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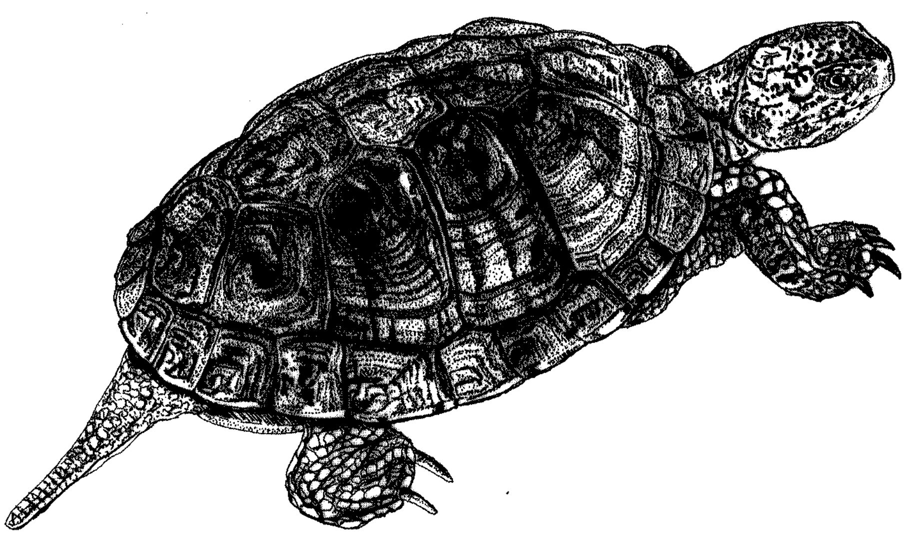


James Buskirk

The Western Pond Turtle, *Emys marmorata*

Abstract

A detailed overview of the Pacific pond turtle *Emys marmorata* is presented. Recently published and unpublished field work revealing hitherto unknown aspects of its natural history including overland and seasonal movements, reproduction, and overwintering strategies are highlighted. The ongoing environmental threats to the survial of this geographically isolated emydid turtle are discussed with special attention to its extraordinary adaptability.

Key words

Emydidae, *Emys marmorata,* geographic distribution, subspecies, sexual dimorphism, habitat, natural history, overwintering, human impacts, predation, reproduction, growth, head-starting, protection.

Far from the European, northwest African, and western Asian habitats of *Emys orbicularis* lives its geographically isolated American cousin, *Emys marmorata* (BAIRD & GIRARD 1852). And like *Emys orbicularis* throughout its range, the Western or Pacific pond turtle is besieged by habitat loss and human-mediated disturbance which have brought about the extinction of some populations, leaving most others threatened (BUSKIRK 1990).

Geographical Distribution

Except on the northern periphery of its range, where *Chrysemys picta bellii* also occurs in the Columbia River gorge and lower Willamette River in Oregon, the pond turtle is the only aquatic chelonian native to the Pacific coast of North America. It occurs from parts of the states of Washington, Oregon and California into northern Baja California, Mexico (ERNST, LOVICH & BARBOUR 1994). The species occurs chiefly west of the Cascade-Sierra Nevada crest; virtually all watersheds inhabited drain into the Pacific Ocean. The exceptions are portions of the mostly dry Mojave River in southeastern California, and at least one much smaller east-flowing desert stream (JENNINGS & HAYES 1994). The latitudinal extremes of its distribution would extend approximately from Bordeaux to Marrakech in the Old World. A handful of specimens from British Columbia, Canada and a single specimen from southern Idaho represent introductions or errors in documentation by museums (HOLLAND 1994). In western Nevada, the species was apparently introduced in the late 19th century, probably from Sierra Nevada foothill populations in adjacent California, but has become extinct nearly everywhere in the past few decades (HOLLAND 1990).

History and Prehistory

The first five specimens of the Western pond turtle were collected at the northern extreme of the historical range, in the Puget Sound area of the state of Washington, in 1841 but were not described by BAIRD and GIRARD as a species, *Emys marmorata*, until 1852 (BURY 1970). Only 2 years later, HALLOWELL described *Emys nigra* from what is now northern Kern County, California. He was unaware that *Emys marmorata* had only recently been described, and also unaware that the geographical identity of his undesignated type specimen (of which an excellent illustration survives, ill. 5) would complicate its nomenclatural placement a century later (SEELIGER 1945). HALLOWELL slightly revised his description of *Emys nigra* in 1859 (SMITH & SMITH 1979). In 1857 AGASSIZ published an exhaustive work on the embryology of North American chelonians, and included in it four exqui-

Map 1. Historical and actual distribution of *Emys marmorata* in western North America (adapted from HOLLAND 1994).
A. Puget Sound Washington. The pond turtle has extirpated from here since the 1980s or earlier.
B. Columbia River Gorge, Klickitat and Skamania Counties, Washington. The current northernmost natural populations of the species inhabit this narrow riparian corridor.
C. Lower Umpqua River, Oregon (not shaded). The presence of *Emys marmorata* has been demonstrated here since the publication of HOLLAND's 1994 work.
D. Truckee River, Nevada. Introduced population apparently extinct.
E. Carson River, Nevada. Introduced population nearly extinct.
F. San Francisco Peninsula and Bay Area, California. Due to urbanization, many populations of *Emys marmorata* have been extirpated in this region.
G. Los Angeles Basin, California. Even more so than in the Bay Area, extant populations are few and mostly small here due to overwhelming habitat loss.
H. San Diego, California and Tijuana, Baja California. Due to urban sprawl and habitat degradation, turtle populations are scarce here.

site lithographs of a neonate of *Actinemys marmorata* (ill. 6). These represent the best composite, published illustrations of the hatchling Western pond turtle until the present work. In 1870 GRAY synonymized *Emys nigra* with *Emys marmorata* as *Geoclemys marmorata* (SMITH & SMITH 1979). STRAUCH (1862) was first to publish the binomen *Clemmys marmorata* (BURY 1970).

The fossil record of *Emys marmorata* is well summarized in ERNST, LOVICH & BARBOUR (1994). Fossil fragments from Pliocene deposits in California and Oregon, many of them from east of the species' current distribution, originally classified as *Clemmys hesperia*, were all synonymized with *Emys marmorata*, as all osseous characters "… fall within the individual variation found in both Recent and Pleistocene *Clemmys marmorata*." (BRATTSTROM & STURN 1959).

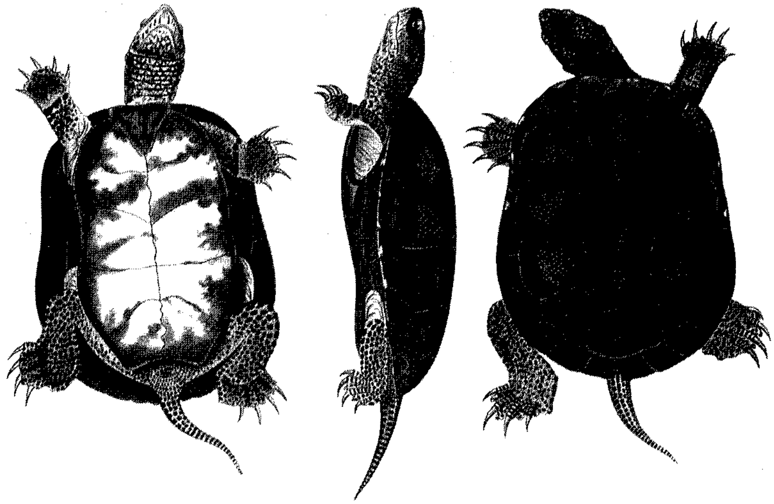
Recent development in systematics

At the time I was completing my manuscript on *Emys marmorata* in summer 2001, I was aware of the impending taxonomic changes facing the genus *Clemmys*. The works of FELDMAN & PARHAM (2002), and of HOLMAN & FRITZ (2001), appeared nearly synchronously and share many conclusions. I feel that the case made by FELDMAN & PARHAM, demonstrating the monophyly of *Clemmys marmorata*, *Emys orbicularis*, and *Emydoidea blandingii*, is the wiser choice. HOLMAN & FRITZ themselves are quick to point out (in the Abstract, in the "Comments on characters of *Glyptemys valentinensis*", and in the Discussion) that *"Actinemys" marmorata* has more in common with *Emys* and *Emydoidea* than with its erstwhile congeners in eastern North America, and they separate it from *Emys* and *Emydoidea* entirely on the basis of its akinetic plastron. FELDMAN & PARHAM, on the other hand, take pains to show that the development and loss of plastral kinesis among emydines is independent of other phylogenetic trends, and that the essential monophyly of *Emys orbicularis*, *"Emydoidea" blandingii*, and *"Clemmys" marmorata* cannot be denied. A holarctic genus *Emys* embracing *Emys orbicularis, Emys blandingii,* and *Emys marmorata* reflects this relationship borne out by paleontological, skeletal, and molecular compari-

Ill.1. *Emys marmorata* – a fascinating turtle. Photo: J. MARAN.

