CHAPTER 2

SYNOPSIS OF BIOLOGY

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OVERVIEW

Here, we summarize the biology and habits of the Western Pond Turtle (*Actinemys marmorata*) to provide a framework for studies of its biological features and a foundation to address sampling issues. It is vital to understand the biology of a species before attempting to conduct field surveys, undertake population studies, or manage populations for long-term viability. Our biological information is from our collective knowledge as well as scientific papers and some unpublished reports. We cite references only for specific statements.

THERMAL ECOLOGY

Turtles are most visible when they are exposed on logs, rocks, or shorelines during periods of aerial basking, one of their primary means to increase body temperature. Western Pond Turtles spend varying proportions of the day basking, depending on a combination of factors that may include ambient air temperature, water temperature, and body size (Bury 1972a; Reese 1996). In the spring-summer activity period, turtles may spend 2 to 4 h a day basking. Turtles may bask out of water less often, if at all, in southern parts of the range or warmer aquatic habitats. Here turtles may engage in aquatic basking (for example, resting in upper thermal layers found in algal mats), where they are not easily observed.

Aerial basking may occur less often in warm areas. In the Central Valley, California, the combination of hot air temperatures in the summer and many shallow-water habitats (for example, marshes, ponds) elevates water temperatures for relatively long periods each year. Turtles can reach suitable body temperatures by floating in the upper water column or sitting in algal mats only partially exposed. Sometimes turtles burrow under algal mats in shallows, where water temperatures are relatively high and there is an abundance of food (algae and many invertebrates). With binoculars, one can sometimes detect emergent nose tips or tops of shells in floating vegetation or open water.

In the Central Valley of California, Germano and Bury (2001) noted low frequency of observed turtles at several sites where they trapped high numbers of turtles. In one slough, they observed few turtles but trapped many in

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algal mats on the banks of a slow creek where the water surface temperature was high (maximum about 34°C at surface). Visual searches would probably yield more observations if conducted in the spring when air and water temperatures are much lower than in summer. Under cooler conditions, turtles may be forced to aerially bask to increase body temperature to required levels for the proper functioning of physiological processes. In a coastal California stream, Rathbun and others (2002) found some turtles with radio transmitters that buried themselves into warm sand and remained for hours.

In many areas, though, basking sites are important for Western Pond Turtles. Wood perches on the Trinity River in northern California were used disproportionately by turtles relative to their availability (Reese and Welsh 1998a). Reese (1996) found basking site characteristics were similar between juveniles and adults with respect to water depth and perch diameter, but differed in flow characteristics, with juveniles using basking sites in lower flow areas more than adults.

Social Behavior

Courtship and mating takes place underwater but has been observed only a few times (Holland 1988; Ashton 2007; Bettelheim 2009). The male moves in front of the female. Then the male scrapes with his toes at the anterior marginal shields of the female carapace usually in sets of 3, alternating between limbs and pausing briefly between bouts. He also waves his forelimbs side to side in front of the female. The female may turn away, with the male in pursuit. Sometimes the female raises her posterior end up off the substrate, a signal for mating. Holland (1988) observed copulation of turtles in the field in mid-June in southern California and in captive specimens in late August and early September. In northern California, courtship has been observed in spring and fall (Reese 1996; Ashton 2007).

Western Pond Turtles may be aggressive toward one another, especially when crowded on basking sites (Plate 3). Although rare in nature, turtles will bite each other, presumably to displace another turtle in its space or in competition for basking sites (Bury and Wolfheim 1973). More often, turtles present an open-mouth gesture that signals an aggressive stance. Turtles may yawn on occasion, but this behavior is not directed at other turtles. When a turtle directs the gesture (wide-open mouth) at another turtle, the recipient usually moves or turns away. Animals will also jostle each other on basking sites and sometimes push one another off into the water.

Daily and Seasonal Activities

Although considered primarily an aquatic turtle (Nussbaum and others 1983), the Western Pond Turtle may spend half the year or more on land in some environments. Overland journeys among multiple bodies of water, often round-trips, have been recorded (Reese 1996; Reese and Welsh 1997). Access to mates, food resources, basking sites, cover, or predator avoidance may prompt this behavior (Reese 1996), although additional studies are needed.

Seasonal cycles of activity are often influenced by reproductive behavior. For example, female turtles may spend a portion of their time nesting in terrestrial habitats in May through July (Reese 1996; Reese and Welsh 1997; Rathbun and others 2002). Aquatic sampling in these months may miss some females, so sampling should also include August and September if the goal is to sample most adult females. Pond turtles may be active all year in the southern part of their range, but are inactive where winters are cool or cold. Even in the northern part of their range, however, they may occasionally engage in emergent basking during sunny winter days.

