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CHAPTER 5

SAMPLING OF TURTLES: TRAPPING AND SNORKELING

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INTRODUCTION

Capturing turtles allows for the assessment of many population parameters, including demographic structure, sex ratio, fecundity, morphometric variation, and individual parameters (age, growth, health, injury, diet, movement). Many of these important features are not feasible or are less reliable when derived from visual surveys (Holland 1994; Germano and Bury 2001), but are possible with animals in hand for accurate measurements (for example, exact shell length, identification of sex, age determination). Further, capture of turtles allows animals to be marked for future recapture, which allows for estimates of population size, individual movement, growth rate, survival, and longevity. Capture of turtles can also be used to validate or calibrate results from visual surveys. Turtle capture is usually accomplished by trapping or by hand, but it is only recommended when visual surveys do not accomplish the goals of the study.

Trapping is often the best technique to capture Western Pond Turtles (*Actinemys marmorata*) in ponds and other standing water, especially if abundant aquatic vegetation, poor water clarity or quality, or muddy substrates make other capture methods difficult or risky. In our experience, trapping is less effective in flowing portions of streams and rivers. Capture in flowing waters is generally best done by hand: walking along the creek and feeling under cover objects or snorkeling in larger waters. However, hand capture methods may

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introduce bias if search effort is not consistent between observers and habitats, and snorkeling can pose safety concerns for the surveyors. Even though trapping in rivers or streams (flowing parts) is generally ineffective, it may be the only option in situations where there is a lack of qualified divers or other safety concerns exist (for example, swift or murky water, obvious or hidden hazards, water quality).

Reliance on a single method may produce a biased sample from the target population (Plummer 1979). For example, Ream and Ream (1966) found different results in sex and size of turtles for 5 techniques of capture (also see Frazer and others 1990). This problem may be corrected by using a variety of sampling techniques to obtain turtles (see Bider and Hoek 1971; Plummer 1979; Vogt 1980; Congdon and Gibbons 1996). Timing of surveys can also introduce bias. For example, a proportion of the females in a given population may not be available for sampling by aquatic methods for some portion of the nesting season (when females are on land). Some researchers report variability in capture rate by life stage, sex, and species (Lagler 1943; Cagle and Chaney 1950; Ream and Ream 1966; Frazer and others 1990). It is time well spent to explore a variety of sampling methods prior to selecting one technique and to minimize any bias in the results. Lastly, investigators need to be cautious about reporting differences in sex ratios and sex classes unless they have obtained large sample sizes of turtles (see Bury 1979). Thus, we review several techniques and methods to capture turtles for studies and monitoring to improve the quality and value of one's efforts.

Required Permits

State scientific collecting permits are required to capture Western Pond Turtles in all states where they occur naturally. Traps must be clearly and durably labeled with the name of the responsible organization, contact name, phone number, and permit number. Investigators and workers must possess a State scientific collecting or study permit. Other permissions may be needed from federal agencies (for example, at units of the National Park Service or refuges operated by US Fish and Wildlife Service), state agencies (for example, state parks, state game management units) or from the landowner or manager.

Trapping

Trapping is best suited for still waters (lentic) such as lakes, reservoirs, ponds, or vernal pools, but is sometimes useful in backwaters or other slow-water portions of rivers and streams (Reese 1996; Germano and Bury 2001; Bury and others 2010). If used in flowing waters (lotic), baited traps should be placed with the opening facing down current so the drifting scent of the bait will guide turtles toward the opening. Traps can also be modified by the addition of drift fences to guide turtles towards and into the trap opening. Baited traps are effective at capturing all but the youngest age classes. Less used but effective under certain conditions are "basking" traps, which are constructed of floating wood or plastic tubes that trap turtles in a net basket when they dive off a basking platform. These basking traps can be hand-built or obtained through several commercial sources.

Trap Designs

There are many types and designs of turtle traps (Figs. 11–15), and most catch turtles (Plummer 1979; Bury 2011). The size of traps should reflect waters to be sampled and available financial resources of the investigator. A variety of turtle traps can be purchased from commercial fisheries suppliers (mostly in the eastern United States) and most cost US$40 to $100 each, with larger traps costing more. Alternately, traps can be constructed out of hardware cloth or chicken wire (Iverson 1979). Most work well, but we suggest having a combination available to adapt to local conditions. Although there are other trapping methods that have been used on turtles elsewhere (for example, eastern North America), here we describe types of traps that have been successful at capturing Western Pond Turtles (baited funnel traps, drift fence with funnel trap), each with various designs. All traps should be constructed with nonstretch fine-mesh netting (2.5-cm size), such that turtle appendages do not become entangled. Traps need to be constructed so that there are no loose areas or sharp edges (for example, traps made out of chicken wire) that could entangle and drown turtles or cause injuries. Special care is needed to ensure the top of the traps remain above water to allow captured turtles to surface for air (Bury 2011).

