DISTRIBUTION AND HABITAT USE OF PACIFIC POND TURTLES IN A SUMMER IMPOUNDED RIVER

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ABSTRACT: The Pacific pond turtle (*Actinemys* [= *Clemmys*] *marmorata*) inhabits a variety of lotic and lentic habitats, including altered habitats such as small reservoirs and other impounded waterways. We determined the distribution and habitat use of the Pacific pond turtle along a 14.8-km-long reach of the Russian River, Sonoma County, California. The study area included a seasonal dam that creates an approximately 5.1-km-long reservoir (the Wohler Pool) with an area of about 360 ha. Basking turtles often used living downed trees with trunks of moderate size, averaging 20.7 cm. Turtles of many sizes were found, including a number of small-sized individuals, indicating some recent recruitment into the population. Turtles also were distributed into a broad range of age classes, including 26.9% juveniles (< 120 mm CL, 1-5 yrs old). Pacific pond turtles are resident of the Wohler Pool, but their numbers decreased downstream closer to the dam. Important factors in the persistence of turtles in the Wohler Pool are probably the presence of a temporary impoundment and the gradual effects of the reservoir from upstream to downstream.

Key words: reptile, radio telemetry, *Actinemys marmorata*, basking habitat

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The Pacific pond turtle (*Actinemys* [= *Clemmys*] *marmorata*) is the only extant native aquatic turtle in California. This species inhabits a variety of lotic and lentic habitats, including streams, rivers, estuaries, ponds, marshes, and lakes (Zeiner et al. 1988). Also, artificial or altered habitats are used, such as canals, excavated ponds, reservoirs and other impounded waterways (Holland 1994). Although this turtle is widespread and exhibits plasticity in habitat use, some believe the species is in decline (Holland 1994, Jennings and Hayes 1994), and it is considered a Species of Special Concern by the California Department of Fish and Game. The primary reason for the decline is the loss or adverse alteration of habitat. Some populations appear stable, however, and may have increased over historical levels due to advantageous human changes to habitat (Germano and Bury 2001). It is reasonably certain, though, that some populations in Southern California are in danger of extinction (Jennings and Hayes 1994). Habitat loss in the Central Valley of California has extirpated many populations (Holland 1994), although some remaining ones appear stable (Germano and Bury 2001). Along the northern coast of California, Pacific pond turtles are widely distributed (Holland 1994), but trends in decline have been reported (see Jennings and Hayes 1994).

Dams can alter or eliminate stream habitat for Pacific pond turtles (Holland 1994). Large reservoirs often have fluctuating water levels that preclude the establishment of bank vegetation needed for basking, cover, and foraging. Dammed rivers alter downstream habitat and suitability for Pacific pond turtles by decreasing water temperatures, increasing velocities, and increasing canopy cover (Reese and Welsh 1998a). Dam-altered rivers may affect turtle recruitment (Reese and Welsh 1998b) resulting in adult-biased populations from low reproduction and hatchling survival. Habitat features for Pacific pond turtles include areas with slow-moving waters and basking sites to thermoregulate body temperatures (Holland 1994). Emergent basking sites are usually composed of downed tree trunks, exposed rocks, and emergent vegetation, which can be affected by altered flow regimes from dams.

The purpose of our study was to determine the distribution and habitat use of the Pacific pond turtle above a seasonal dam on the Russian River, Sonoma County, California. Also, we wanted to determine if the population was adult biased. The objectives of the study were to: 1) determine the distribution and movement patterns of the Pacific pond turtle in the study area, 2) characterize the size and age structure, and 3) determine what basking habitat features are important.

STUDY AREA

The study area consisted of a 14.8-km-long reach of the Russian River from Healdsburg Dam to an inflatable dam located 0.9 km downstream of Wohler Road Bridge, Sonoma County, CA. The river within the study area is free-flowing from the upstream end for about 9.7 km. The lower 5.1 km of the study area is a reservoir. Dry Creek is a major tributary of the Russian River and has its confluence about 2 km downstream from Healdsburg Dam. The study area contained 4.8% lower gradient riffle, 45.2% flat water, and 49.7% pool habitat. River flows during our study ranged from 282 cfs to 501 cfs. The width of the river in the study area averaged 35.0 m (range 14.4 m to 110.4 m). In general, the riparian forest along the river had a patchy distribution. Historic and recent levees along the banks of the river occurred throughout most of the study area. Surrounding land-uses included infiltration ponds, pit gravel mining, and vineyard.