Overwintering

Most Western Pond Turtles overwinter buried in substrates on land or underwater from beginning in September or October and ending between March and May (Reese 1996; Rathbun and others 2002). Adult pond turtles in Washington overwinter about equally on land and in the water, with the proportion of turtles in each habitat varying somewhat from year to year (F Slavens, pers. comm.). Adult turtles in central California moved out of a stream in fall and spent the winter (mean of 111 d) on land, whereas turtles living in a nearby human-created pond remained in the pond all winter (Rathbun and others 2002). In flowing waters (streams, rivers) and flood-control reservoirs, turtles move up to 500 m or more into upland habitats where they burrow into duff and soils and remain over the winter (Reese 1996; Goodman 1997a; Reese and Welsh 1997). Turtles may move out of stream channels to reduce mortality caused by winter/spring high flows (Rathbun and others 2002; H Welsh, pers. obs.), but this relationship is poorly documented.

In Oregon, turtles living on the floor of the southern Willamette Valley departed flood-control reservoirs as early as 23 August and as late as 20 November (K Beal, pers. obs.). Further, the average date of emergence from the aquatic habitat to occupy a terrestrial overwintering site was 15 October for 12 turtles tracked with radio transmitters. In southern Washington, turtles tracked with radio transmitters moved to overwintering sites as early as August and as late as December, then reappeared at ponds from February to April (F Slavens and K Slavens, pers. obs.).

Along the Trinity River in northern California, turtles dug into hillsides above the high-water mark for overwintering sites (Reese 1996). Habitat at overwintering sites includes conifer, hardwood, and mixed conifer-hardwood forest, with canopy closure generally greater than 50%. Turtles mostly dug into duff under shrubs in Oak (*Quercus* sp.) stands and avoided Pine (*Pinus* sp.) stands. Slopes of overwintering sites along the Trinity River varied from 0 to 30%, with no apparent preference for a particular aspect (Reese 1996). Turtles moved from the river to terrestrial sites from 17 August to 25 December, but mostly in September and October (Reese 1996; Reese and Welsh 1997). They began moving back to aquatic habitat (usually side pools next to the river) in February and March. This may allow them to take advantage of warmer, more productive waters, while cold, high-flow conditions still exist in the mainstem of the river. They returned to the main river from 15 April through 17 June (Reese 1996).

In the upper Mad River in northern California, Bondi (2009) found turtles moving to overwintering sites at different times related to the hydrologic characteristics of the river section. Turtles living in an upstream stretch that had intermittent flow and dry stretches in late summer left the sometimes widely separated pools in early August. Those in a downstream stretch with permanent water did not move to land until early October. Turtles using the upper intermittent reach migrated back to the river earlier than those at the lower permanent reach. Bondi (2009) also found that turtles inhabiting the intermittent portion of the river had significantly smaller body size than those residing in the perennial reach. Thus, the amount of time spent on land versus in water appeared to differentially influence important physiological processes in the 2 populations.

In the Willamette Valley, Oregon, turtles selected overwintering sites that had predominately southern aspects and slopes between 10 and 35 degrees (K Beal, unpubl. data). Near Lookout Point Reservoir in Lane County, Oregon, turtles selected sites with cover of low shrubs including Salal (*Gaultheria shallon*) and Oregon Grape (*Berberis nervosa*). They appeared to prefer duff layers 2.5 to 12.5 cm deep or surface debris, and sites typically lacked tree cover. Turtles often traveled for several days on land over steep and rocky slopes to reach overwintering sites (K Beal, unpubl. data).

Turtles tracked with radiotelemetry showed that individuals often return to the same terrestrial overwintering site each fall (Reese 1996; Goodman 1997a; Bondi 2009). In northern California, Reese (1996) determined an average distance of 167 m for overwintering sites from the Trinity River, whereas Bondi (2009) found that turtles had average distance from water of 101 to 119 m over 2 y along the nearby Mad River. During terrestrial overwintering, turtles may emerge to bask on sunny days and may even move to new overwintering sites (Holland and Goodman 1996; Reese 1996).

HOME RANGE

Most turtles remain in a relatively small home area (Bury 1979). In a northern California stream, male turtles had linear movements (mean = 367 m) that were twice those of females (149 m) and juveniles (145 m; Bury 1972a, 1979). Some adult turtles, however, moved over 1 km over a 3-y period and one marked individual covered a distance of 1.5 km in a 2-wk period. Reese (1996) found that during the summer months, juveniles in the Trinity River had a mean aquatic home range length covering 84 m of river channel. Their home ranges were smaller than those of adults but similarly included terrestrial components. Juvenile turtles may exhibit considerable mobility.

Reese (1996) reported that juveniles sometimes travel back and forth between low-flow portions of the river and adjacent ponds. These journeys may be motivated by thermal preferences, distribution of food resources, swimming abilities, or predator avoidance (Congdon and others 1992). Bondi (2009) found that males had larger home range sizes and greater average length of aquatic movements than did females at 2 sites (permanent and intermittent flow) of the Mad River in northern California.

Sporadic, long-distance movements may constitute dispersal and mate searching by males (Reese 1996), and if they span long distances may facilitate genetic dispersal. Goodman and Stewart (2000) found that total aquatic home range area of female turtles in 2 southern California streams lacked differences (1342 ± 1235 m^2 and 3059 ± 2249 m^2, respectively). There were differences, however, for linear movements (1273 ± 1138 m and 335 ± 276 m, respectively) perhaps because one stream was much wider (mean = 9.5 m compared to 1.0 m).

