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Note

Northwestern Pond Turtles (*Actinemys marmorata*) Under Ice

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***Abstract.*—Freshwater turtles on the North American continent have adapted to endure seasonal cold weather across a range of climatic conditions. The Northwestern Pond Turtle may move around within its chosen overwintering habitat, whether it be terrestrial or aquatic. Here we report observations of overwintering turtles active under a frozen pond surface. Remote sensors recorded the edaphic conditions under which our observations were made. Conditions under the ice were less severe than those in the adjacent terrestrial habitat. For turtles, the reduced risk of predation, and protection from extreme temperatures, make overwintering in lentic habitat a better fitness choice than overwintering on land.**

Key Words.—basking; brumation; cloacal breathing; hibernation; Northwestern Pond Turtle; overwintering; remote sensor.

In the Northern Hemisphere, freshwater turtles have adapted to cope with the seasonal cold temperatures of winter (Ultsch 2006; Bury and Germano 2008; Rödder et al. 2013). During winter months, most turtles enter a prolonged period of inactivity referred to as hibernation, or brumation, but turtles may become intermittently active when winter temperatures warm periodically (Holland 1994; Bury et al. 2012). Herein we refer to this prolonged inactive period as overwintering. In overwintering, turtles have adapted to lower their metabolic rate to a low constant that minimizes energy consumption (Ultsch 2006). During this metabolic depression, turtles choose a location that provides a suitable environment; one in which they are least likely to succumb to freezing temperatures, prolonged anoxia, or predation (Ultsch 2006; Bury and Germano 2008). Freshwater turtles may overwinter on land, or in lakes and ponds, but overwintering mortalities are generally lower in aquatic overwintering sites (Ultsch 2006).

Northwestern Pond Turtles (*Actinemys marmorata*) inhabit a range that extends from the San Francisco Bay in the south, northward to the Puget Sound area of Washington (Bury and Germano 2008; Spinks et al. 2016; Todd et al. 2022), and along the Pacific Coast west of the Sierra Nevada and Cascade Range peaks, with few isolated populations east of the Sierra Nevada (Storer 1930; Seeliger 1945; Thomson et al. 2016; Bury 2017). *Actinemys marmorata* generally overwinters aquatically if living in lakes and ponds, and on land when it occurs in riverine habitats (Ultsch 2006; Bury et al. 2012). Often, *A. marmorata* from lentic systems overwinter under water, while those in lotic systems overwinter on land to escape seasonal scouring flows (Reese and Welsh 1997; Ultsch 2006; Bury and Germano 2008; Bury et al. 2012). There appears to be plasticity in overwintering behavior; however, as individual turtles may alternate between overwintering aquatically and terrestrially from year to year (Dan Holland, unpub. report), perhaps due to extremes in the Mediterranean climate that predominates throughout much of their distribution (Ultsch 2006; Bury et al. 2012).

During the depressed metabolic state of overwintering, *A. marmorata* may move around in their overwintering sites, whether terrestrial or aquatic, including occasional basking (Reese and Welsh 1997). *Actinemys marmorata* have been found basking in temperatures as low as 6º C in a lake in Oregon, and a radio-telemetry study suggested that *A. marmorata* may actively move under the frozen surface of a mountain lake in central Oregon (Dan Holland, unpubl. report). Here, we offer evidence of *A. marmorata* moving under an ice-covered pond in northern California. We also provide clarity on the thermal conditions of the pond environment immediately surrounding these active turtles, and discuss the possible benefits for *A. marmorata* to overwintering aquatically under the threat of such extreme environmental conditions.

We found *A. marmorata* moving under the ice at Bonnie's Pond, which is located on the Mitsui Ranch Preserve, 8 km east of Petaluma in Sonoma County, California. The pond is a small (0.18 ha surface area), relatively deep (3.5 m) stock pond constructed in the 1980s, at an elevation of 682 m, for the purpose of watering livestock (M. E. Mitsui, pers comm). Bonnie's Pond hosts a breeding population of California Red-legged Frogs (*Rana draytonii*; Wilcox et al. 2017).