Ill. 2. The carapace of the Western pond turtle is sometimes magnificently patterned. Photo: J. MARAN.

Ill. 3. & Ill. 4. Profiles of an adult female from Colusa County, and of an adult male from Kings County, revealing the great variability in the coloration of head, extremities and carapace. Photo: J. MARAN.



Ill. 5. *„Emys nigra"*: Drawing of the holotype from HALLOWELL (1854). Photo: J. MARAN.

sons. All four workers agree that the Western pond turtle does not belong in *Clemmys.*

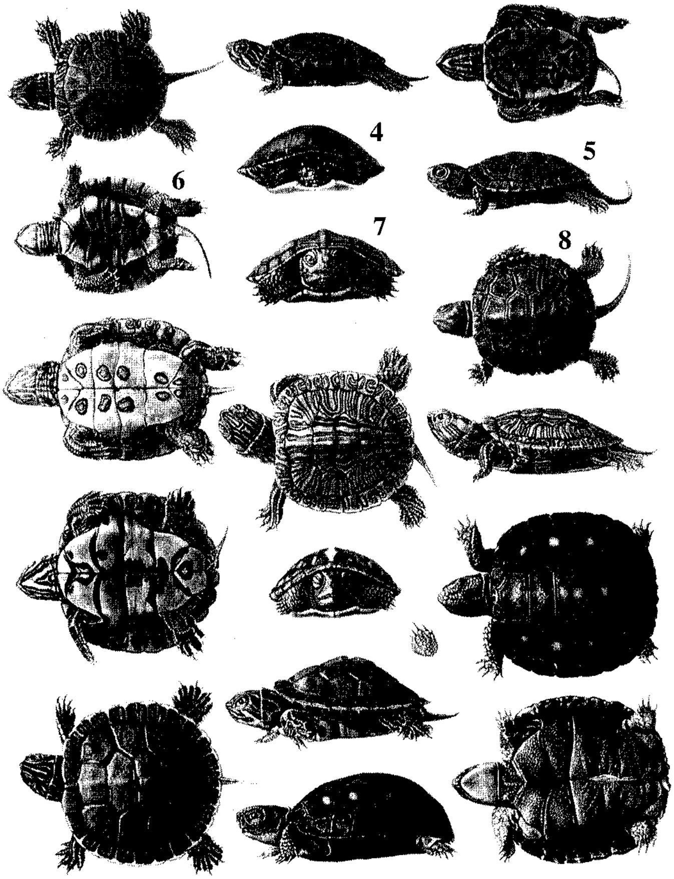
Description and Sexual Dimorphism

The specific name *"marmorata"* refers to the marbled pattern of both the soft parts and carapace of many specimens. Nonetheless, this marbling is reduced or lacking on the carapace of many northern specimens, as well as on most adult specimens from Baja California and from high elevations in California. At a glance, many specimens recall the European pond turtle; the carapace is unkeeled, broad, and slightly widened beyond the bridge, the posterior marginals being unserrated (ERNST, LOVICH & BARBOUR 1994). The carapace is usually light or dark brown, or olive, with fine dark radiating markings in many cases. In some populations, old males develop a peculiar piebald melanism. And in some turtles, the pale background color is separated by intervening darker areas such that light rays or spots seem to predominate over a darker background color, as in many *Emys orbicularis* or in *Calemys (Clemmys) insculpta.* The shells of some specimens from tannin-rich waters, or from those tainted with iron oxide, may be almost entirely brown or reddish-brown (see Plate 26 in ERNST, LOVICH & BARBOUR 1994, and Ill. 20).

It is in the unarticulated plastron that one sees the first major distinction from *Emys orbicularis.* Although there is no „typical" plastron pattern in *Emys marmorata*, in many adults, the plastron is yellowish and nearly without pattern. In others, the plastron is nearly entirely dark, or there are nearly symmetrical dark blotches along the posterior scute seams, as in *Emys blandingii.* The sutures of the bony plastron are often visible through the pale scutes in adults; the osseous structure of the carapace is less frequently evident, and chiefly in aged individuals. Neonates strongly resemble those of *Emys orbicularis* except that the dark central plastron blotch is usually somewhat smaller, the head slightly less robust. And like neonates of *Emys orbicularis, Emys blandingii, Calemys (Clemmys) insculpta, Calemys (Clemmys) muhlenbergii,* and *Clemmys guttata*, the tail is about as long as the carapace. Overall, the carapace of neonates is often of a uniform gray-greenish color, usually bearing a narrow yellow ring around the outer edge of the marginals, but some hatchlings possess an intricate pattern of blotches and streaks of diverse hues.

The soft parts of *Emys marmorata* are primarily dirty yellow, gray, or brown, with varying degrees of darker mottling. Neonates bear a broad yellowish stripe across the forelimbs, rather than the delicate tan and black flecking present on each forelimb scale of many adults. All surfaces of the head may be mottled, far less so in neonates than in other size classes, and the dorsum of the head of adult males is often unpatterned. The chin of juveniles and females is yellowish with indistinct black markings. These are typically lost in adult males, in whom the entire chin, throat, and lower sides of the neck may be pale yellow or nearly white. The yellowish iris, sometimes red in males, is crossed by a transverse dark bar (JENNINGS & HAYES 1994).

There is no size sexual dimorphism among *Emys marmorata.* The largest known specimens, having a carapace length (CL) of about 210 mm, are from two inland areas of extreme southern Oregon (HOLLAND 1994). Whereas the largest known museum specimen from California, a female having CL of 190.8 mm, was found in the adjacent portion of California near the Oregon state line (MCKEOWN & HOLLAND 1985), a living male from Marin County, having a CL of 197 mm has been captured and marked, by FIDENCI (1999). The third largest known specimen of *Emys marmorata* from California, also a male, is from the San Joaquin Valley and measures



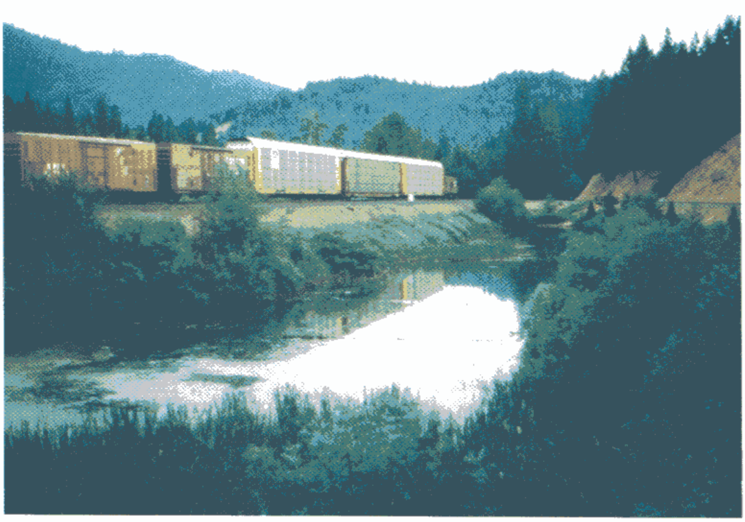
Ill. 6. „*Actinemys marmorata*": from AGASSIZ (1857). Four views of a neonate Western pond turtle are shown above numbers 5, 6, 7, and 8. Photo: J. MARAN.

only CL 182.2 mm (McKEOWN & HOLLAND 1985). Typically adults measure 130-170 mm CL (HOLLAND 1994), becoming sexually mature upon attaining CL 110-120 mm (JENNINGS & HAYES 1994). In some populations, notably those living in smaller streams and ponds, adults tend to remain rather small.

Whereas both sexes have rather long tails, the vent is located more distally in males than in females. The head of males is usually more massive than that of females, and the snout more pointed. Ontogenetic masculine color changes have already been described. Females generally possess broader and deeper shells. Males also typically bear a marked plastral concavity, but this trait is present in about 1 % of females (HOLLAND 1994 and pers. obs.). HARDIN (1993) found as many as 17 % of adults captured in one Oregon population difficult to identify by gender using external morphological traits.