DIET

Western Pond Turtles are dietary generalists, locating food by sight or smell (Evenden 1948; Bury 1986). The majority of their diet consists of small aquatic invertebrates, while carrion and small vertebrates (fish, frogs, tadpoles) are occasionally eaten but appear to be a minor component (Bury 1986). Food items include aquatic insect larvae, crustaceans (cladocerans and crayfish), and annelids. Plant material is consumed in variable amounts and includes Pond Lily (*Nuphar polysepalum*) inflorescences, Willow (*Salix* sp.) and Alder (*Alnus* sp.) catkins, Ditch Grass (*Ruppia* sp.) inflorescences, and green filamentous algae. Juvenile turtles are principally insectivorous, whereas adults may consume more plant material (Bury 1986).

Small vertebrates, including tadpoles and egg masses of Foothill Yellow-legged Frogs (*Rana boylii*), have been found in the stomachs of Western Pond Turtles, but it is unclear whether these were ingested as prey or carrion (Holland 1985; Bury 1986). A variety of small animals occurs in filamentous algae and may supplement the diet when algae are consumed by turtles (Bury 1986). Pond turtles may also feed on *Daphnia* sp. and other small invertebrates in the water column using neustophagia, which is a modified form of gape-and-suck feeding allowing turtles to siphon food from the water surface (Belkin and Gans 1968; Holland 1994).

HABITAT ASSOCIATIONS

Western Pond Turtles are habitat generalists and can be found in a variety of waters from sea level up to 1370 m (4500 ft), and even up to 2000 m (6600 ft) in the southern part of their range. However, they seldom occur in large numbers over 1500 m (4900 ft). Turtles occur in rivers, streams, lakes, ponds, reservoirs, stock ponds, settling ponds of wastewater treatment plants, and permanent and ephemeral wetland habitats (Plates 4–6). In general, aquatic habitats for this species are relatively rare across much of the western landscape. For example, a pond or stream may have turtles present but then there can be 5 to 25 km (or more) of open, dry terrain before another waterway is present. There are some large marsh areas (for example, Klamath Lake basin, Oregon and California border), but many other shallow lakes and marshes have been converted to agricultural fields (for example, San Joaquin Valley, California). Standing water is often limited across the range of the turtle (for example, only 1–5% of the land surface area is water).

Turtle populations appear to occur in a disjunct distribution pattern. Germano and Bury (2001) found presence (that is, at least 1 turtle observed or caught) at 10 of 28 (35.7%) sites in the San Joaquin Valley, California, and only 5 of 20 sites (25%) in the Sacramento Valley, California. They observed turtles at 37.0% of the pond and lake sites, 14.3% of the canal/slough/stream habitats, 33.3% of the river sites, and 50.0% of the marsh habitats in the Central Valley. However, their surveys suggested that visual searches may not have been a reliable predictor of turtle presence or population size in Central Valley habitats. Turtles in this region apparently do not bask out of water regularly (DJ Germano, pers. obs.). The most ever observed were 20 turtles basking at 1 large water body, yet more than 700 have been trapped and marked in 12 y at this same site. It appears that pond turtles in the San Joaquin Valley bask less as water temperatures increase. Additionally, fewer than a dozen Western Pond Turtles are ever seen basking at a 1.3-ha pond at high elevation near the town of Gorman, California, but more than 250 turtles have been marked there (DJ Germano, pers. obs.). Thus, reliable determination of presence of these turtles, especially in the southern portion of the range, should employ both visual searches and trapping or snorkeling surveys.

Use of thermal regimes may differ among size classes. There were thermal differences in aquatic microhabitats used by turtles in the Trinity River, California. Juveniles were found in areas with water temperatures of 12 to 33°C and adults used areas with temperatures from 10 to 17°C (Reese 1996). Hatchling turtles are relatively poor swimmers and seek areas with slow, shallow, warmer water with emergent aquatic vegetation (Holland 1994; Reese 1996).

Reese and Welsh (1998a) examined differences in habitat use between a dammed and a natural fork of the Trinity River in northern California. The dammed fork had more sedimentation, lower water temperatures, increased canopy cover, and higher water velocities compared with the natural fork, all of which are potentially relevant to pond turtles. While turtles selected for deep water, low velocities, and the presence of underwater refugia on both forks, on the dammed tributary they were more associated with basking structures, which may be especially important due to the lower water temperatures. On the natural tributary, pond turtles tended to be in slower-flowing portions of the river with warmer water (Reese and Welsh 1998a).

Aggregations in Aquatic Habitats

Pond turtles tend to aggregate where favorable conditions exist: quiet waters with cover and basking sites. For example, a suitable site along a small river or stream is a deep pool (for example, 1–2 m deep) with boulders, fallen trees, or brush piles. Intervening riffles and shallows are likely used only for movement between pools or foraging opportunities. Turtles also congregate in waters with dense thickets along the shore or where there are undercut banks. Some turtles occur in marshes or ponds with surrounding open terrain. Most abundant populations occur in areas lacking dense human population or development (Bury and Germano 2008), although small populations do occur in urban settings.