As part of a research project to determine conditions of oviposition by *R. draytonii*, various environmental sensors were previously installed in and around the pond (unpubl. data). A Hobo UA-001-64 temperature logger (Onset Corp., Bourne, Massachusetts, USA) was mounted on a 1 m-tall post approximately 1 m from the pond shore to record temperatures every half hour. A Hobo MX-2202 temperature/light data logger mounted

approximately 5 cm under and parallel to the water surface on a PVC pipe, collected data on light falling on the pond surface (in lumens), in addition to water temperature, every 30 min. Finally, from a raft in the pond center, a Hobo U26-001 dissolved oxygen logger was suspended at a depth of 1 m in the water column (unpubl. data). This unit also recorded water temperature and dissolved oxygen every 15 min.

Between 1 and 2 January 2019, the minimum overnight temperature (Mitsui Ranch weather station; about 300 m southeast of Bonnie's Pond) was -5.35º C (RX-3000, Onset, Corp.), and by 0840 had increased to -3.89° C, resulting in an approximately 1 cm-thick layer of ice over the entire surface of Bonnie's Pond (Fig. 1). Given the rarity of temperatures this low, we visited the pond to photographically record the freezing event. Standing on the earthen berm of the pond, we noticed movement approximately 2 m away along the shoreline. Closer inspection revealed two adult *A. marmorata* under the ice, one larger pond turtle slowly moving near the frozen edge in shallow water, and the other smaller pond turtle less active, nestled in a vegetated substrate (Fig. 2). Our initial observations occurred over 10 min, with the larger turtle slowly exploring the pockets and depressions where the ice met the shoreline. The turtles moved slowly and our presence did not seem to elicit any kind of flight response.

We investigated the remainder of the shoreline, and discovered four additional turtles a few meters from the first two. One of the four was exploring the shoreline in the same manner as the first turtle (Fig. 3), with two others exploring the substrate in the shallows of the pond. We observed another turtle swimming at an upward angle from deep within the pond but the turtle turned immediately and swam at a faster speed back in the direction from which it had come. Our last observation involved a turtle that had been at rest near the shore and swam away at our approach, but not before we captured a digital image showing it had a large leech attached to the posterior end of its carapace (Fig. 3). We recorded the air temperature at the Mitsui Ranch weather station on the day of our observations, but the remainder of the temperatures were downloaded from sensors retrieved later in the spring. Remote sensor readings at or around 0830 on 2 January 2019 contrasted with sensor readings from mid-afternoon (1530) on the same day (Table 1), illustrating the large temperature fluctuation on that winter day.

Figure 1. A layer of ice covers the surface of Bonnie's Pond on the Mitsui Ranch Preserve in Sonoma County, California. We detected six Northwestern Pond Turtles (*Actinemys marmorata*) near the shoreline in the lower right corner of the photo, under the ice. (Photographed by Jeffery T. Wilcox).

We observed six *A. marmorata* of various sizes active under ice on the morning of 2 January 2019. Previous researchers inferred turtles were moving under the ice of a frozen lake in Oregon while tracking movements with radio transmitters (Dan Holland, unpubl. report). Conditions at the surface of Bonnie's Pond on the morning of 2 January seemed extreme to us, but just under the ice, conditions were more tolerable for turtles. Air temperatures at 0830 were well below freezing, but just under the ice surface, 4 m from shore, the MX-2202 remote sensor recorded water temperature of 1.12º C, and the U26-001 sensor recorded a temperature of 6.24º

Figure 2. (Left) Two Northwestern Pond Turtles (*Actinemys marmorata*) under ice in Bonnie's Pond on a January morning in 2019 at the Mitsui Ranch Preserve near Petaluma, California. The turtle farthest right was slowly exploring the pond substrate at the ice edge, while the smaller turtle, at bottom center, moved very little during our observation. (Right) A single adult Northwestern Pond Turtle (*Actinemys marmorata*) shown leaving the shallow edge of an ice-covered pond making its way to deeper water. (Photographed by Jeffery T. Wilcox).

Figure 3. An adult Northwestern Pond Turtle (*Actinemys marmorata*) under ice in Bonnie's Pond, Sonoma County, California. Note the large leech attached to the rear marginal scute of the carapace. (Photographed by Jeffery T. Wilcox).

C at a depth of 1 m in the pond center (Table 1). By mid-afternoon on that same day, the surface temperature had increased by 5º C and ice had largely melted from the surface.