Geographical Variation

In 1945 SEELIGER distinguished a nominative, northern subspecies *Clemmys marmorata marmorata* from a southern one, *Clemmys marmorata pallida,* based on subtle differences in coloration and relative size (or presence vs. absence) of inguinal scutes, based on the analysis of 158 museum specimens. She concluded that from California's vast Central Valley (or San Joaquin Valley) to the southern and eastern portions of the San Francisco Bay Area, populations of *Emys marmorata* represented intergrades between the northern and southern races. The contrast between the (darker) sides of the head and the (lighter) chin is greater in the north *(Emys marmorata marmorata)*, than in the south, where the background color of both the sides and underside of the head tend to be rather light („*pallida*"). SEELIGER found that in 60 % of her southern sample, the inguinal scutes were entirely lacking, and were "small" in nearly all the remainder. Conversely, all but a very few of her northern specimens boasted "comparatively large triangular inguinals". Although there is no doubt that adult turtles in the north tend to be both larger and darker than their conspecifics farther south, the distinctions are relative, subjective, and unreliable, and are ontogenetically influenced. Excluding hatchlings, I examined 77 turtles or turtle shells from southern Oregon to



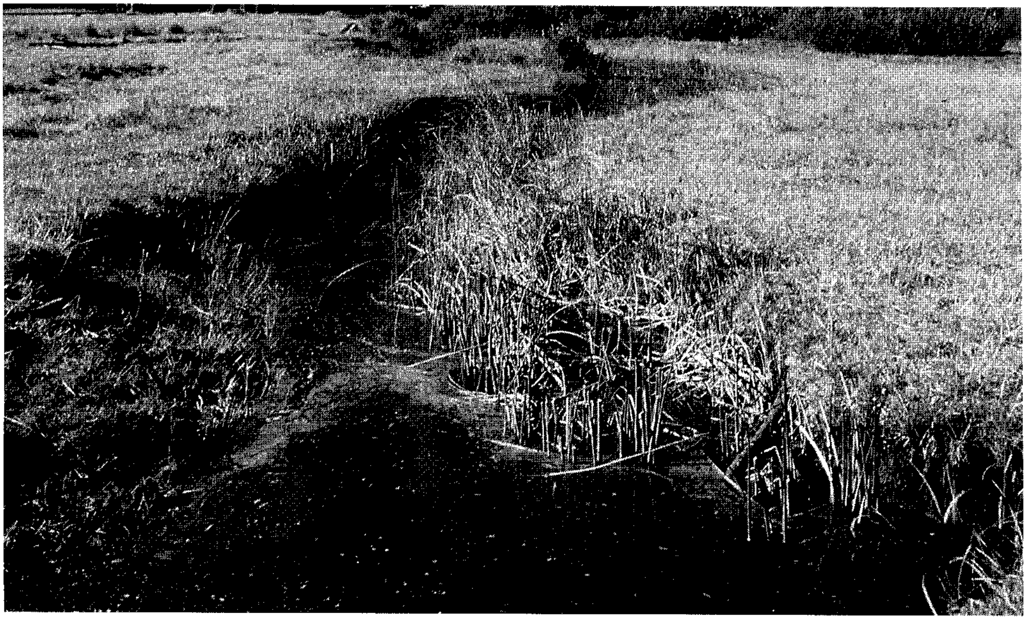
Ill. 7. An oxbow of the Sacramento river, Shasta County is a habitat for *Emys marmorata*. Photo: J. BUSKIRK.

Ill. 8. Such a hilly stream supports a healthy population of *Emys marmorata*, Los Angeles County. Photo: J. BUSKIRK.

Baja California and found inguinals completely absent from 8 % of the northern sample (BUSKIRK 1990); their absence in 11 of 17 turtles from the "*pallida*" area reinforces SEELIGER's figure of 60 % absence. Inguinal scutes were absent also from more than half of the turtles (7 of 12) examined from the intergrade zone. However, "comparatively large" inguinal scutes (greatest length > 9 % of total plastron length) were to be found on specimens throughout my sample area (BUSKIRK 1990), and I have not attempted to test the rather subjective contrasting coloration criteria. It is not unusual to find a Pacific pond turtle bearing an inguinal scute on one side, and lacking the other. Of the only two populations in which I have found the inguinals invariably absent, one is in the northwestern tip of the „intergrade zone" in Alameda County, the other near the northern, coastal tip of the "pure *pallida*" area, in the Carmel River. Inexplicably, this population has been declared extinct (JENNINGS & HAYES 1994). In certain lowland populations, particularly those with extreme summer heat and low rainfall, many juvenile and adult specimens of *Emys marmorata* exhibit nearly orange-colored soft parts. The significance and cause of this attractive variation are not clear. Possibly this is a seasonal phenomenon.

Habitat

In English, *Emys marmorata* is popularly known as the "Pacific pond turtle" or "Western pond turtle". Whereas the species does inhabit ponds, sometimes in surprising densities, and may be more easily observed in such settings than elsewhere, in truth, this species is an aquatic habitat

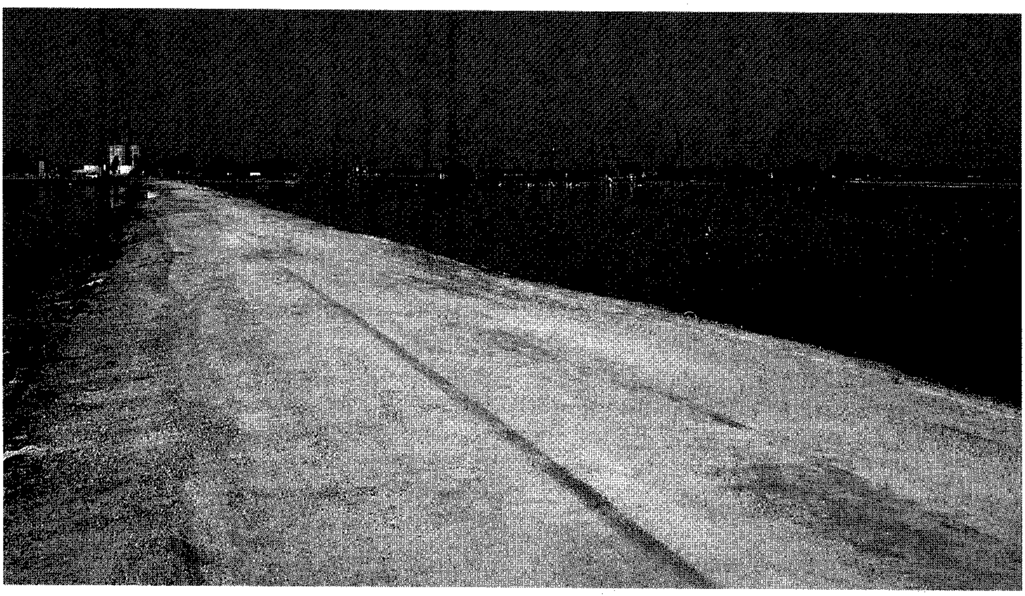


Ill. 9. A Marshy creek with steep, undercut banks, Siskiyou County. Photo: J. BUSKIRK.

generalist (HOLLAND 1994). They occur from sea level to nearly 1500 m in the Sierra Nevada Mountains (JENNINGS & HAYES 1994). Their aquatic habitats include lakes, natural ponds, rivers (including their dead branches, or oxbows), streams (permanent and ephemeral), marshes, vernal pools, freshwater and brackish estuaries, and man-made or modified water bodies such as drainage ditches, reservoirs, mill ponds, ornamental park ponds, stock ponds, abandoned gravel pits, and sewage treatment plants (BUSKIRK 1990, HOLLAND 1994). However, with the advent of telemetry studies since the 1970s, the movements of individual pond turtles have been studied, and found to include a significant degree of terrestrial habitat use (REESE 1997, HOLLAND 1994). Some river-dwelling populations seem to hibernate (up to 6.5 months) in level or sloped upland areas, usually beneath the leaf litter from conifer dominant, broadleaf dominant, or mixed coniferous and broadleaf forest (REESE 1997). The implications for safeguarding the survival of this species, thus, require paying attention to the upland habitat as well as to that of the bodies of water with which the turtles are associated. Most of these studies have been carried out in the northern third of the geographical range of *Emys marmorata,* in which a variety of vegetation zones may lie close to the turtles' aquatic habitat, whereas the upland movements of turtles inhabiting the often isolated small streams or ponds in the more xeric south, in which terrestrial cover sites are fewer, remain largely unknown. Turtles estivate in the mud when ephemeral water bodies dry out, or move elsewhere (HOLLAND 1994). Female *Emys marmorata* everywhere travel overland to deposit their eggs, sometimes up to 0.4 km distant from the inhabited body of water (STORER 1930).

