | 2300.00 | 2490.00 | 1.50 | 1.80 | 6.80 | 6.60 | 70.4 | 47.6 | 0.00 | 0.00 | 0.40 | 0.60 | 8.05 | 7.83 | 0.0 | 0.0 | 0.0 | 0.0 |
| 10-Sep-92 | 0641 | 0625 | 18.3 | 18.2 | 2280.00 | 3300.00 | 1.80 | 2.20 | 7.20 | 5.10 | 72.0 | 93.0 | 0.00 | 0.00 | 0.30 | 0.40 | 8.06 | 7.73 | 0.0 | 0.0 | 0.0 | 0.0 |
| 17-Sep-92 | 0640 | 0630 | 17.8 | 15.1 | 2200.00 | 2110.00 | 1.80 | 1.90 | 6.50 | 5.00 | 51.2 | 66.4 | 0.00 | 0.00 | 0.40 | 0.50 | 8.01 | 7.68 | 0.0 | 0.0 | 0.0 | 0.0 |
| 24-Sep-92 | 0637 | 0625 | 17.0 | 17.1 | 2310.00 | 2900.00 | 2.90 | 2.20 | 6.45 | 6.65 | 61.0 | 69.2 | 0.00 | 0.00 | 0.40 | 0.40 | 8.14 | 7.92 | 0.0 | 0.0 | 0.0 | 0.0 |
| 01-Oct-92 | 0715 | 0655 | 19.0 | 18.1 | 2200.00 | 2100.00 | 1.80 | 1.60 | 6.60 | 2.40 | 72.4 | 90.0 | 0.00 | 0.00 | 0.60 | 0.50 | 8.37 | 8.12 | 0.0 | 0.0 | 0.0 | 0.0 |
| 08-Oct-92 | 0720 | 0718 | 15.8 | 16.5 | 2000.00 | 2980.00 | 1.30 | 2.00 | 5.50 | 3.70 | 68.6 | 60.0 | 0.00 | 0.00 | 0.40 | 0.30 | 7.83 | 7.67 | 0.0 | 0.0 | 0.0 | 0.0 |
| 15-Oct-92 | 0730 | 0728 | 17.0 | 17.0 | 2200.00 | 2400.00 | 1.60 | 1.80 | 5.60 | 4.20 | 64.0 | 68.2 | 0.00 | 0.00 | 0.40 | 0.60 | 7.99 | 7.84 | 0.0 | 0.0 | 0.0 | 0.0 |
| 22-Oct-92 | 0740 | 0730 | 17.0 | 16.0 | 2190.00 | 2100.00 | 1.80 | 1.80 | 5.61 | 4.80 | 57.8 | 82.4 | 0.00 | 0.00 | 0.50 | 0.60 | 8.23 | 8.03 | 0.0 | 0.0 | 0.0 | 0.0 |
| 28-Oct-92 | 0640 | 0625 | 16.9 | 17.1 | 33200.00 | 38900.00 | 26.00 | 30.00 | 1.00 | 4.20 | 68.8 | 40.8 | 0.00 | 0.00 | 9.99 | 9.99 | 7.19 | 7.10 | 0.0 | 0.0 | 0.0 | 0.0 |
| 03-Nov-92 | 0735 | 0725 | 12.9 | 17.0 | 2210.00 | 3100.00 | 0.20 | 23.80 | 6.80 | 0.65 | 57.8 | 145.6 | 0.10 | 0.00 | 0.40 | 3.00 | 7.85 | 6.92 | 0.0 | 0.0 | 0.0 | 0.0 |
| 05-Nov-92 | 0745 | 0730 | 14.0 | 14.2 | 3600.00 | 29900.00 | 3.10 | 24.00 | 8.40 | 0.41 | 74.2 | 57.2 | 0.00 | 0.00 | 0.40 | 0.30 | 7.40 | 7.47 | 0.0 | 0.0 | 0.0 | 0.0 |
| 12-Nov-92 | 0740 | 0725 | 8.2 | 15.0 | 4090.00 | 34500.00 | 4.10 | 29.00 | 4.20 | 4.40 | 83.6 | 77.6 | 0.00 | 0.00 | 0.30 | 0.30 | 7.41 | 7.59 | 0.0 | 0.0 | 0.0 | 0.0 |
| 21-Nov-92 | 0723 | 0720 | 10.8 | 16.8 | 2000.00 | 33000.00 | 1.50 | 26.00 | 6.80 | 0.80 | 73.3 | 999.9 | 0.00 | 0.00 | 0.40 | 9.99 | 7.78 | 6.85 | 0.0 | 0.0 | 0.0 | 0.0 |
| 07-Dec-92 | 0748 | 0730 | 10.8 | 12.0 | 250.00 | 201.00 | 0.00 | 0.00 | 11.20 | 11.00 | 46.0 | 44.0 | 0.00 | 0.00 | 0.50 | 0.70 | 7.73 | 7.72 | 0.0 | 0.0 | 0.0 | 0.0 |
| 11-Dec-92 | 0720 | 0718 | 12.0 | 1.6 | 265.00 | 270.00 | 0.00 | 0.00 | 9.50 | 9.50 | 37.6 | 39.0 | 0.00 | 0.00 | 0.70 | 0.90 | 7.66 | 7.62 | 0.0 | 0.0 | 0.0 | 0.0 |