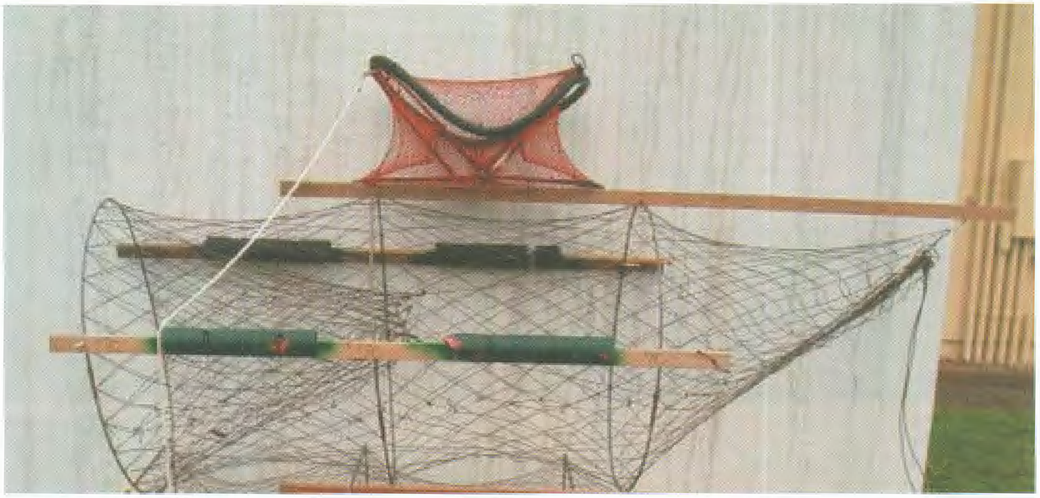

FIGURE 11. Two types of traps used to catch Western Pond Turtles. Top: Smaller version of collapsible trap with addition of bicycle inner tube zip-tied to outside rim to serve as a float. Bottom: Large hoop trap with wood spreaders and Styrofoam floats attached around spreaders.

Traps can be secured on top of a shoal or outfitted with reliable floats to keep a portion of the trap chamber on the surface to reduce the drowning hazard. Some turtles may become wary of traps after their initial capture (Tinkle 1958), but this may be rectified by changing type of bait. We advise a period of experimentation and field testing of type and number of traps, location, and other variables prior to establishing a survey effort. Trap types, materials, and costs are individual decisions. Experiment with types and settings to adapt to local conditions.

Funnel Traps

Most investigators trapping Western Pond Turtles use baited funnel traps (Germano and Bury 2001; Lovich and Meyer 2002; Rathbun and others 2002; Spinks and others 2003; Germano and Rathbun 2008). Collapsible traps can be home built, but most investigators purchase them. One of the most effective baited traps is a lightweight, small trap (about 0.6 m long) with funnels at one or both ends to allow easy turtle entry (Iverson 1979). These can be made by rolling a sheet of chicken wire or hardware cloth to form a 0.6-m long tube and wiring 2 pieces of mesh into funnels to attach to each end. The materials are cheap, but construction is time consuming and is hard on the hands, so wear gloves when building them. The round design can be flattened and easily pulled open in the field. Traps can also be formed into more of a rectangular shape, but these do not collapse as well. Rarely, turtles will get entangled in the mesh so traps need to be checked at least every 12 h. Also, semiaquatic mammals cannot chew out of these wire-mesh traps and may drown inside.

A similar design can be followed using nylon netting with a frame for support. These can be constructed of nylon mesh stretched between 2 to 4 hoops about 0.3 m in diameter. Materials can be purchased from net companies. An adaptation has been developed that uses polyvinyl chloride (PVC) pipes (sealed on each end with caps) tied along the outside of the trap. Hooks on the PVC pipes spread the hoops (resulting in taut netting) and the PVC tubes serve as flotation devices. Attach a dark- or drab-colored cord to the trap and tether to shore near basking objects.