In most habitats where they occur, these turtles favor areas with offshore basking sites such as floating logs, snags, protruding large rocks, emergent vegetation (FIDENCI 1999), and overhanging tree boughs unless a steep and/or preferably vegetated shoreline adjacent to deep water is also available for this purpose (REESE & WELSH 1996). In the absence of offshore basking areas or a protected, steep shoreline, turtles will bask on shore if unmolested (FIDENCI 1999). They avoid staying in areas of strong current though no doubt they traverse them, at times unwillingly. Under windy conditions, turtles will select basking sites screened by emergent vegetation *(Phalaris)* in one Oregon reservoir (HARDIN 1993). It seems crucial for hatchlings to have shallow, eutrophic, food-rich areas warmed by the sun, but adults also utilize such areas at times, which are typically found at the margins of natural bodies of water (pers. obs.). Submergent vegetation *(Potamogeton, Ruppia)* also provides a trapped, warm layer of water as well as support for turtles to thermoregulate without exposing themselves to possible predation by basking aerially (JENNINGS & HAYES 1994). The opportunities to bask undisturbed seem to be a major requirement for this species to thrive.

The average home ranges of individual Pacific pond turtles are much greater in males (0.976 ha) than in females (0.248 ha), although there is considerable overlap (BURY 1972). Total aquatic home ranges for females in two southern California streams were not significantly different (661 to 4558 m^2 vs. 294 to 7284 m^2), but linear aquatic home ranges and pre-nesting movements were inversely proportional to the length of the watercourse (GOODMAN & STEWART 2000). These authors concluded that the turtles inhabiting the more restricted (and seasonally variable) aquatic habitat were at greater risk from predation due to their increased mobility to find suitable microhabitats as well as prey and nesting sites. Densities in an undisturbed stream habitat range up to 215 turtles/ha of water (BURY 1972), and up to six times



Ill. 10. Even artificial, inhospitable looking places like this sewage treatment pond may provide important refuges for *Emys marmorata*. Photo: J. BUSKIRK.

Ill. 11. A pair of adult *Emys marmorata* from North Central California (left female, right male). Photo: J. MARAN.

this figure in undisturbed ponds (HOLLAND 1990). Under conditions of impending drought, numerous adult turtles may congregate in a single deep pool (BURY 1986a).

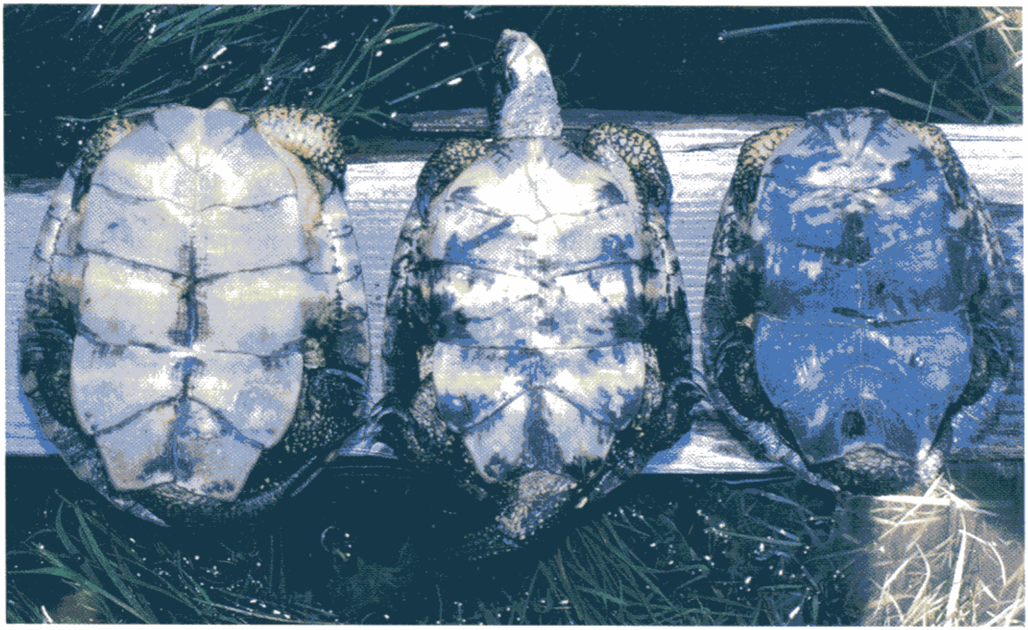
Behavior

The seasonal and dial movements of *Emys marmorata* vary with habitat, topography, latitude, and weather conditions. Turtles in the northern half of the range, and those from higher elevations in California, may be inactive more than half the year, hibernating either on land or in the body of water. In such areas the turtles typically cease activity in October or November, becoming visible again around March (HOLLAND 1994, JENNINGS & HAYES 1994). Individual radio-tagged turtles in the Trinity River in northern California left their terrestrial overwintering sites (located at a mean distance of 203 m from the riparian zone) as early as February, and as late as June 1993 (REESE & WELSH 1996). All had left the river sometime in September 1992 and changed their locations while on land during autumn and winter (REESE & WELSH 1996). Turtles inhabiting lakes and ponds have been seen moving about beneath the ice, and may congregate densely in hibernacula in shallow areas (HOLLAND 1994). At air temperatures as low as 3 °C, turtles are occasionally active during winter months but seldom emerge to bask aerially (HOLLAND 1994). Typically turtles begin to become visible when surface water temperatures remain at or above 15 °C. However, in a pond not far from San Francisco, PIERRE FIDENCI (pers. comm.) has observed turtles basking en masse in late winter when the air temperature hovered at 12 °C. They are most easily observed in early spring, when perhaps every member of a single pond population may be counted while aerially basking (FIDENCI 1999).

The thermoregulation achieved by basking enables the turtles to withstand the cooler temperatures of the water body in which they seek and digest food, and locate mates and refugia. As water temperatures increase, particularly in standing bodies of water in which evaporation shrinks the surface area seasonally, aerially basking seems to occur less frequently or perhaps not at all (JENNINGS & HAYES 1994). HOLLAND & GOODMAN (1996) discovered 19 pond turtles in a narrow crevice in granite a short distance above a 40 m^2 pool, in September 1993, and suspected that the turtles had sought both a thermal refugium and safety from predation. On three visits in 1994, only once were two juveniles again found in the same crevice. BURY (1986) documented overland movements up to 1.6 km in search of dwindling bodies of water during summer drought in central and northern California.

Telemetry studies, chiefly of adult turtles during summer months in the northern third of the species' range, have revealed a surprising degree of terrestrial activity (HOLLAND 1994, REESE & WELSH 1996, NORM WEITZEL pers. comm.) unrelated to females' search for nesting sites and return to the aquatic milieu. However, turtles moving from one drainage to another have very seldom been documented (HOLLAND 1994), although it is not unusual for a turtle to travel as much as 5 km overland.

Within the bodies of water themselves, recent work in an Oregon reservoir has shown that adult turtles moved 2.8 to 5 km within a for to six week summer period (HARDIN 1993). Turtles inhabiting other reservoirs in Oregon and also monitored by telemetry were found to move on average 3 km in five weeks in one case, but



Ill. 12. Variability of plastron coloration among males from the same locality. Photo: J. MARAN.

only 0.25 to less than 2 km in five months in another (HOLLAND 1994). Within natural streams in northwestern California and Oregon, turtles monitored during June and July exhibited contrasting degrees of mobility. The greatest single (implicitly, unidirectional) movement measured in one day by a female was 629 m, and was 434 m by a male. Some turtles moved less than 10 m per day, and average daily distances in m covered by individual turtles varied from 26 (a female) to 128 (a male). Three males moved between 585 and 780 m in one week. HOLLAND (1994) concluded that in general, turtles inhabiting ponds moved less in a day than turtles in streams or lakes, and that many turtles inhabiting reservoirs (an artificial body of water) were obliged to be extremely mobile in search of scarce food resources and optimal basking sites. Three female turtles inhabiting a natural lake, however, moved between 11 and 13 km within only 54 days. HOLLAND (1994) also concluded that river-dwelling *Emys marmorata* males were more than twice as mobile as females or juveniles. One Oregon male moved 7 km upstream in five weeks. HOLLAND (1994) cautions that all estimates of true movement in turtles equipped with transmitters are conservative.

A surprising revelation that has come about due to radio-telemetry concerns nocturnal behavior in this species. During summer, measurable overnight movements in stream-dwelling females ranged up to 140 m, with some nocturnal movement recorded on 63 % of the nights vs. 72 % of the days (HOLLAND 1994). In an Oregon lake, the results were even more astonishing: nocturnal movement was registered on 89 to 91 % of nights (vs. 88 to 98 % of days). Pre-nesting nocturnal activity among *C marmorata* was first tentatively documented about a century ago by GRINNELL & GRINNELL (in STORER 1930). WEITZEL (in REIBER 1999) and his fellow „turtle watchers“ in central Oregon have not only discovered nocturnally active turtles (in one case, evidently consuming dog food behind a home at 02H) but have extended the known geographical distribution of *Emys marmorata* in the lower Umpqua River.