Western Pond Turtles often show a clumped distribution within flowing water. Along 3.5 km of stream in northern California, Bury (1972a) found most turtles in 37 pools and few in connecting, long shallow riffles (Fig. 2). Moreover, about a third (36%) of all captures were consistently made in just 5 pools (13.8% of the number of pools) and most turtles (59%) were in just 10 pools (27.0% of the pools). Several pools (n = 8) had a low catch with means of 0 to 2 turtles present on repeated visits. These were usually shallow (<1 m) with few or no basking sites. The distributions of turtles were significantly correlated to size of pools (more turtles in larger, deeper pools) with abundant cover such as logs or boulders (used for basking and underwater retreats). This pattern was for subadult and adult turtles because few turtles less than 3 y old were found in this stream. Reese (1996) also found clumped distributions on the 2 forks she studied on the Trinity River in northern California.

In the Umpqua River basin of southern Oregon, basking turtles were concentrated in relatively few pools (Fig. 3). The pools with large numbers usually had haul-out sites such as logs or boulders. Sites were revisited 3 times. There were 111 turtles observed at 4 sites (94.9%), whereas 4 other sites had only 1 turtle each and 1 site had 2 turtles. Those 9 pools represented 30% of the sites visited; no turtles were seen in the remaining pools.

Population Densities

Densities vary between aquatic systems based on factors such as amount of suitable habitat, hydroperiod, and level of disturbance. For example, Bury (1972a) estimated a density of approximately 250 Western Pond Turtles per hectare in a tributary of the Trinity River, California. This site was searched for 3 summers, yet some animals may have moved in and out of the defined study area. Reese and Welsh (1998b) determined population densities of 19 turtles per hectare on 2 reaches of the mainstem Trinity River, and 13 turtles per hectare on 3 comparable reaches of the South Fork Trinity River. These are relatively wide rivers (for example, more than 15 m wide in many places). In southern Oregon, 114 turtles were observed in a 0.5-ha pond (S Wray, pers. obs.). Pond turtles may congregate in a few remaining portions of streams or ponds as waters dry up in late summer and early fall. If

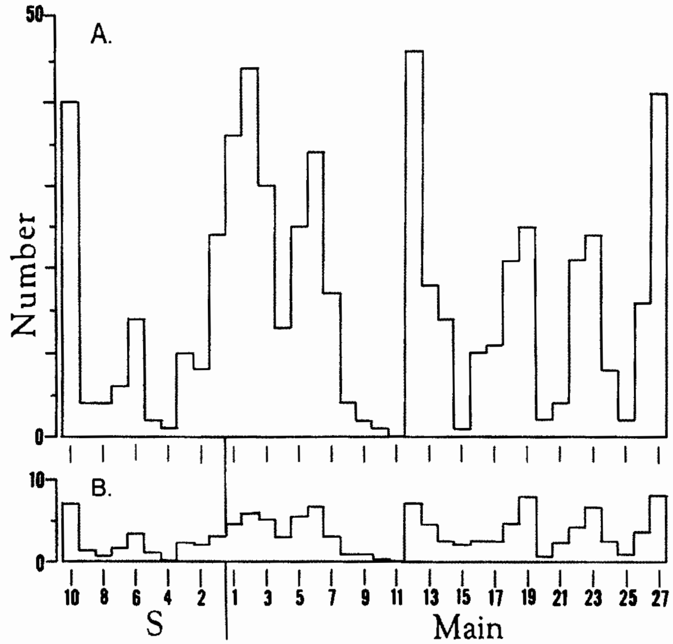

FIGURE 2. Turtle distribution in 37 pools spaced along 3.5 km of a tributary stream of the Trinity River, Trinity County, California, 1969 to 1971. Top: Total catch by pool and only for 1st capture. Bottom: Mean number of turtles captured at each pool (number of visits varied slightly), includes new and marked turtles. From Bury (1972a).