An adaptation to the funnels could include use of a 1-way door because there is some evidence that turtles escape traps (Frazer and others 1990). One-way doors are used on commercial crab traps, but these have not been tested rigorously for use in trapping Western Pond Turtles. Frazer and others (1990) briefly mentioned that 1-way Plexiglas doors did not make any difference in escape rates of turtles in the eastern United States, and the use of 1-way doors on several traps at 2 sites seemed to hinder the capture of Western Pond Turtles (DJ

FIGURE 12. Commercial collapsible traps. Top Left: View of a moderate sized trap that is lightweight and portable. Top Right: Side view of large version. Bottom: Side-by-side comparison of mouth and funnel of traps. Bicycle inner tubes tied around outside of traps serve as floats (air added when in field). White twine on large trap shows areas where we mended traps in field.

Germano, pers. obs.). For the Red-eared Slider (*Trachemys scripta*), baited hoop traps appear to catch more males than females (Thomas and others 1999). If a female enters a trap, it may attract males. We have found no consistent difference in catch of sexes of Western Pond Turtles in baited traps (Germano and Bury 2001; Germano and Rathbun 2008; Germano 2010).

Commercial collapsible traps have been our favorite choice in recent years as they catch turtles well, are portable, and are reasonably low cost. Contact fishing supply companies that

FIGURE 13. Large commercial traps (see Fig. 12) without floats set in a pond where there is no concern for the trap moving.

specialize in nets. These traps are of various sizes and primarily used for crayfish and fish (Fig. 12). We have found that the moderate-sized traps (smaller one; Fig. 12) are highly effective for Western Pond Turtles. This design (model FT-D in some catalogs) is 70 cm long with a flat bottom (will not roll in water), and the dome-shaped "roof" (33 cm tall) allows turtles access to air. These traps are lightweight (approximately 1.5 kg), and relatively inexpensive (half the price of the larger size). Still, it is a small size overall and, if many turtles enter the trap, it may sink or be moved to deeper water. If you are concerned that the trap could move into deeper water, add a cord to the trap and tie it to something on shore. There may also be a benefit to having the trap set further into a pond (for example, to thwart predators or vandals). Add floats to the trap (Fig. 12), tie the cord to a solid object on shore (for example, tree trunk, vegetation, or a stake driven into the ground), and cast the entire trap out into a pond (for example, into an area with aquatic vegetation or next to branches).

A larger trap (95 cm long) with a higher dome (60 cm tall) and thicker rings is useful in deeper waters, such as lakes. Again, floats can be added but are not necessary in waters with shallow, sloping bottoms (Fig. 13). Additional floats can be made from 1-L empty soda bottles and put inside the trap as an added measure to ensure turtles can access air. These traps (model FT-FA) are moderately heavy (3.4 kg) and tend not to move once in place, such as on a shoal. Still, we always use parachute cord (doubled) or rope to tie the trap to the shore or to an upright stake in the water. In our experience (RB Bury, DJ Germano, pers. obs.), these traps may also catch semiaquatic mammals that can easily chew through the nylon mesh and some turtles that had been caught may escape.

Most commercial turtle traps are large sized (for example, 1–2 m long) and constructed of metal hoops 1 m in circular diameter. They are sturdy and durable (Fig. 11, bottom), but heavy: 2.2 kg without spreaders and 4.5 kg with spreaders. These hoop traps are best for large waters, and where invasive species may occur (as they capture Snapping [*Chelydra serpentina*] and Softshell [*Apalone* sp.] Turtles effectively because they have large mouth openings). Traps can be placed alone in shallow water (Fig. 13).