| 17-Dec-92 | 0757 | 0730 | 10.0 | 11.2 | 7100.00 | 21100.00 | 0.00 | 18.50 | 8.20 | 6.40 | 72.2 | 68.4 | 0.00 | 0.00 | 0.00 | 9.99 | 7.44 | 7.43 | 0.0 | 0.0 | 0.0 | 0.0 |
| 24-Dec-92 | 0729 | 0720 | 11.0 | 13.0 | 31000.00 | 32200.00 | 22.50 | 28.10 | 6.00 | 99.99 | 90.6 | 66.2 | 0.00 | 0.00 | 0.70 | 9.99 | 7.71 | 7.65 | 0.0 | 0.0 | 0.0 | 0.0 |
| 31-Dec-92 | 0749 | 0725 | 7.9 | 8.0 | 650.00 | 111.00 | 0.00 | 0.00 | 10.60 | 10.40 | 77.8 | 73.2 | 0.00 | 0.00 | 0.80 | 0.60 | 7.76 | 7.61 | 0.0 | 0.0 | 0.0 | 0.0 |
| 14-Jan-93 | 1513 | 9999 | 12.9 | 99.9 | 190.00 | 99999.99 | 0.00 | 0.00 | 10.40 | 99.99 | 27.0 | 999.9 | 0.00 | 9.99 | 0.40 | 9.99 | 7.90 | 9.99 | 0.0 | 9.9 | 0.0 | 9.9 |
| 22-Jan-93 | 0727 | 0726 | 12.5 | 12.5 | 212.00 | 210.00 | 0.00 | 0.00 | 9.60 | 9.80 | 40.0 | 43.6 | 0.00 | 0.00 | 0.10 | 0.20 | 7.70 | 7.90 | 0.0 | 0.0 | 0.0 | 0.0 |
| 28-Jan-93 | 0737 | 0730 | 10.0 | 9.9 | 418.00 | 419.00 | 0.00 | 0.00 | 8.65 | 8.65 | 62.0 | 45.4 | 0.00 | 0.00 | 0.00 | 0.50 | 7.99 | 8.00 | 0.0 | 0.0 | 0.0 | 0.0 |

APPENDIX 5C: WATER CHEMISTRY VALUES AT SEGMENT 6, PICO CREEK

| DATE | TIME | | WATER TEMP. | | CONDUCTIVITY | | SALINITY | | OXYGEN | | CO2 | | NO2 | | NH4 | | PH | | CL | | TOTL CL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B |
| 04-Feb-93 | 0733 | 0720 | 11.1 | 12.1 | 19000.00 | 28000.00 | 19.50 | 24.00 | 99.99 | 99.99 | 70.6 | 77.4 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 12-Feb-93 | 0815 | 0812 | 10.2 | 10.3 | 368.00 | 362.00 | 0.00 | 0.00 | 9.40 | 9.50 | 54.0 | 999.9 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 18-Feb-93 | 0813 | 0811 | 12.0 | 13.0 | 2400.00 | 24000.00 | 1.50 | 21.80 | 9.50 | 9.80 | 46.0 | 999.9 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 04-Mar-93 | 0710 | 0709 | 10.4 | 10.6 | 351.00 | 350.00 | 0.00 | 0.00 | 10.20 | 10.20 | 51.4 | 49.0 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 11-Mar-93 | 0731 | 0725 | 11.8 | 11.7 | 460.00 | 460.00 | 0.00 | 0.00 | 9.50 | 9.40 | 40.4 | 43.2 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 18-Mar-93 | 0706 | 0705 | 12.0 | 12.0 | 412.00 | 412.00 | 0.10 | 0.20 | 9.40 | 9.40 | 51.0 | 54.2 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 25-Mar-93 | 0748 | 0746 | 12.9 | 12.9 | 322.00 | 325.00 | 0.00 | 0.00 | 9.80 | 9.10 | 49.8 | 45.8 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 01-Apr-93 | 0736 | 0735 | 12.2 | 12.2 | 412.00 | 398.00 | 0.00 | 0.00 | 9.80 | 9.80 | 60.6 | 59.8 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 