Interactions between individual *Emys marmorata,* other than courtship and copulation, are poorly documented. Aggression among aerially basking specimens was described in detail a generation ago (BURY & WOLFHEIM 1973), but seems exceptional. Pushing, ramming, gaping and biting among basking Pacific pond turtles have been unquestionably documented, nonetheless. HARDIN (1993) observed only one such incident during her 217 sightings of turtles in two Oregon reservoirs. HOLLAND (1994) notes that „stacking“ among basking *Emys marmorata* is uncommon, an observation with which I concur. A stream-walking companion in April 1986 witnessed the head-on ramming of two male *Emys marmorata* in shallow water, making a loud noise as both turtles emerged briefly entwined, perpendicular to the substrate, plastron to plastron. As the commotion directed his attention to these heretofore undetected turtles, within seconds he located them and we determined both were males. I know of no other such observations.

The behavior of neonates remains poorly understood (HOLTE 1998, HOLLAND 1994). While some writers have commented on their wariness and overall crypsis (MONJE 1993, HOLTE 1998, FIDENCI 1999), in some situations they may be highly visible and less wary than adults or yearling turtles (pers. obs.). Although they often select shallow and eutrophic microhabitats, sometimes mere puddles, they will enter deeper water and sometimes bask in the immediate vicinity of adults.

When captured, many *Emys marmorata* including neonates produce a pungent, distinctive musk. Some specimens struggle, often only briefly, and many others partially or completely retract their head and limbs. I have never heard of one attempting to bite. Although the shortcomings of repeated use of traps has been highlighted (HOLLAND 1994, FIDENCI 1999), resulting in skewed estimates of turtle numbers owing to turtles becoming „trap shy," in one case, HARDIN (1993) withdrew the same vigorous turtle 4 times from a trap. She concluded that the turtle had learned to submit to temporary captivity in exchange for the chance of something to eat in the relatively impoverished artificial, reservoir environment.

Ill. 13. Author, measuring and recording notes in the field. Photo: J. MARAN.

Diet

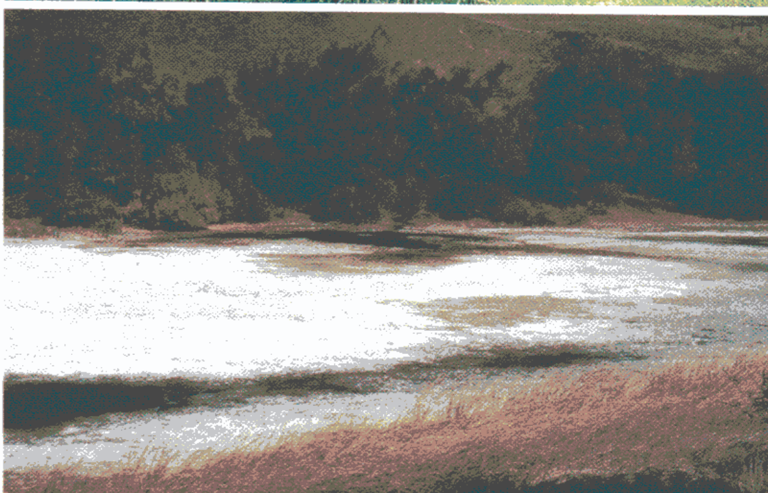
As would be expected from a turtle inhabiting a variety of habitats not shared by any other species of chelonian, *Emys marmorata* is an opportunistic feeder (BURY 1986). It is a scavenger but also employs various strategies in foraging for live prey. Adults are partially herbivorous, and prey size varies as the size of the feeding turtle increases. Aquatic invertebrates including crustaceans are consumed by turtles of all size classes. Insects and their larvae, particularly dipterid larva, were the major component of the stomach contents of 77 turtles from northwestern California (BURY 1986). On 2 April 1983 I photographed, then captured and released an adult turtle in northern Baja California (BUSKIRK 1984) which was feeding upon simulid fly larvae attached to a rock, in clear water about 30 cm deep in a slow-moving stream. I have also observed moving turtles whose eyes were closed, apparently foraging in shallow water among filamentous algae. When picked up, the turtles opened their eyes which did not appear diseased, and behaved normally. If eye closure was a protection

Ill. 14. Stream and Steppe, vulnerable wildlife habitats in arid Fresno County. Photo: J. BUSKIRK.

Ill. 15. Remarkable radiating markings in a young male turtle from an isolated Mojave desert population of *Emys marmorata*. Photo: J. BUSKIRK.

against some irritant or trauma to which the turtles might have been exposed, I can only surmise that the abundant presence of California newts *(Taricha torosa),* whose skin secretions are highly toxic, may have been the explanation.

Healthy fish are able to avoid hungry turtles in open water. Neustophagia, or filter-feeding, was observed in nature by HOLLAND (1985), and in captivity by BURY (1986). Filamentous algae is an important source of food, particularly for females after egg-laying, despite being relatively protein-poor compared to animal prey. However tiny animals living in the algae, difficult to quantify by human observation, may be of nutritional importance to the turtle (BURY 1986). A juvenile *Emys marmorata* was seen consuming the scat of a coyote *(Canis latrans)* in a stream in southern California (GOODMAN & STEWART 1998). These turtles spend quite a lot of time while in the water in search of food,



Ill. 16. to Ill. 18. Turtle habitat changing with the seasons, Los Angeles County. Photos: J. BUSKIRK.
(16) Snow and ice, February 1989.
(17) Lushness of spring, May 1988.
(18) Nearly dry from drought showing salts left by evaporation, November 1989.

County	Date (m/d/y)	Number (s. Legend)
Shasta	05/15/1996	
Teharma	06/08/1912	*
Colusa	04/27/1987	
	05/15/1989	
	04/28/1990	
	06/15/1997	(9)
	05/15/1998	(2)
	09/10/2001	
Yolo	05/12/2001	
Sonoma	04/13/1911	*
	04/20/1911	*
Napa	05/02/1987	(4)
Sacramento	06/01/1922	(2)*
Contra Costa	06/07/1997	(3)
Alameda	04/24/1982	(2) et seq.
	05/27/1996	
Tuolumne	04/19/1986	(4)
	05/13/1990	(3)
Mariposa	06/05/1915	*
San Mateo	06/05/1957	(7)
Santa Clara	05/08/1898	*
	04/04/1908	*
	03/21/1990	
Kings	04/25/1992	(4)
	04/02/1994	(7)
	04/01/1995	(6)
	04/25/1998	(4)
San Luis Obispo	04/22/1990	
Los Angeles	11/05/1917	
	05/23/1988	(3)
	05/07/2001	(2)
Ventura	05/19/1949	*

Tab. 1. Selected counties of California, showing localities and dates at which neonate *Emys marmorata* have been documented, 1898-2001. The number in parenthesis indicates the number of hatchlings found on that date if greater than one. Hatchlings are defined as juveniles having a CL of less than 40 mm. In cases of sites visited more than once per season yielding hatchlings on each visit, only the earliest date is given. Museum specimens are indicated with *.

and are often seen foraging in shallow water late in the afternoon.

Feeding out of water by free-living *Emys marmorata* has never been documented. Captives apparently are able to master this skill however, and there is the report cited of turtles helping themselves to dog food in the middle of the night, presumably too far from their aquatic haunts to return there in order to swallow.

Reproduction

The first biologist to compile information on the breeding activities of the Pacific pond turtle was TRACY STORER (1930), who cited previous single observations, and provided dates for nesting as well as for the discovery of nests and of dead females containing eggs. Today it is recognized that this species typically nests in June or July in the north, earlier in the south, each female depositing one to 13 thin, hard-shelled, slightly oval eggs (JENNINGS & HAYES 1994). The eggs measure 30.0 to 42.6 mm × 18.5 to 22.6 mm (ERNST, LOVICH & BARBOUR 1994). Two clutches per season are deposited occasionally, at least in southern California. A captive female in Washington also deposited two clutches of nine eggs each in 1994 (BOWDOIN 1997). Of seven gravid, California stream-dwelling females in 1993 carefully monitored by GOODMAN (1997), three produced two clutches. Internesting intervals were 38, 38, and 41 days; the earliest first clutch was deposited on 4 May, and the latest second clutch on 20 June. In two of the females, the number of eggs in the second clutch exceeded that of the first; clutch sizes varied from four to eight, and whereas two females produced a total of twelve eggs in 1993, the third produced 15. The mean egg width, assessed by x-ray, of two turtles was greater in the second than in the first clutch, and was nearly identical in the other.