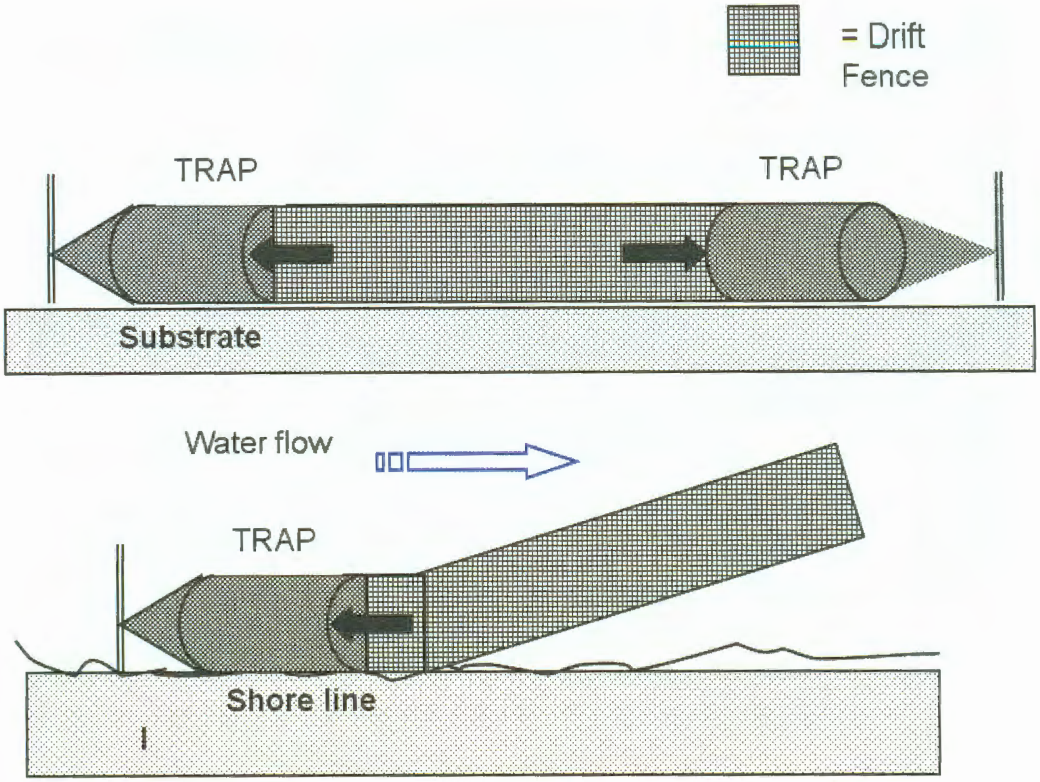

FIGURE 14. Two designs of drift fences and wings used to guide turtles into fyke traps. Top: Side view of drift fence stretched between two traps. Bottom: Slanted view of a trap with one arm serving as a drift fence. Black arrows indicate entrance into traps.

In standing water with a mud bottom, the turtle hoop trap is pulled taut by driving a stake in front through the front hoop or using cord to tie it to a stake in front. Then, a rope is tied to the back "V" area of the trap (which itself is tied in a big knot and used to access the trap) to another stake or to objects on shore, and pulled taut. We modified this system because traps sometimes need to be set in rocky substrate. We added wooden spreaders (2.5 × 3.5 cm; 1.5 m long). The netting must be taut for the mouth funnel to work properly. We attach the spreaders up the sides so the trap mouth will be underwater when the trap is floating. Large hoop traps from commercial sources are moderately expensive and can be cumbersome in the field because of their large size, long spreaders, and extra setup times. Further, they simply may be too large for many areas where Western Pond Turtles live.

Turtles can be attracted to traps by the scent of bait. The bait can be suspended in the middle of the trap either in a bait bag or tying string around the key of a sardine or tuna can. However, there appears to be no increase in catch over just placing the bait inside and on the trap floor (see Nall and Thomas 2009; DJ Germano, pers. obs.). For canned bait, perforate the can with small holes or open along one edge with a can opener to release the juices, but do not open cans all the way, as turtles or fish will eat the bait. To reduce expense in large studies, bulk baits (for example, fresh fish, raw meats) can be placed in bait boxes (for example, 35-mm film canisters, plastic bottles, or aluminum beverage cans with punched holes) or in wire mesh bags inside the trap. When emptying bait containers, pour off excess liquid in cans and then place them in a large plastic bag for disposal off-site.

Plummer (1979) stated that it is important to be open-minded and opportunistic in any collecting endeavor and suggested investigators experiment with several different kinds of bait on each population to determine the most