08-Apr-93 | 0719 | 0717 | 12.0 | 12.0 | 454.00 | 450.00 | 0.00 | 0.00 | 9.40 | 9.20 | 47.2 | 46.0 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 15-Apr-93 | 0730 | 0722 | 12.5 | 12.5 | 475.00 | 480.00 | 0.00 | 0.00 | 9.00 | 9.00 | 25.0 | 58.0 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 22-Apr-93 | 0720 | 0718 | 12.5 | 13.9 | 800.00 | 18000.00 | 0.10 | 14.50 | 8.00 | 7.00 | 68.2 | 65.2 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 29-Apr-93 | 0720 | 0715 | 13.2 | 13.0 | 510.00 | 520.00 | 0.10 | 0.10 | 8.10 | 7.90 | 50.4 | 47.0 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 06-May-93 | 0725 | 0719 | 14.0 | 13.5 | 520.00 | 525.00 | 0.10 | 0.10 | 7.90 | 7.70 | 56.6 | 53.4 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 13-May-93 | 0722 | 0720 | 13.0 | 20.0 | 690.00 | 30000.00 | 0.20 | 22.00 | 7.00 | 2.80 | 53.4 | 47.0 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 20-May-93 | 0725 | 0720 | 16.0 | 15.5 | 2050.00 | 37000.00 | 1.20 | 30.00 | 6.00 | 4.80 | 65.2 | 65.8 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |
| 27-May-93 | 0638 | 0628 | 16.5 | 19.0 | 500.00 | 20000.00 | 0.20 | 14.50 | 5.60 | 4.40 | 61.8 | 67.3 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.99 | 9.9 | 9.9 | 9.9 | 9.9 |

APPENDIX 5D: WATER CHEMISTRY VALUES AT SEGMENT 23. PICO CREEK

| DATE | TIME | | WATER TEMP. | | CONDUCTIVITY | | SALINITY | | OXYGEN | | CO2 | | NO2 | | NH4 | | PH | | CL | | TOTL CL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B |
| 04-Jun-92 | | 0850 | | 17.0 | | 580.00 | | 0.30 | | 4.38 | | 50.0 | | 0.00 | | 9.99 | | 7.50 | | 0.0 | | 0.0 |
| 10-Jun-92 | | 0940 | | 16.0 | | 99999.99 | | 99.99 | | 6.10 | | 18.2 | | 0.00 | | 0.00 | | 7.50 | | 0.0 | | 0.0 |
| 18-Jun-92 | | 0809 | | 14.9 | | 489.00 | | 0.20 | | 4.00 | | 74.6 | | 0.00 | | 0.20 | | 7.43 | | 0.0 | | 0.0 |
| 25-Jun-92 | | 0702 | | 15.1 | | 498.00 | | 0.30 | | 3.60 | | 58.0 | | 0.00 | | 0.00 | | 7.41 | | 0.0 | | 0.0 |
| 03-Jul-92 | | 0659 | | 15.0 | | 500.00 | | 0.30 | | 3.40 | | 82.8 | | 0.00 | | 0.20 | | 7.40 | | 0.0 | | 0.0 |
| 09-Jul-92 | | 0655 | | 15.0 | | 492.00 | | 0.20 | | 3.70 | | 54.6 | | 0.00 | | 0.30 | | 7.52 | | 0.0 | | 0.0 |
| 16-Jul-92 | | 0636 | | 15.8 | | 56.00 | | 0.30 | | 3.20 | | 58.4 | | 0.00 | | 0.10 | | 7.16 | | 0.0 | | 0.0 |
| 23-Jul-92 | | 0648 | | 13.8 | | 482.00 | | 0.30 | | 4.40 | | 51.6 | | 0.00 | | 0.30 | | 7.53 | | 0.0 | | 0.0 |
| 30-Jul-92 | | 0653 | | 15.0 | | 510.00 | | 0.30 | | 3.70 | | 60.6 | | 0.00 | | 0.20 | | 7.49 | | 0.0 | | 0.0 |