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The study area was influenced by 2 seasonal summer dams that were located at the ends of the study area, which impounded water for recreation and municipal uses. The Healdsburg Dam located at the upstream border of the study area had a 3-m-high permanent concrete base and 3-m-high flashboards that were regularly installed from June through September. Since 1975, the Sonoma County Water Agency operated an inflatable dam located at the downstream end of the study area. The dam consisted of a 3.4-m-high rubber bladder and was usually in place from April through November. This dam impounded water creating a 5.1-km-long narrow reservoir, called the Wohler Pool. The surface area of the Wohler Pool varied but was about 360 ha. The dam substantially influenced aquatic conditions in the lower Wohler Pool by increasing water depths and temperatures, decreasing velocities, and flooding bank vegetation. The upper Wohler Pool, 3.2 km to 5.1 km above the dam, had minimal influence from backwatering and had a maximum depth change of 0.2 m at the downstream end and no effect at the upstream end.

The summer flows in the Russian River were augmented by 2 large permanent dams located upstream of the study area; Coyote Dam at Lake Mendocino near Ukiah, and Warm Springs Dam at Lake Sonoma. Historically, the Russian River probably had limited summer flows and likely dried in areas. Currently, water releases from the dams maintain perennial flows in the river.

METHODS

Visual Surveys

A 2-person crew conducted visual surveys to detect basking Pacific pond turtles and collect habitat data at observed basking sites. Visual surveys are a common method used to detect turtles (e.g., Reese and Welsh 1998b, Holland 1994, Germano and Bury 2001). We conducted 6 surveys on warm sunny days from 17 June through 2 September 2003 by floating downstream in 1-person kayaks. Both surveyors searched the river banks for turtles. If we observed more than 1 basking turtle at a time, basking sites were marked and then we returned to collect data. Hatchlings and very young turtles spend most of their time in areas with dense emergent vegetation (Jennings and Hayes 1994) and likely went undetected.

At all basking sites where turtles were observed, we collected habitat data, determined the coordinates using a Garmin GPS III Plus global positioning system (GPS) receiver, and marked each site to avoid collecting duplicate data on subsequent surveys. Data recorded at basking sites included distance to shore, river depth at the basking site, and canopy cover. We visually estimated the percentage of canopy cover within a 1-m-radius centered at the basking site. If the basking site was a tree trunk, we measured the trunk diameter and condition based on 5 categories: "living downed tree" had living branches with leaves; "new snag" had small branches attached, rough/splintered edges, and bark present; "worn snag" had medium-sized branches attached with worn ends and bark partially present; "old snag" had trunk present with worn ends and bark absent; and "decomposed snag" had large trunk with soft wood.

Dive Surveys

We conducted dive surveys using snorkel equipment to assist in the hand capture of turtles. We searched for turtles in the same manner as visual surveys for basking turtles, discussed above. Once basking turtles entered the water, we searched underwater and hand captured individuals. For each captured turtle, we measured the carapace length (CL), determined sex, marked the turtle by filing notches along the edge of marginal scutes, and then released individuals at the point of capture. We marked turtles to avoid collecting duplicate data on subsequent surveys. The sex of turtles was determined based on morphological traits and all females were palpated for shelled eggs.

We conducted 7 dive surveys weekly or bi-weekly from 2 July through 2 September 2003. On 17 July and 2 September, we conducted dive surveys in concert with visual surveys, as discussed above. On these 2 dates we marked basking sites, captured turtles, and then collected habitat data. In our experience, snorkeling for turtles at basking sites and collecting measurement data resulted in similar disturbance that was not likely to alert turtles located downstream and out of sight.

We determined the age of turtles by counting growth rings on the carapace and plastron (Bury and Germano 1998). We grouped turtles into 3 age-classes based on a combination of carapace length and growth rings. Turtles $\leq$ 120 mm CL (and $\leq$ 5 yrs old) were considered sexually immature juveniles (Germano and Bury 2001). Young adults were > 120 mm CL and 5 - 9 yrs old. Turtles with $\geq$ 10 rings or with no visible rings due to worn shells were considered mature adults.

Radio Telemetry

We radio-tagged 6 adult Pacific pond turtles captured within the Wohler Pool on 2 and 3 July 2003. These turtles were captured by hand and with 1-m-diameter commercial hoop traps with nylon mesh and a single funnel mouth. We set 4 traps near the inflatable dam and 5 in the upper Wohler Pool and baited them with canned sardines and fresh beef liver. We epoxied radio transmitters (9.2 mm diameter, 20 mm length, 2.0 g, 30 cm antenna length, 149 MHz, estimated life 4 weeks) to the middle of the carapace of each turtle, and released turtles at their capture locations. The whip antenna was allowed to trail behind the turtle.