Most turtles in the Emydidae family (including *Actinemys*) are capable of cloacal breathing, where oxygen is exchanged with water absorbed across areas of dense capillaries in the cloacal walls (Carr 1995; Ultsch 2006). Turtles also have a very low metabolic rate in cold water, which lowers their oxygen demand, and also have relatively high tolerance to lactic acid build-up in the tissues, which allows them to use anaerobic respiration in low-oxygen conditions (Carr 1995; Ultsch 2006). Cold water has a higher capacity for holding dissolved oxygen, and the dissolved oxygen levels on that January morning were within the normal range of many other California water bodies sampled during warmer months (Silbernagel et al. 2013; see Table 1). Additionally, enough light was penetrating the water surface for algae in the water column to respire, likely contributing to oxygen production in the water column beneath the ice (Yang et al. 2017).

The Mediterranean climate of coastal northern California is not generally characterized by cold weather extremes, but periods of prolonged drought alternating with those of high rainfall are not uncommon (Schoenherr 1992). Prior to European settlement, *A. marmorata* primarily occupied stream habitat because ponded water was not a common feature in historically unglaciated areas of California (Trenham et al. 2001; Wilcox 2015; McMurry 2020). Thus, periodic high flows may have necessitated *A. marmorata* leaving lotic waters and overwintering on land to escape winter flooding (Reese 1996; Reese and Welch 1997; Ultsch 2006). The construction of stock ponds and reservoirs over the past century in California, however, has provided *A. marmorata* safer alternative water bodies in which to overwinter (Bury et al. 2012; Tu and Trulio 2022).

Water, in general, is thought to be a more favorable environment for overwintering turtles because the risk of predation is reduced (Ultsch 2006). Furthermore, water temperatures are less susceptible to the dramatic fluctuations that are physiologically stressful to ectotherms; and turtles are not forced to expose themselves to predation and desiccation as they search for suitable terrestrial overwintering sites (Ultsch 2006). Therefore, the temporary disadvantage of sequestration under a frozen surface may outweigh the risk of terrestrial overwintering for *A. marmorata*.

Table 1. Remote sensor readings from two times of the day during 2 January 2019 on the Mitsui Ranch Preserve, Sonoma County, California. The sensors UA-001-64, MX-2202, and U26-001 were located at or in Bonnie's Pond, and the RX-3000 weather station was located approximately 400 m east of the pond. The abbreviation Temp. = temperature.

Sensor	Time	Temp. (ºC)	Light intensity (lumens/m^2)	Dissolved Oxygen (mg/L)
RX-3000	0830	-3.89	—	—
	1530	9.24	—	—
UA-001-64	0830	-3.28	—	—
	1530	11.2	—	—
MX-2202	0830	1.12	16	—
	1530	5.10	1,033	—
U26-001	0830	6.24	—	5.06
	1530	6.83	—	5.69

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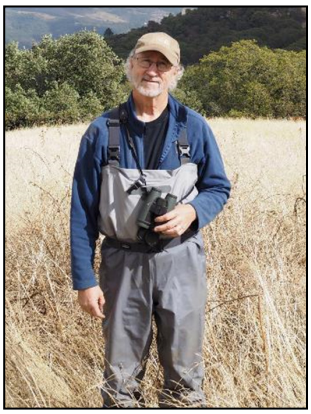

Jeff Wilcox is the Managing Ecologist for the Mitsui Ranch Preserve near Petaluma in Sonoma County, California. He has worked with landscape-scale parcels to manage sites for endangered species, native grasses, and compatible uses such as organic cattle grazing, education, and research. Jeff has decades of experience working collaboratively on projects that include pond management and construction, native grasses restoration, and species-level projects with California Red-legged Frogs (*Rana draytonii*), Wild Pigs (*Sus scrofa*), American Bullfrogs (*Lithobates catesbieanus*), California Tiger Salamanders (*Ambystoma californiense*), and Foothill Yellow-legged Frogs (*Rana boylii*). (Photographed by Lou Silva).

Jeff Alvarez is a Herpetologist who has specialized in California reptiles and amphibians for 37 y. He has worked with California Red-legged Frogs (*Rana draytonii*), California Tiger Salamanders (*Ambystoma californiense*), western pond turtles (*Actinemys* spp.), and Alameda Whipsnakes (*Masticophis euryxanthus*) for much of his career. His focus is on the conservation and natural history of herpetofauna, survey techniques development, and conducting peer-level special-status species workshops. (Photographed by Jorge Valdez-Villavicencio).