| 06-Aug-92 | | 0658 | | 14.9 | | 590.00 | | 0.30 | | 4.20 | | 57.0 | | 0.00 | | 0.30 | | 7.53 | | 0.0 | | 0.0 |
| 13-Aug-92 | | 0743 | | 15.6 | | 580.00 | | 0.40 | | 5.60 | | 60.4 | | 0.00 | | 0.50 | | 7.48 | | 0.0 | | 0.0 |
| 20-Aug-92 | | 0721 | | 14.9 | | 500.00 | | 0.10 | | 6.20 | | 76.0 | | 0.00 | | 0.20 | | 7.25 | | 0.0 | | 0.0 |
| 03-Sep-92 | | 0653 | | 15.0 | | 700.00 | | 0.50 | | 1.40 | | 63.2 | | 0.00 | | 0.80 | | 7.28 | | 0.0 | | 0.0 |
| 10-Sep-92 | | 0659 | | 16.1 | | 590.00 | | 0.20 | | 1.41 | | 62.0 | | 0.00 | | 0.60 | | 7.38 | | 0.0 | | 0.0 |
| 17-Sep-92 | | 0657 | | 13.9 | | 600.00 | | 0.50 | | 0.14 | | 94.6 | | 0.00 | | 0.60 | | 7.47 | | 0.0 | | 0.0 |
| 24-Sep-92 | | 0654 | | 17.9 | | 390.00 | | 0.10 | | 2.10 | | 105.8 | | 0.00 | | 0.90 | | 7.52 | | 0.0 | | 0.0 |
| 01-Oct-92 | | 0730 | | 16.3 | | 168.00 | | 0.10 | | 1.20 | | 84.4 | | 0.00 | | 0.90 | | 7.59 | | 0.0 | | 0.0 |
| 08-Oct-92 | | 9999 | | 99.9 | | 99999.99 | | 99.99 | | 99.99 | | 999.9 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 15-Oct-92 | | 9999 | | 99.9 | | 99999.99 | | 99.99 | | 99.99 | | 999.9 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 22-Oct-92 | | 0757 | | 99.9 | | 99999.99 | | 99.99 | | 99.99 | | 999.9 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 28-Oct-92 | | 0715 | | 15.0 | | 2100.00 | | 1.70 | | 2.60 | | 137.8 | | 0.50 | | 0.90 | | 7.91 | | 0.0 | | 0.0 |
| 03-Nov-92 | | 0805 | | 13.0 | | 370.00 | | 0.00 | | 3.80 | | 59.4 | | 0.30 | | 0.07 | | 7.50 | | 0.0 | | 0.0 |
| 05-Nov-92 | | 0820 | | 14.0 | | 610.00 | | 0.80 | | 6.70 | | 150.2 | | 0.00 | | 0.50 | | 7.70 | | 0.0 | | 0.0 |
| 12-Nov-92 | | 0805 | | 11.2 | | 481.00 | | 0.20 | | 7.00 | | 74.8 | | 0.00 | | 0.10 | | 7.47 | | 0.0 | | 0.0 |
| 21-Nov-92 | | 0802 | | 11.2 | | 462.00 | | 0.30 | | 6.80 | | 68.2 | | 0.00 | | 0.30 | | 7.53 | | 0.0 | | 0.0 |
| 07-Dec-92 | | 0800 | | 11.5 | | 231.00 | | 0.00 | | 10.80 | | 50.0 | | 0.00 | | 0.60 | | 7.73 | | 0.0 | | 0.0 |
| 11-Dec-92 | | 0739 | | 11.0 | | 159.00 | | 0.00 | | 10.80 | | 43.0 | | 0.00 | | 0.70 | | 7.81 | | 0.0 | | 0.0 |
| 17-Dec-92 | | 0810 | | 9.9 | | 308.00 | | 0.00 | | 9.00 | | 65.4 | | 0.00 | | 0.00 | | 7.85 | | 0.0 | | 0.0 |
| 24-Dec-92 | | 0750 | | 12.0 | | 225.00 | | 0.00 | | 8.50 | | 53.4 | | 0.00 | | 0.50 | | 7.81 | | 0.0 | | 0.0 |
| 31-Dec-92 | | 0812 | | 7.1 | | 269.00 | | 0.00 | | 10.89 | | 21.8 | | 0.00 | | 0.40 | | 7.78 | | 0.0 | | 0.0 |