We conducted mobile tracking surveys for tagged turtles 1 to 3 times per week with a scanning receiver and H-antenna. We used a 2-person kayak to track turtles so one person could paddle while the other operated the telemetry equipment. Mobile tracking consisted of paddling the kayak to where the transmitter signal strength was maximized for a tagged turtle. When the scanner receiver indicated that a tagged turtles was beneath the kayak we determined the coordinates with a GPS receiver. We supplemented kayak tracking surveys with vehicle tracking surveys on nearby roads when a turtle could not be found in the river.

We used Maptech® Terrain Navigator topographic program to assist in analyzing spatial data from GPS coordinates. Basking site coordinates were plotted on topographic maps to analyze their distribution and to determine distances from the inflatable dam. Movement distances of radio-tagged turtle are linear distances taken along the centerline of the river based on GPS-determined loci.

RESULTS

Distribution and Movement Patterns

The number of turtle observations ranged from 0 - 11 / km in the study area with no apparent pattern in relation to Healdsburg Dam, Dry Creek confluence, and the Wohler Pool (Fig. 1). The 1-km segment above the inflatable dam was the only section with no observed turtles during visual surveys (although we trapped 1 Pacific pond turtle in this segment, as discussed below). The closest basking turtle observation above the inflatable dam was approximately 1.9 km upstream.

The 6 radio-tagged turtles varied in their movement patterns, but all remained within the Wohler Pool (Table 1). Three turtles (R1221, R1320, and R2220) were captured and remained in the upper Wohler Pool > 3.2 km upstream of the dam, where the influence of the inflatable dam is limited. Turtles R1820 and R1220 were located in and/or near the upper Wohler Pool, while R2020 was always located downstream of the upper Wohler Pool area. The average maximum river distance moved by turtles was 667 m. A gravid female turtle (R1221) radio tagged on 3 July 2003 had the shortest movement distance of 100 m. We recaptured her on 7 August 2003 and she was no longer gravid. We did not detect any terrestrial movements and she apparently deposited her eggs and returned to the river between our tracking surveys. Turtle R2020 had the longest movement at 2,309 m. She was