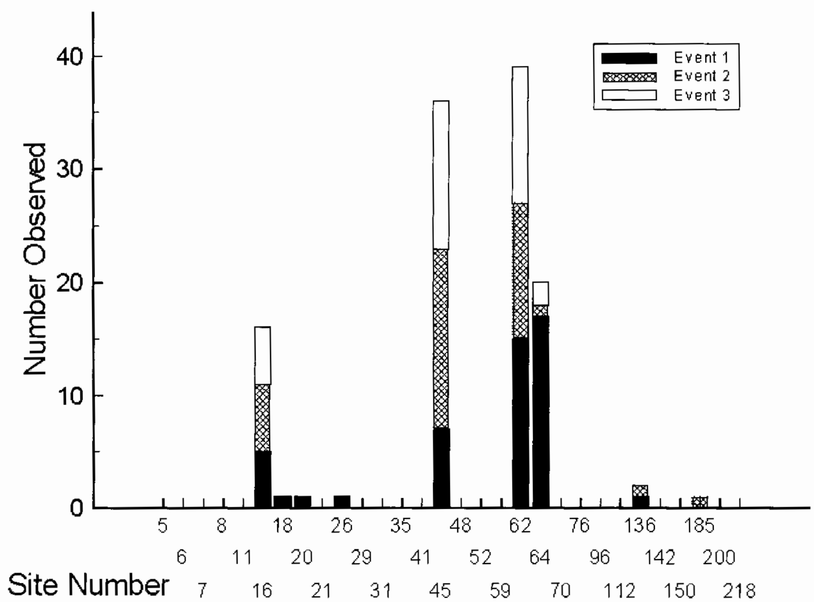

FIGURE 3. Number of all turtle observations during 45-min periods at 30 pools in the Umpqua River basin, Oregon, 12 June to 31 July 1997 (RB Bury and R Sisk, unpubl. data). Each site was visited 3 times.

sampled at these times, a high density is found but represents only a snapshot of the turtle's activities. Turtles could forage and live in temporary waters and then move to permanent water holes or streams with increased drying of the landscape. Conversely, turtles may move to sites on land (D Pilliod, pers. obs.). The type of survey, time of year, and experience of surveyors can bias estimates of density. All of these factors need to be taken into account when comparing densities of turtles between systems.

REPRODUCTION AND SEX RATIOS

Age at sexual maturity of Western Pond Turtles is poorly known. The youngest females to carry eggs were 4 y of age in coastal central California (Germano and Rathbun 2008), an average of 4.4 y at a site in the southern San Joaquin Valley (DJ Germano, unpubl. data), and 4.4 and 5.4 y of age at settling ponds of 2 sewage treatment facilities in the San Joaquin Valley of California (Germano 2010). Most females found with eggs are older than 6 y of age.

Sexual maturity is usually estimated based on size. Females appear to start carrying eggs at 130- to 135-mm carapace length (CL) (Holland 1994; Germano and Rathbun 2008; Germano 2010; DJ Germano, unpubl. data). We do not know when males become sexually mature, but external signs of sexual dimorphism appear at 110- to 120-mm CL (Plate 7, Plate 8). Age at maturity influences adult sex ratio (Gibbons 1990a; Lovich and Gibbons 1991). Sex ratios in most populations of Western Pond Turtles appear to be equal, but there can be local variation (Bury and Germano 2008). We advise caution when interpreting data with deviations from a sex ratio of 1 male: 1 female unless sample sizes are large (for example, more than 300 individuals; see Bury 1979).

Females usually deposit eggs from May through July with the more northern populations depositing eggs later in the season than those in the south. In southern Washington State, nesting occurs as early as 27 May and as late as 15 July (F Slavens, pers. obs.). In a nesting area searched daily at Fern Ridge Reservoir in the southern Willamette Valley, Oregon, turtles began nesting between 2 June and 15 June every year from 1993 to 2000 and the duration of the nesting period ranged from 32 to 42 d (K Beal, unpubl. data). In the Trinity River of northern California, nesting occurs in June and July (Reese 1996).

When nesting, gravid female turtles generally leave the water in the evening and move into upland habitats to excavate a nest. Females may be out of the water for a few hours to several days. In the Willamette Valley, Oregon, radio tracking of female turtles and daily search of nesting areas in late spring suggested annual nesting by females and repeated use of the same nesting area by some individuals (K Beal, pers. obs.). One female was found to nest in the same area for 5 consecutive years, 1993 to 1997. Most nest sites were 5 to 80 m from the edge of water bodies, whereas some were 100 to 150 m and a few about 500 m away (Storer 1930; Holland 1994; Holte 1998).

Nests are typically excavated in compact, dry soil with high clay or silt fractions, in areas with short grasses or forbs that allow exposure to direct sunlight (Rathbun and others 1992, 2002). Nests have been found on constructed dike slopes, road-cuts, and roadsides (K Beal, pers. obs.). Aspect is usually south or west facing and on a slope of 25 degrees or less. Nesting areas may have many false scrapes.

Female turtles may void their bladders to soften the soil and then excavate a flask-shaped nest chamber with their hind limbs. Once eggs are deposited, females pack moist soil and surrounding vegetation into a dirt plug that closes the neck of the nest chamber (Bettelheim and others 2006). This plug dries into a hard seal within a few days.

Eggs are off-white in color, elliptical-oval in shape, and range from 32- to 42-mm long and from 18- to 25-mm diameter. Mass of eggs ranges from 7 to 11 g. The egg shell is hard with a "bone-china" texture. The time from ovulation of eggs to deposition in a nest is unknown. Incubation time is 73 to 132 d under artificial conditions (Lardie 1975; Feldman 1982) and 94 to 122+ d in the wild (Holland 1994; Goodman 1997a). Hatchlings appear to overwinter in the nest in northern California (Reese and Welsh 1997) and western Oregon (K Beal, unpubl. data). In southern and central California, some hatchlings may emerge from the nest chamber in the fall, whereas others overwinter in the nest chamber and emerge in spring (Holland 1994). Hill (2006) reported finding 20 hatchlings (excluding recaptures) in the San Joaquin Valley, California, with most in April (65%), some in May (20%), and fewer in June (15%). It