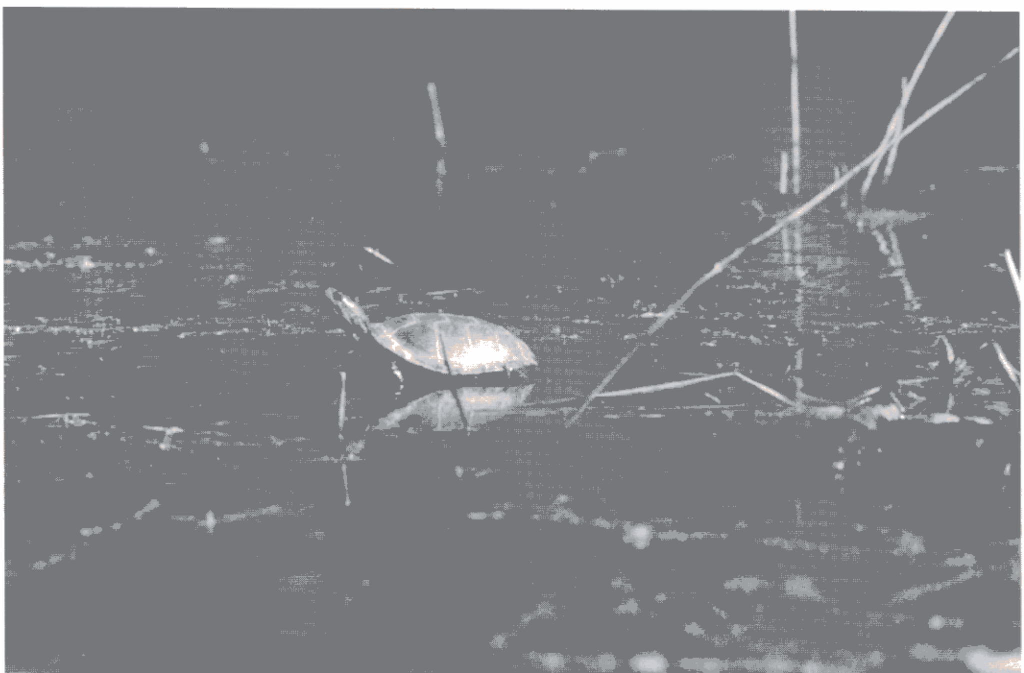
Until recently little was documented about the incubation of *Emys marmorata* eggs under natural conditions. It is still not known whether TSD (temperature dependent sex determination) prevails in this species (RATHBUN et al. 1992, HOLTE 1998);

Date	Number
04/24/82	2
05/01/82	3
05/18/82	6
04/14/85	4
05/13/85	2
03/24/86	2
04/18/86	1
04/23/87	8
04/18/88	1
05/01/89	8
03/24/90	6
04/12/93	1
03/14/94	2
04/01/95	6
05/03/96	3
05/10/99	6
04/17/01	3

Tab. 2. Earliest capture dates of neonate *Emys marmorata* at a pond in Alameda County, and numbers found per visit. A neonate at this easily accessible locality is defined as juvenile having a CL lower than 37 mm.

without providing data, the authors of two reports on „head-starting“ programs declare that it does (KEYS & HANSEN 1997, OVERTREE & COLLINGS 1997). Detailed parameters of a natural egg chamber near an Oregon reservoir are provided by HOLTE (1998), including hourly temperature measurements varying from 19 to 30 C in a 24-hour period on 12 July 96. The same author describes nest sites, including abiotic parameters (eg weather conditions) in great detail as well.

A few published reports (summarized in BUSKIRK 1990) indicate that artificial incubation varies from 73 to 132 days. In contrast to the eggs of eastern U.S. *Clemmys* and *Calemys*, these eggs must be kept relatively dry or they absorb too much fluid, and rupture (FELDMAN 1982, OVERTREE & COLLINGS 1998). In nature, neonates are very seldom found in late summer or fall, as one would expect from the wide range of artificial incubation periods. Rather, even in the parts of the range with



Ill. 19. Basking *Emys marmorata* in an ornamental urban park pond. Photo: H. BROUWER.

Ill. 20. Juvenile specimen, iron oxide-stained, Marin County. Photo: P. FIDENCI.

very mild winters, the neonates of *Emys marmorata* remain in the nest cavity until early spring (BUSKIRK 1990, RATHBUN et al. 1992, JENNINGS & HAYES 1994, HOLTE 1998). Neonates typically lack the caruncle, presumably having been shed during the months spent within the nest cavity. Table 1 documents dates on which neonates have been found at various sites in California, from 1898 to 2000. The earliest dates per year and numbers of hatchlings seen at a single pond in Alameda County (central California) are given in Table 2. HOLTE (1998) observed young leaving nests in Oregon in early March. Springtime emergence guarantees the neonates freedom from scouring floods (RATHBUN et al. 1992), an abundance of microbiotic prey items on which to gorge themselves, the presence of seasonal algae rafts providing refugia, aerial and sub-surface basking, gradually lengthening days, stable or rising water temperatures, and thus the opportunities for rapid growth before late summer desiccation.

The best and most detailed description of underwater courtship which took place on 30 August 1987 (HOLLAND 1988) is carefully summarized by ERNST, LOVICH & BARBOUR (1994). In much shallower water on the edge of a reservoir near San Francisco, I observed and photographed on 8 March 88 a male circling a nearly immobile female, his limbs and head extended. Both turtles seemed unaware of my presence less than 3 m distant. As with HOLLAND's observation, the male touched the anterior carapace of the female with his forelimb and „nosed" but did not bite her. Unfortunately I was forced to depart after only a few minutes of observing these turtles. Under similar weather conditions (air temp ca. 22 °C, light southwest wind) at an elevation of about 350 m in the Santa Monica Mountains (Los Angeles Co.) on 22 February 97 shortly before noon, MICHAEL CONNOR and I watched a male *Emys marmorata* pursue a female which kept ahead of him, pausing always on the surface without submerging as she swam slowly towards us, until she became aware of our presence some 5 m distant. When close to her, the male circled her, making quite a commotion with his limbs. The male followed the female to the bottom after she evidently noticed our intrusion. The site is an isolated small pond atop a narrow, steep canyon.

Copulation is suspected to occur year-round (HOLLAND 1990). HARDIN (1993) observed a pair of turtles copulating atop a floating log in a reservoir in Oregon on 26 May 93 (possibly 1992). I know of no other observations of copulation out of water for this species. I have found copulating turtles in shallow water among large rocks on 20 April 87 (Colusa Co.); on the bottom of a very cold, rather fast-flowing stream about 80 cm deep on 8 June 87 (Shasta Co.); and in a small lake, „perched" in an algae raft offshore, the female unseen beneath a male protruding from the algae at a gentle angle, on 21 May 88 (Los Angeles

Ill. 21. In the left foreground, a neonate was found in the puddle among rocks; adults inhabit the stream beyond, Colusa County. Foto: J. MARAN.

Co.). The male's head was withdrawn such that the silhouette was that of an empty turtle shell sticking out of the offshore muck at a 25 degree angle.

Females may wander a great deal in the course of seeking an ideal nesting site, spending as much as four days on land, and appear wary even when „at rest" during these excursions (HOLLAND 1994). In Oregon, nesting activity is often correlated with overcast, humid weather, sometimes with rainy spells. Rain is extremely rare during June and July in the southern half of the species' range, however. Early observations that river-dwelling females deposit their eggs in the sand banks nearby (STORER 1930) are valuable, as today river-dwelling populations are very scarce and riparian habitat modification has eliminated many of the sand banks in which traditionally they would nest. Female *Emys marmorata* living elsewhere often take tortuous routes, frequently at night, up steep banks and through a variety of vegetational assemblages to reach their preferred nesting site (RATHBUN et al. 1992). The soil in which the nest is excavated is generally compact and often contains clay or silt (HOLLAND 1994). The nesting microsite is typically on a slope of 25 % or less, and usually south-facing. Stream-dwelling females typically nest beyond the riparian corridor, subject to seasonal floods, in upland areas possibly affording better incubation conditions as well (RATHBUN et al. 1992). Open, grassy areas are selected; the female voids into the flask-shaped nest cavity before oviposition (RATHBUN et al. 1992). Eggs are sometimes laid in rapid succession, and the nest is skillfully concealed as in many other species (HOLLAND 1994). Nonetheless, predation on nests is very high in some areas, particularly by raccoons *(Procyon lotor)*. At many Oregon sites, the figure of nest destruction approaches or reaches 100 % (HOLLAND 1994).