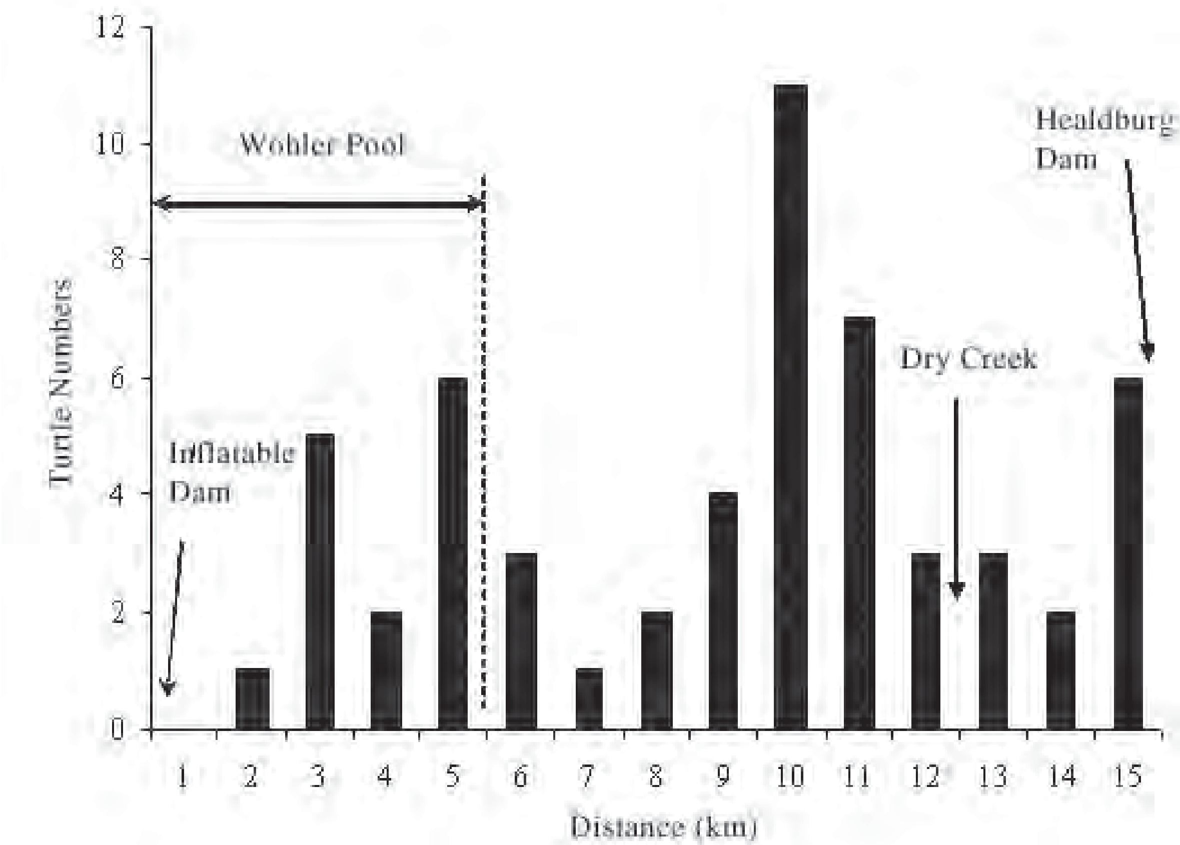

Figure 1. Distribution of observations of basking Pacific pond turtles along a 14.8-km section of the Russian River, Sonoma County, California. Distances begin at the inflatable dam (0 km) located at the downstream end of the study area and extend upstream to the Healdsburg Dam.

captured in a hoop trap 151 m upstream of the inflatable dam on 3 July 2003 at 1600 hrs. On the following morning at 1100 hrs, she had moved upstream 762 m. Four days later she moved an additional 1,241 m upstream and 306 m 8 days later. She then stayed within 113 m of this site at least until 28 July 2003. Turtle R1220 was tracked until 14 July when the transmitter apparently malfunctioned.

Size and Age Structure

We captured 52 Pacific pond turtles in the study area and found a wide range of body sizes (Fig. 2). Carapace lengths ranged from 68 - 198 mm (Fig. 2). The average CL of juveniles was 95.3 mm ± 16.5 (n = 14) of adults was 169.4 mm ± 14.3 (n = 38). Mean male CL was 172.6 mm ± 17.5 (n = 22), and mean female CL was 165.4 mm ± 6.2 (n = 17). The CL of turtles was correlated with our age estimates ($R^2 = 0.8806$, n = 31). We were able to estimate the age of one turtle as being 11 yrs old based on 11 visible growth rings, but our limit for detecting individual growth rings was usually 9 or 10 rings. All ages up to 11 yrs were found in our study area, except for hatchlings (0 yrs) and 2-yr old turtles (Fig. 3). The age-class composition in our study area was 26.9% juveniles, 30.8% young adults, and 42.3% mature adults. The male to female sex ratio was 1:0.77, which was not significantly different than 1:1 ($\chi^2 = 1.64$, df = 1, $p < 0.10$, n = 39).

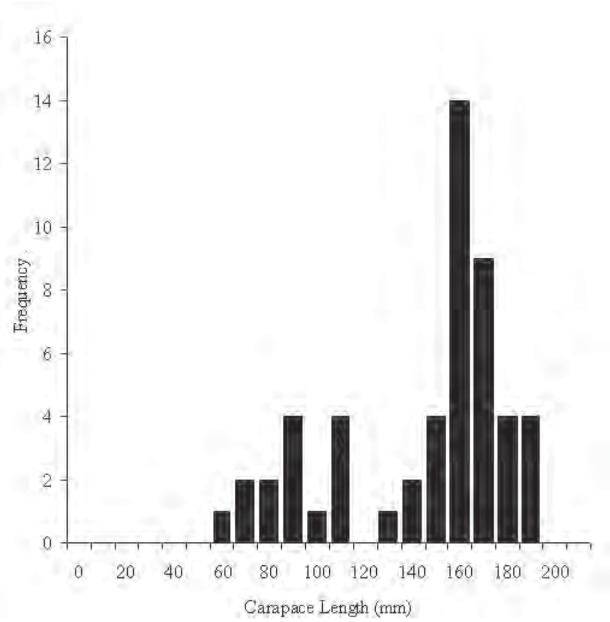

Figure 2. Carapace lengths of Pacific pond turtles (n = 52) captured along a 14.8-km section of the Russian River, Sonoma County, California.