| 14-Jan-93 | | 9999 | | 99.9 | | 99999.99 | | 99.99 | | 99.99 | | 999.9 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 22-Jan-93 | | 0755 | | 12.0 | | 202.00 | | 0.00 | | 10.40 | | 35.6 | | 0.00 | | 0.20 | | 7.84 | | 0.0 | | 0.0 |
| 28-Jan-93 | | 0820 | | 9.8 | | 340.00 | | 0.00 | | 10.20 | | 65.4 | | 0.00 | | 0.60 | | 8.01 | | 0.0 | | 0.0 |

APPENDIX 5D: WATER CHEMISTRY VALUES AT SEGMENT 23, PICO CREEK

| DATE | TIME | | WATER TEMP. | | CONDUCTIVITY | | SALINITY | | OXYGEN | | CO2 | | NO2 | | NH4 | | PH | | CL | | TOTL CL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B | S | B |
| 04-Feb-93 | | 0751 | | 9.1 | | 1850.00 | | 1.50 | | 99.99 | | 75.4 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 12-Feb-93 | | 0839 | | 10.2 | | 298.00 | | 0.00 | | 10.60 | | 41.8 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 18-Feb-93 | | 0839 | | 12.0 | | 99999.99 | | 99.99 | | 10.20 | | 41.8 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 04-Mar-93 | | 0739 | | 10.3 | | 350.00 | | 0.00 | | 10.30 | | 47.0 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 11-Mar-93 | | 0752 | | 11.6 | | 400.00 | | 0.00 | | 10.20 | | 47.2 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 18-Mar-93 | | 0736 | | 11.8 | | 410.00 | | 0.00 | | 9.80 | | 51.2 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 25-Mar-93 | | 0820 | | 12.7 | | 290.00 | | 0.00 | | 10.20 | | 44.0 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 01-Apr-93 | | 0803 | | 12.2 | | 355.00 | | 0.00 | | 10.00 | | 50.0 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 08-Apr-93 | | 0759 | | 11.8 | | 398.00 | | 0.00 | | 9.80 | | 46.4 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 15-Apr-93 | | 0754 | | 12.0 | | 428.00 | | 0.00 | | 10.00 | | 45.0 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 22-Apr-93 | | 0805 | | 12.0 | | 429.00 | | 0.00 | | 9.60 | | 55.0 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 29-Apr-93 | | 0740 | | 14.0 | | 490.00 | | 0.00 | | 8.50 | | 49.4 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 06-May-93 | | 0755 | | 14.0 | | 500.00 | | 0.00 | | 8.30 | | 47.0 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 13-May-93 | | 0740 | | 12.5 | | 650.00 | | 0.10 | | 7.20 | | 50.4 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 20-May-93 | | 0740 | | 16.0 | | 480.00 | | 0.10 | | 8.20 | | 53.0 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |
| 27-May-93 | | 0704 | | 16.0 | | 400.00 | | 0.10 | | 7.40 | | 55.4 | | 9.99 | | 9.99 | | 9.99 | | 9.9 | | 9.9 |