Growth

HOLLAND (1994) estimates that neonates grow approximately 3.3 mm per month during their first year. This growth spurt helps ensure a more rapid attainment of a size at which they are at lower risk of predation. Perhaps no other closely related turtle grows so rapidly during the first year. This accelerated growth, coupled with the seeming incongruity of springtime emergence, helps explain why STORER (1930) identified hatchlings as „beginning their second season," rather than their first, and thus caused him to underestimate the growth of juveniles. HARDIN (1993) identified a juvenile having CL 55 mm as a probable two year-old, and another of CL 50 mm as a yearling. I suspect both were yearlings (see Table 2, BURY & GERMANO 1998). The variation in carapace length of neonates is considerable (Table 2, BUSKIRK 1990), from 24.4 mm to 39.2 mm. Most measure 29 -33 mm. CL.

Females become mature upon attaining a CL of less than 110 mm, usually after about seven years (HOLLAND 1994); evidence suggests that the smallest reproductively active females in Oregon are considerably larger (CL more than 131 mm). Here in the northern part of their range, maturity may take eight to twelve years (KEYS & HANSEN 1997). Males as small as CL 90 mm have been observed engaging in courtship activity, but it is unknown whether they are reproductively mature.

Counting scute rings to determine age in this species has proven somewhat problematical (BURY & GERMANO 1998, FIDENCI 1999). Juvenile turtles from northwestern California bearing a single annulus varied in CL from 42.5 to 60 mm, though some turtles bearing two rings were as small as 55 mm CL (BURY & GERMANO 1998). Twenty-nine of 36 juvenile or small adult turtles marked and recaptured between 1993-98 showed the addition of one annulus per year; of the remainder, six bore two new annuli two years later, and one showed one annulus after two years. The authors concluded that growth slows down in the eleventh year, that counting rings to determine age is reliable at least up to ten years, and that most turtles in this population deposited one ring per year. The age beyond which the counting of separate annuli becomes unreliable is estimated at twelve to 14 years (BURY & GERMANO 1998). The largest turtle with countable annuli (16, the largest number seen) was an Oregon specimen of CL 162 mm. Most adult Pacific pond turtles show little or no trace of annuli, as the accompanying photographs reveal.

The average life expectancy of this species is estimated to be 40 years (HOLLAND 1994).

Human impacts, Conservation, Status, Management

Like most temperate chelonians inhabiting regions desirable for permanent human occupation, *Emys marmorata* is being squeezed out of its haunts by real estate development, conversion of wetlands to agriculture or aquatic recreation, channelization and damming of rivers and streams, livestock grazing, gold and gravel mining, and other human mediated impacts (BUSKIRK 1990, HOLLAND 1994, REESE & WELSH 1996). Direct mortality from automobiles may be significant among females during the nesting season, or among turtles moving overland for whatever purpose. However, it is habitat loss which is the leading culprit, estimated as causing an 80 to 85 % decline in turtle populations in California alone since the 1850s (HOLLAND 1990). MILNER (1986) surveyed all sites in the Puget Sound area of Washington State in which there were records for *Emys marmorata,* as well as propitious habitat elsewhere in the region, and found not a single member of this species. The most recent reliable reports of the species in the area had been from the early 1970s. A single adult male was found in Skagit County, near possible habitat, in 1982 (MILNER 1986). The only known populations remaining in Washington occur in ponds along the Columbia River, in the extreme south (HOLLAND 1994). There, a mysterious and virulent epidemic somewhat akin to Upper Respiratory Distress Syndrome affecting *Gopherus agassizii,* has recently decimated the remainder of the free-living turtles of Washington, whose total number is estimated at 100 (KING 1990).

In two regions of extraordinary former abundance, there has been an estimated 98 % reduction in the numbers of turtles inhabiting Oregon's Willamette Valley (HOLLAND 1994), and a 95 % (HOLLAND 1990) or even 99.9 % reduction (MAYER 1992) in California's San Joaquin Valley. Today a dreary mosaic of cotton fields, orchards, cattle feedlots and depressed small towns endured by travelers driving as fast as possible between Los Angeles, San Francisco and Yosemite, the San Joaquin Valley was once California's Serengeti. Here vast savannah watered by meandering rivers alternated with seemingly endless, shallow wetlands including the largest freshwater lake west of the Rocky Mountains, Tulare Lake. There is no remnant of this lake today except during winters of heavy rainfall, and then, only transiently and to the annoyance of landowners. Where once, uncounted *Emys marmorata* greeted arriving and departing waterfowl in their millions, surrounded by oak-studded grasslands where numerous elk, deer, and pronghorn antelope provided prey for bands of indigenous Yokuts and roving grizzly bears, today there are grids of pesticide-carrying ditches and others of asphalt, interrupted by a surprising number of new state prisons, dying small towns, and oil wells. Two of the largest surviving populations here of Pacific pond turtles face an uncertain future in sewage treatment plants, in one of which the dirt roads on which females found their only nesting sites have recently been covered with coarse gravel, effectively halting further recruitment into this vulnerable, isolated population (pers. obs.).

The Willamette Valley was described 150 years ago as where "Open prairies of inexhaustible fertility, swelling into hills and sinking into valleys, stretch away in picturesque beauty" (THORNTON 1849 in HOLLAND 1994). Here the decline of *Emys marmorata* has been even more precipitous. The prairies described were partially the result of periodic burning of low-lying grasslands by the Native Americans, as a method of ensuring habitat for desirable game species. After the arrival of European-Americans, the selective burns were discontinued and the former prairies, where not settled or cultivated, succeeded rapidly to scrub or evergreen forest (HOLLAND 1994). The impacts upon the turtle from the resulting "natural" modification of the terrestrial habitat are not clear, but probably limit the opportunities for locating optimal nesting sites. Along the riparian corridor itself, human-mediated impacts on the Willamette and other rivers adversely affecting the remaining turtle populations include „bank stabilization" (channelization), inundation and consequent loss of shallow areas caused by damming, and diversion for irrigation (REESE & WELSH 1996, HOLLAND 1994). The study of dammed and undammed portions of California's Trinity River revealed that whereas damming produces areas of deeper water and sub-surface refugia (undercut banks) possibly beneficial to turtles, much favorable, shallow shoreline habitat is erased, the water velocity itself increases as its temperature decreases, making the areas uninhabitable to *Emys marmorata* (REESE & WELSH 1996).

Elsewhere, near the southern limit of the species' range in heavily urbanized, coastal southern California, BRATTSTROM (1988) indicated that only five reproductively viable populations (= containing more than 25 individual turtles each) were present from Los Angeles County to the Mexican border. This author cited 28 populations, viable or otherwise, at that time in the five Southwesternmost California counties. BRATTSTROM & MESSER (1988) concluded from direct surveys and responses to a questionnaire than only one viable population of the pond turtle remained in Los Angeles County, located on the very edge of adjacent Ventura County. A small gleam of hope is provided by the more recent discovery of seven additional populations within Los Angeles County, by the author and others, of which at least two meet criteria for viability (Anonymous 1993 and pers. obs.). Furthermore, two populations totaling perhaps 250 individuals have been located, for the moment safe under U.S. military protection, within Camp Pendleton in Orange County (MAYER 1992). However there is no question that these nuclei, some more readily accessible than others, remain vulnerable to outright collection for the pet trade (prohibited since 1972 but covertly practiced) or to habitat destruction. As elsewhere, surviving populations of *Emys marmorata* are now highly fragmented (HOLLAND 1994).

The role of the pet trade in the decline of this species remains unclear. Reportedly, hundreds of turtles from a single lake not far from Los Angeles were shipped to Europe for the pet trade in the late 1960s (BURY 1970). There are still reports of small numbers of *Emys marmorata* being sold by animal dealers in the eastern United States. Often the turtles being sold are qualified as having been "long-term captives", which is likely a ploy to encourage customers to buy a turtle known frequently to do poorly in captivity, and to assuage the guilty conscience of the would-

Ill. 22. Plastral view . Photo: J. MARAN.

Ill. 23. Neonate, Yolo County, same animal. Photo: J. MARAN.

be buyer. From the mid-19th century until perhaps the 1930s, the Pacific pond turtle was a luxury food item in west coast cities, many of them gathered from seemingly inexhaustible Tulare Lake (BUSKIRK 1990). It is assumed that the commercial trade in this species ceased when it became no longer easy to capture large numbers, nor to ship them cheaply to the cities. Surely the Great Depression played a role in the cessation of this commerce as well.