Habitat Use

We measured habitat variables at 108 basking sites of Pacific pond turtles. Downed tree trunks constituted 96.3% of the basking sites. Other basking sites included 1.9% exposed rocks, 0.9% metal debris, and 0.9% flotsam material. Trunk basking sites were usually associated with the riparian forest located along the margins of the river. Basking sites were located close to shore ($\bar{x}$ = 2.81 m ± 1.45, range 0.6 m to 9.1 m) where downed riparian trees were most prevalent.

Pacific pond turtles used a variety of basking trunk types but their use was highest with the more recently formed basking sites and decreased with the deteriorating condition of trunks (Fig. 4A). We did not quantify availability of basking types, but we did not observe turtles crowded on any particular basking type, suggesting that preferred basking types were not a limited resource. Living downed tree trunks constituted 34.6% of the observed basking sites, while decomposed snags were used less frequently at 3.8% (Fig. 4A). Recently created basking sites are formed by winter flooding that scours the roots of riparian trees and topple into the river. Living downed tree trunks had numerous twigs and small branches that may hinder turtles when they to try to haul

Table 1. Characteristics and movement distances of 6 Pacific pond turtles with radio transmitters tracked in summer 2003 at Wohler Pool of the Russian River, Sonoma County, California.

Turtle No.	CL (mm)	Sex	Age	Maximum Movement (m)	Distance from Inflatable Dam (km)
R1220	159	M	6	462	3.01-3.47
R1221	159	F	10+	100	3.35-3.45
R1320	162	M	10+	794	3.29-4.08
R1820	143	M	10+	108	3.01-3.12
R2020	166	F	6	2309	0.15-2.46
R2220	160	F	5	227	3.67-3.89

out. The average diameter of basking trunks was 20.7 cm (range 3 cm to 70 cm; Fig. 4B).

Cover appeared to be an important feature in the use of basking sites. Canopy cover above basking sites varied from open to completely closed canopy, and 64% of all basking sites had >20% canopy cover (Fig. 4C). The mean depth of water used by turtles was 1.45 m (Fig. 4D). We did not quantify submergent cover (i.e., wood debris, exposed roots, undercut banks, etc) beneath basking sites, but an abundance of submerged cover was observed during our dive surveys at all basking sites.

DISCUSSION

Pacific pond turtles commonly used living downed tree trunks of moderate size, averaging 20.7 cm, for basking. Reese and Welsh (1998) found a similar association with intermediate successional forest and indicated that deep water with low velocities and the presence of exposed basking and underwater refugia are important habitat features. Riparian trees within the winter flood-prone areas are necessary for scour-pool formation and to provide slow or slack-water habitat. Downed riparian trees provide basking sites, as well as submergent cover for turtles.

Conventional wisdom suggests that aerial basking maximizes solar exposure, which is important in thermoregulation. The use of living downed trees with an abundance of small branches and shade for basking is counter to this concept. A benefit to these apparent restrictions to aerial basking is protection from terrestrial predators. Also, the use of basking sites with as high as 100% canopy cover suggests that aerial basking may be for ambient air temperatures and not necessarily direct solar basking.

The number of Pacific pond turtles in the study area is likely a fraction of the historic number present prior to intense development in the area (e.g., paved roads, levee construction, vineyards, gravel mining, etc.). However, the size and age structure of the population indicates a fairly even structure with some recruitment, not the adult-biased structure thought to be a sign of decline in other areas of the state (Jennings and Hayes 1994). Also, turtles in our study grew to sizes that approached the 210 mm CL maximum size reported for the species (Jennings and Hayes 1994). Pacific pond turtles are a long-lived species and a large proportion of a sustaining population are expected to be adults (Germano and Bury 2001). We did not find any hatchlings or many young turtles. However, very young turtles spend much of their time in shallow water with dense cover (Jennings and Hayes 1994). Consequently, ages 0, 1, 2, and possibly 3 year old turtles were probably underrepresented by our visual surveys, which were used to detect turtles for capture. Turtles were distributed fairly evenly among age classes including 26.9%

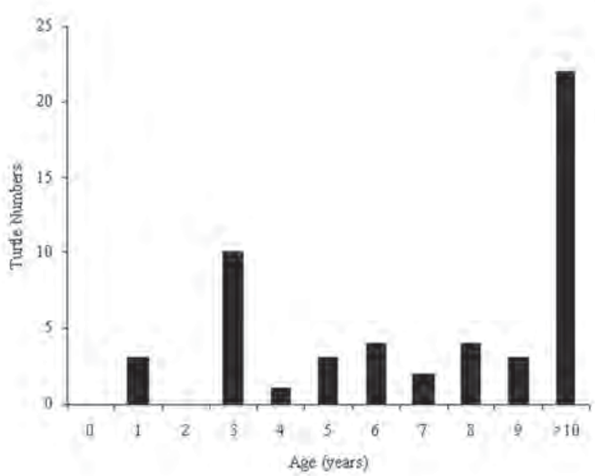

Figure 3. Age structure of Pacific pond turtles ($n = 52$) captured along a 14.8-km section of the Russian River, Sonoma County, California. Age was based on the number of annual growth rings.