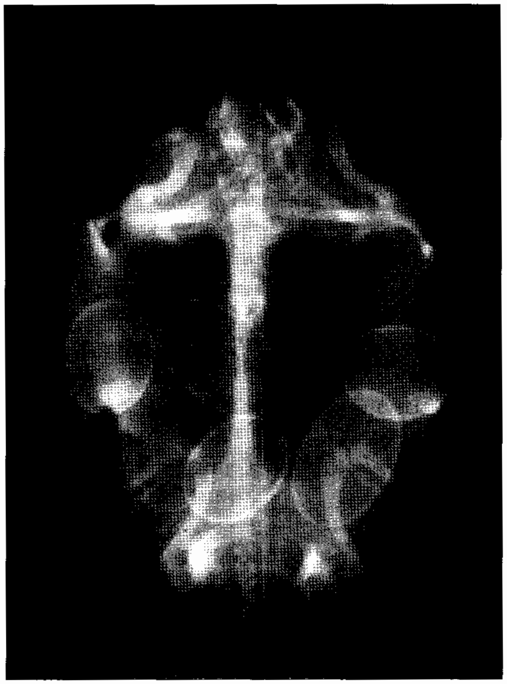

FIGURE 4. Radiograph of adult female Western Pond Turtle showing shelled eggs. Photograph by David J Germano.

was not clear if these were from eggs deposited in the prior or current year. The pattern of overwintering of eggs and hatchlings is widespread in freshwater turtles (Gibbons and Nelson 1978; Ultsch 2006) but needs further study to elucidate possible differences across the range of the Western Pond Turtle.

Most counts of clutch sizes in Western Pond Turtles are from radiographs of gravid females (Fig. 4). Mean clutch size varies from 4.5 to 8.5 eggs (range 1–13): Feldman (1982); Rathbun and others (1992); Goodman (1997a); Pires (2001); Lovich and Meyer (2002); Germano and Rathbun (2008); Scott and others (2008); Germano (2010); DJ Germano, unpubl. data. Larger females have more eggs per clutch.

The number of annual clutches a Western Pond Turtle has appears to vary geographically. Females in western Oregon may deposit 1 clutch per year (Holte 1998). Females can produce 2 clutches per year in southern California (Goodman 1997b; Goodman and Stewart 2000; DJ Germano, unpubl. data), coastal Central California (Germano and Rathbun 2008; Scott and others 2008), and Oregon's Willamette Valley (K Beal, unpubl. data). A few females had 3 clutches in 1 y in the San Joaquin Valley, California (DJ Germano, unpubl. data). Recently, Scott and others (2008) reported that the estimated range of intervals between the laying of 2 clutches in the same season was 27 to 43 d. They tracked 39 turtles through 66 individual turtle nesting seasons, during which time they deposited an average of 1.3 (SD = 0.7) clutches per year. Individual turtles had no eggs in 10 seasons, a single clutch in 27 seasons, and double clutches in 29 seasons. Clutch frequency did not vary significantly with turtle size. For turtles with 2 clutches in a single year, the average 1st clutch (mean = 6.0, SD = 0.9) had significantly more eggs than their 2nd clutch (mean = 5.3, SD = 1.3).

GROWTH

Ontogeny, environmental conditions, geography, and individual variation all contribute to the variable growth rates seen in this species. Most hatchlings are 25- to 32-mm CL upon emergence from the nest (Plate 9). Growth rates are proportionally greatest in hatchlings, which can almost double in size by the end of the 1st growing season (Bury and Germano 1998; Germano and Rathbun 2008; Germano 2010). Generally, growth rate is high for the first several years, then decreases each successive year, and, depending on the part of the range, growth slows rapidly by the end of the 8th year in the southern part of the range and by the 14th to 16th year in the northern part of the range (Germano and Rathbun 2008; Germano and Bury 2009; Bury and others 2010; Germano 2010). Estimated growth rates for hatchlings from the Trinity River, California, during their first 4 growing seasons ranged from 6.1 mm/mo in the 1st season to 1.3 mm/mo in the 4th season (Reese 1996).

Growth rates vary geographically (Table 2), tempered by local conditions. Turtles in coastal central California take about 4 y to reach 120 mm (Germano and Rathbun 2008) and slightly less than 2 y in the San Joaquin Valley of California to reach 120 mm (Germano 2010), but in northern California and southern Oregon turtles require from 5 to 10 y to reach the same size (Germano and Bury 2009; Bury and others 2010). In general, growth rates of turtles in central California are much faster than those

TABLE 2. Comparison of approximate carapace lengths (in mm) of young turtles at different ages based on Richards growth modeling of carapace lengths.