Human activities indirectly harmful or fatal to this species include recreational activities which interfere with basking, such as high-speed boating, water skiing, and jet skiing, as well as toxic spills (BRATTSTROM & MESSER 1988, HARDIN 1993, HOLLAND 1994). Fishermen or hunters may consider the turtles a nuisance and shoot or otherwise kill them. Frustrated fishermen sometimes leave fish hooks in the turtle's mouth, probably leading to its eventual death. The only detailed study of the effects of cattle grazing on *Emys marmorata* in a pond habitat has been carried out by FIDENCI (1999). The author's research revealed that favorable abiotic parameters (pH, sulfate and nitrate levels, dissolved oxygen) were strongly altered by the extent of cattle grazing, which also could damage or destroy the fragile shoreline on which the young in particular find their microhabitat. Even adult *Emys marmorata* are not sufficiently robust to withstand being trampled by cattle, as I have found at two central California streams and one pond.

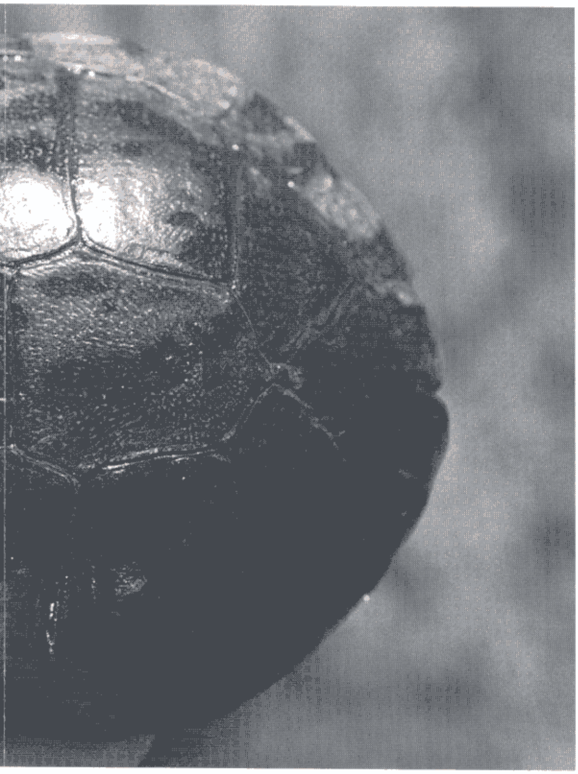
In addition to nest predation by raccoons, several other native mammals may destroy nests and/or consume neonates, as do large birds such as herons (HOLLAND 1994). However, the introduction of two predator species deemed desirable for human consumption, the large-mouth bass

Ill. 24. Specimen with remarkable anomalous scutes, Los Angeles County. Photo: J. MARAN.

(Micropterus salmoides) and bullfrog *(Rana catesbeiana)* into aquatic habitats in the Far West has been particularly damaging. A large bullfrog is capable of eating not only neonate *Emys marmorata* (BOWDOIN 1997), but even yearlings (HOLLAND 1994). A female frog may produce up to 20,000 eggs per season. It is unknown whether

California's endangered native frog, *Rana aurora* preys (or preyed) upon small turtles (HOLLAND 1994).

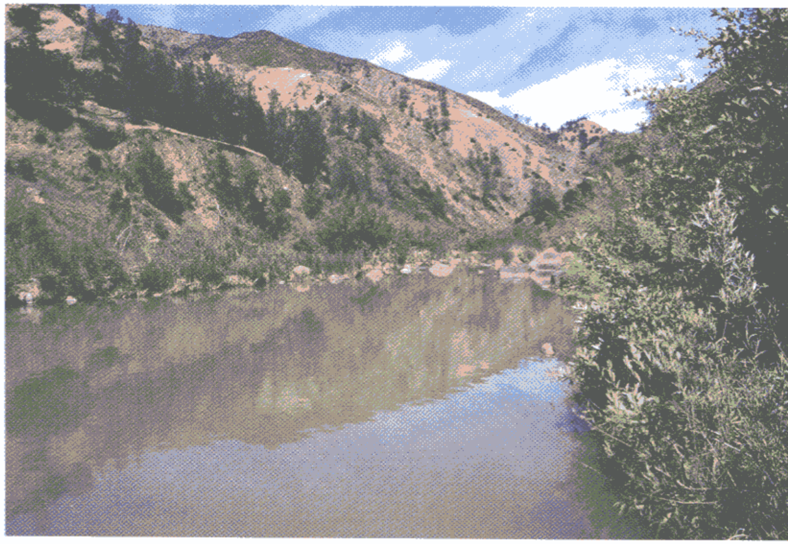
Another exotic species whose effect on the Pacific pond turtle remains controversial is the red-ear slider *Trachemys scripta elegans*. Now widespread in temperate and even tropical areas worldwide, this species is suspected of being capable of reproduc-



ing as far north as Oregon's Willamette Valley (HOLLAND 1994). However, efforts to prove an incompatibility with the native species remain inconclusive. Mishaps including the escape of several turtles following a heavy storm marred the attempt at a controlled study of the interaction of both species in a semi-natural habitat belonging to the University of California at Davis (HOLLAND 1994). The unidentified author of the actual study frequently qualified his findings as inconclusive, but declared that possibly, *Trachemys* dominated the more desirable basking areas to the detriment of *Emys marmorata*. Some urban park ponds and suburban reservoirs contain surprising numbers of *Trachemys scripta elegans*, but in many of these reproduction is not taking place, and few if any such sites contain native populations of the Pacific pond turtle.

Among the earliest known attempts to mitigate adverse human impacts to this species in California was the translocation of some dozens of *Emys marmorata* from a stream and ponds in eastern Orange County, to less vulnerable habitats in adjacent counties about 20 years ago (BRATTSTROM & MESSER 1988). Prior to their removal, hundreds of these turtles had inhabited a nearby sewage treatment plant whose ponds were emptied and leveled in 1980. Whether the removed turtles are being monitored is not known to me, but the project admittedly fell short of its goals owing to insufficient funding (BRATTSTROM & MESSER 1988). The original creek still contained a breeding population of *Emys marmorata* when I visited it in 1985, but on a longer visit in 1998, I did not see a single turtle.

Three head-starting programs are known to me, one in each of the coastal U.S. states inhabited by this species. Owing to the sudden, devastating URDS-like disease among the relictual Washington population, several ill adult turtles as well as eggs from natural nests were transported to the Woodland Park Zoo in Seattle, beginning in 1991 (BOWDOIN 1997). Three years later, it was concluded that 2/3 of the 23 head-started juveniles which had been hatched and reared in captivity, had survived after their release into the parental ponds in the Columbia River gorge. There is hope of



Ill. 25. A quiet stretch of a river habitat, Yolo County. Photo: J. MARAN.

re-establishing populations in the Puget Sound area where the species first became known to science, but securing founder stock has been problematical and controversial. *Emys marmorata,* for good reason, is considered an Endangered Species in Washington (HOLLAND 1998).

In Oregon, the species is granted the status of Special Concern (HOLLAND 1998). Near the university town of Corvallis, a head-starting program for these turtles began in 1994 (KEYS & HANSEN 1997). An unstated number of hatchlings from 62 rescued eggs, taken from an area of almost universal nest predation, were released in May after having attained a CL of about 7.5 cm (KEYS & HANSEN 1997). It is not stated whether they were released into the same habitat as where the eggs had been collected, or were translocated to an area formerly or presently inhabited by the species.

Below the headwaters of the southernmost river which flows out of the Sierra Nevada into the San Joaquin Valley, since 1992 there has been a head-starting program in an effort to boost the survivorship of turtles inhabiting a series of relatively isolated ponds (OVERTREE &D COLLINGS 1997). After attaining a weight of 50 g (10 times the average neonatal weight), the head-started young are placed in a secure, „natural" outdoor enclosure for one month to ensure that they maintain their weight under near-natural (predator-free) conditions. Limited data from the second year of the program, 1993, indicated that the four turtles recaptured (of twelve released into the original ponds) had gained weight and seemed healthy. HOLLAND (1994, 1998) has voiced skepticism over the effectiveness of head-starting programs. *Emys marmorata* is considered a species of Special Concern in California, as in Oregon. Since 1994 it has been illegal to remove this species from the wild, without a permit, in California.

Relatively few populations of *Emys marmorata* inhabit Federal or State Parks, as appropriate habitat is often lacking, even though legal protection is theoretically enhanced (BURY & HOLLAND 1992). Within California's vast network of regional parks, cattle grazing is sometimes allowed despite the presence of aquatic species even more at risk than the turtle, e.g. *Rana aurora.* The overall outlook for this two-million year survivor is troubled. It is my hope that this turtle will endure perhaps beyond humanity itself, and that through these words and images, readers will feel an affinity for this shy turtle and its mysterious, awesome world.

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All Counties mentioned at the captions lie within California.