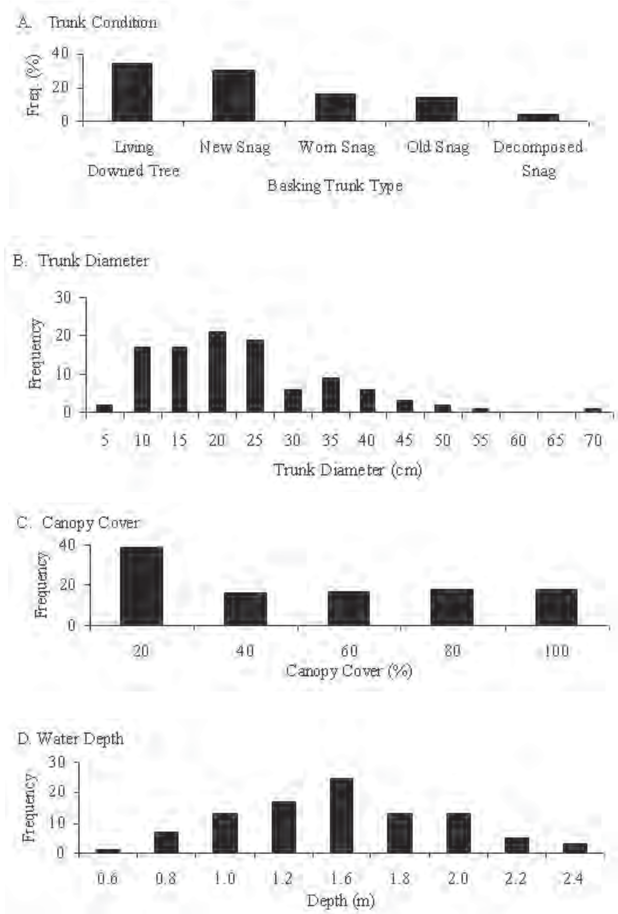

Figure 4. Habitat characteristics of observed basking sites ($n = 104$) of Pacific pond turtles along the Russian River, Sonoma County, California.

juveniles, which is similar to a known stable population with 35.2% juveniles (Bury 1979; Reese and Welsh 1998b). This suggests that although turtle numbers in the study area may be lower than historic levels, the population is currently stable. Also, based on our observation of juvenile recruitment, it is possible that the population in the study area is increasing.

Pacific pond turtles were summer residents and occurred throughout the seasonal Wohler Pool. All of our radio-tagged turtles remained in the Wohler Pool during the study and most remained in or near the upper Wohler Pool. Movement patterns of radio-tagged turtles ranged from near sedentary to long-distance movements within a few days, which are similar to reports from other populations (Rathbun et al. 1992; Holland 1994; Reese 1996; Goodman and Stewart 2000).

Important factors in the persistence of turtles in the Wohler Pool are probably the temporary nature of the impoundment and the gradual effects of the reservoir. This is consistent with the relatively high abundance of turtles in the upper Wohler Pool and the gradual decrease closer to the dam where the effects of the impoundment (i.e., relatively deep and slow-moving water, flooded bank vegetation, etc.) are the greatest.

The relatively few observations of Pacific pond turtles in the lower Wohler Pool may have been biased by the sampling techniques we used (Ream and Ream 1966). Germano and Bury (2001) found that visual surveys underestimated Pacific pond turtle numbers somewhat and that trapping surveys were more effective at detecting turtles. In the lower Wohler Pool, we observed no basking turtles. Trapping surveys captured a single turtle (R2020) near the dam, indicating that turtles do occur in the lower Wohler Pool, although this turtle spent most of the time in the central Wohler Pool area. These data suggest that the lower Wohler Pool, where the influences from the dam are greatest, is used by Pacific pond turtles but at relatively low frequencies compared to other areas. We did not quantify basking habitat available to Pacific pond turtles, but we did observe a variety of potential basking locations within the Wohler Pool that appeared suitable.

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