Age (y)	Central California coast (Germano and Rathbun 2008)	Hayfork, northern California (Bury and others 2010)	Southern San Joaquin Valley (Germano 2010)
0	27	35	26
1	69	46	88
2	96	58	125
3	114	69	146
4	126	80	158
5	136	90	165
6	143	100	169
7	147	108	172

from the mountains of northern California (Fig. 5). Surprisingly, turtles in the Klamath Lake basin of southern Oregon (relatively high elevation of 1200 m) had fast growth rates; this pattern is likely related to abundant food in eutrophic waters in the basin (Bury and others 2010). Growth rates may vary widely within regions, particularly with faster rates occurring in some standing waters compared to flowing conditions (Germano and Bury 2009; Bury and others 2010).

SURVIVORSHIP OF LIFE STAGES

High mortality of many turtles is known to occur in nests, which are subject to predation by a variety of predators (Bury and Germano 2008; Wilcox 2010). Also, hatchlings must crawl from the nesting area to aquatic sites, which can be a challenge for an animal about the size of an American quarter (Plate 9). Nests can also dry out or be invaded by ants (Lovich and Meyer 2002). In areas where hatchlings emerge in the spring, eggs or hatchlings may drown during winter rains or flooding. Although the maximum life span is unknown, some turtles live to be over 55 y old in the wild (Plate 10). This is based on turtles first captured and marked as adults (estimated age of 15+ y) and recaptured 39 to 42 y later (Bury 1972a; RB Bury, unpubl. data). Mature females may nest over several

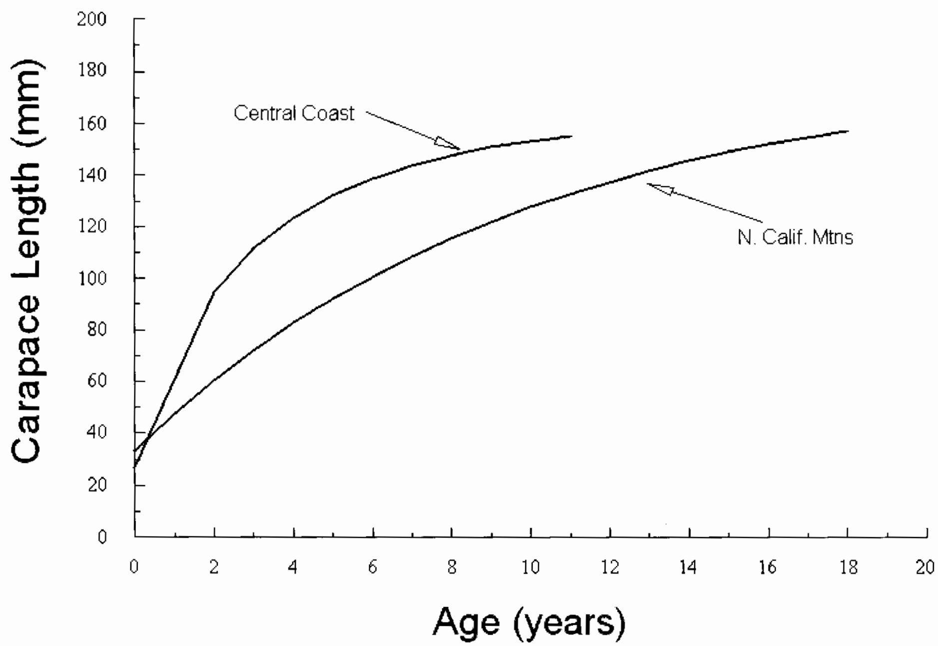

FIGURE 5. Comparison of representative growth rates of Western Pond Turtle populations from northern and southern (central coast) California sites.

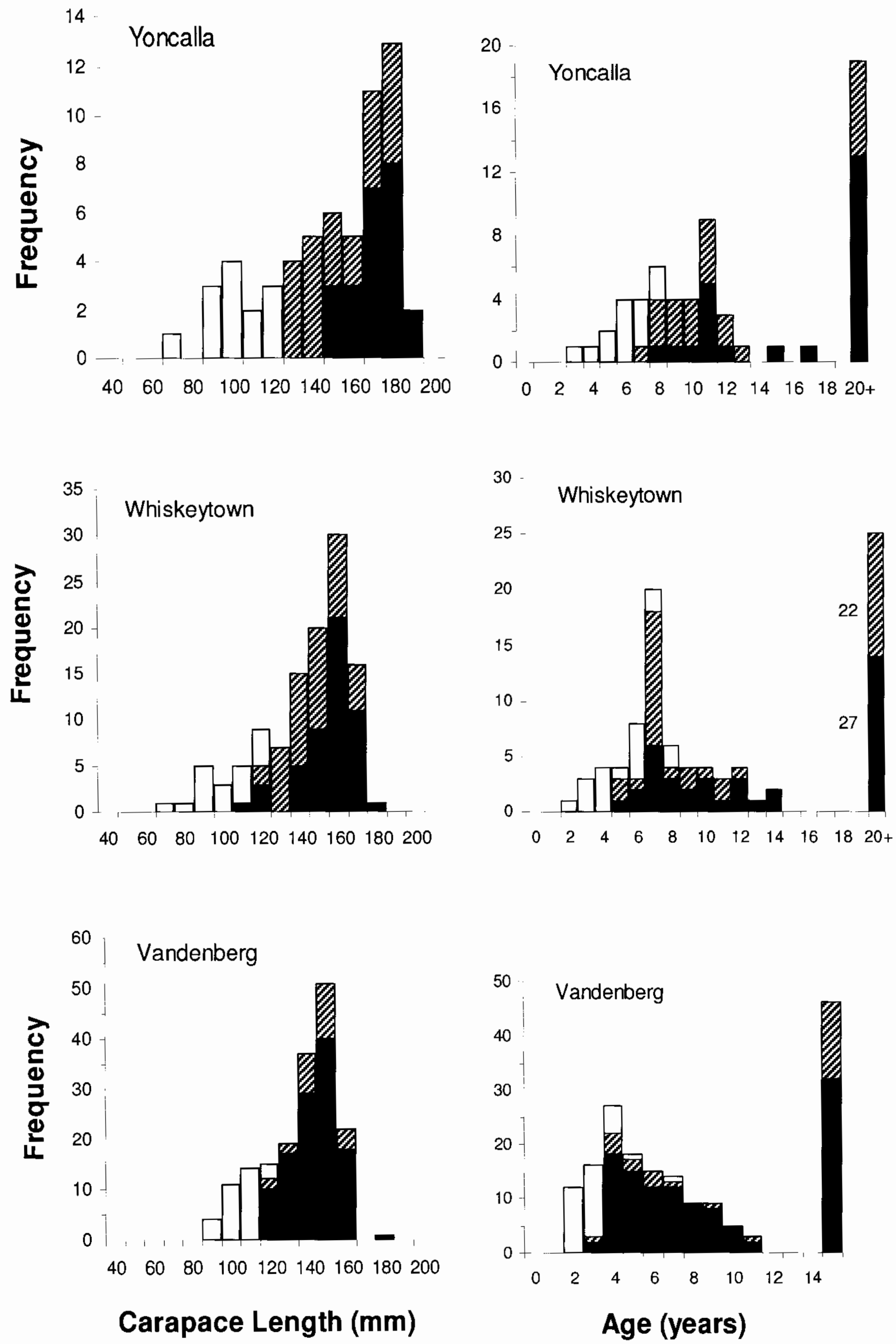

FIGURE 6. Comparisons of size structure (left) to age structure (right) for 3 populations across the range of the Western Pond Turtle: northern (Yoncalla, Oregon), midrange (Whiskeytown, northern California), and southern (Vandenberg, southern California). In each case, the size structure has few small turtles, a situation that is often interpreted as failed reproduction. Those age-structure profiles that show many young turtles are indicative of recent successful reproduction. Open symbols = juveniles; hatched = females; solid = males.

decades, which increases chances for successful nesting events. However, we do not know if females of this species continue to produce eggs over their entire life span.

Currently, there is no estimate of survivorship in this species. Thus, we caution against speculation of population status and trends until such data are reported. Survival is likely low for early age classes (1–3 y of age) because these are small-sized animals that are vulnerable to many predators. However, young turtles are seldom found in populations because they are small, cryptic, and sedentary. Thus, their numbers may be underestimated unless one makes a concerted effort to carefully search shallows, small backwaters, and feeder tributaries where the young tend to occur.

POPULATION STRUCTURE: SIZE AND AGE

The demographic structure of populations is important to understanding the status and conservation needs of turtles (Ricklefs 1990; Charlesworth 1994). Turtle populations often consist of many adults and few young (Dunham and Gibbons 1990; Gibbs and Amato 2000). In most populations large turtles are by far the most often sighted or captured, which often is interpreted to indicate little to no reproduction in populations. For example, concern has been raised for the long-term persistence of the Western Pond Turtle based on analyses of size to define its demographic structure (Reese and Welsh 1998b; Lovich and Meyer 2002; Spinks and others 2003; Lubcke and Wilson 2007). However, size structure does not correspond to age structure in many populations (Germano and Bury 2009; Bury and others 2010; Germano 2010).

It is important to determine the proportion of young turtles based on their actual ages. Even though size structures indicated little recent reproduction, many young turtles have been found across the range of the species (for example, Germano and Bury 2009; Bury and others 2010). Age determination is accurate in Western Pond Turtles up to 10 to 15 y depending on latitude and elevation (Germano and Bury 1998). In most habitats in the southern part of its range, turtles grow relatively quickly and discernable annuli form for up to 8 to 10 y (Germano and Bury 2001; Germano and Rathbun 2008; Germano 2010), whereas in northern latitudes and some high-elevation habitats in the central part of the range, annulus formation can be discerned for 15 to 16 y (Germano and Bury 2009; Bury and others 2010). Ages as determined from scute annuli properly reveal the proportion of young in turtle populations (Fig. 6). Size alone has been shown not to be useful as an indication of population trends or for conservation assessments of turtle populations (Bury and others 2010). The lack of hatchlings and 1- to 2-y-old turtles can just as likely be due to the inability of biologists to capture these secretive individuals as to their actual absence from the population. Thus, at a minimum, a scute annuli–based age structure of a population is needed to best evaluate demographic structure in the Western Pond Turtle.