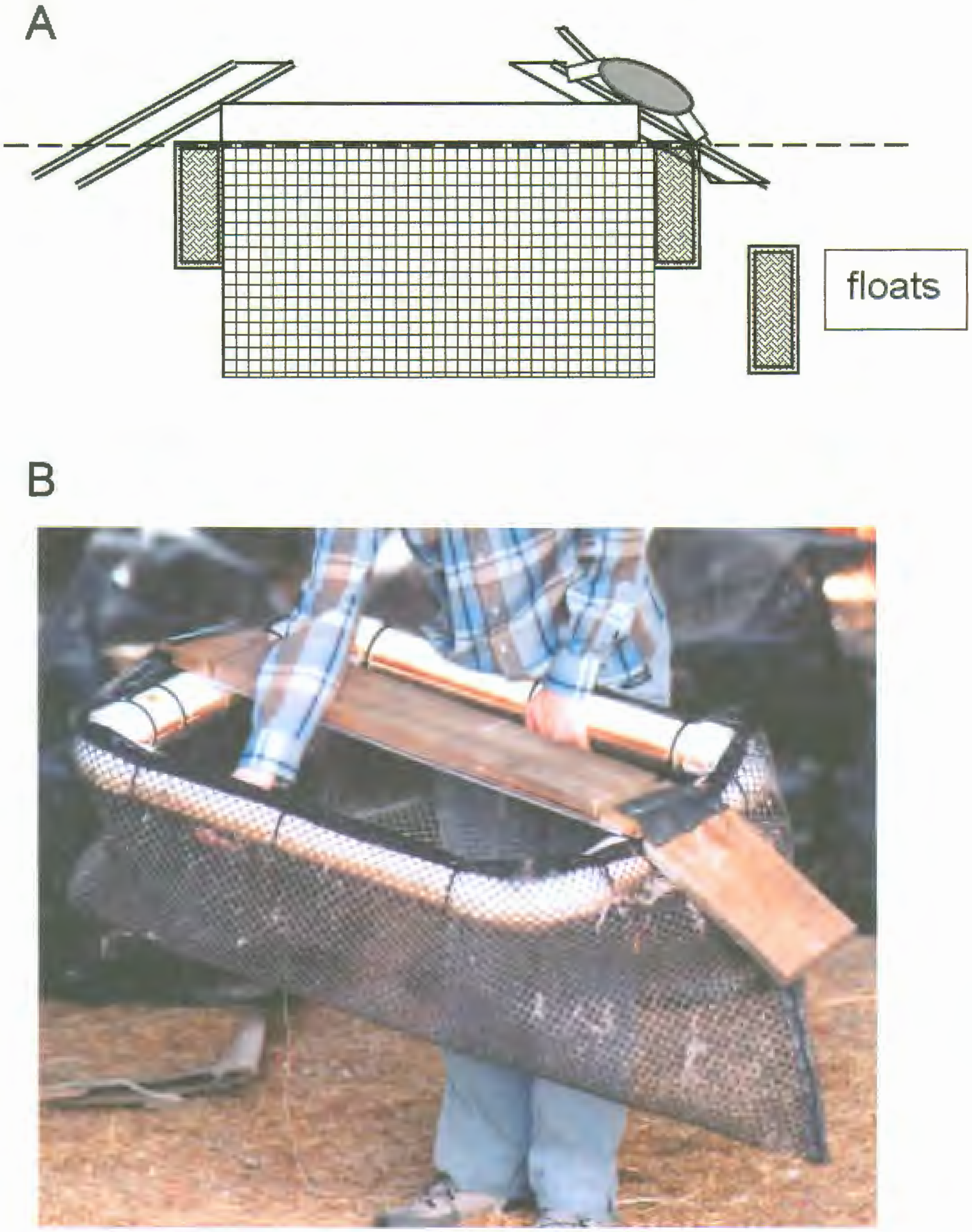

FIGURE 15. Top: Schematic side view of a basking trap that catches turtles when they slide or dive off end of ramps into the mesh trap. Smooth railing at top of trap prevents turtles from crawling out. Bottom: Picture of a basking trap. Photograph by Hannah Lucas.

attractive bait. Of 17 different types of bait used on aquatic turtles in Kansas, Voorhees and others (1991) had most success with bait with a jelly-like fluid: fresh mussels (freshwater) and canned creamed corn. Plummer (1977) found equal yield in catch of Smooth Softshell Turtles (*Apalone mutica*) in traps baited with fresh chopped fish or commercial dog food (sauce cubes), but turtles did not enter unbaited traps or those with bait more than 1 to 2 d old. Jensen (1998) caught most Alligator Snapping Turtles (*Macrocheelys temminckii*) with fish and most Red-eared Sliders with chicken entrails. Thomas and others (2008) reported that they caught significantly more Sliders (and Painted Turtles [*Chrysemys picta*]) in traps baited with frozen fish or canned mackerel than using creamed corn. Other baits used include fresh chicken, pieces of beef, or beef liver (Rose and Manning 1996; Spinks and others 2003; Thomas and others 2008). Although it is widely held that putrid baits are best to attract turtles, fresh baits are by far the most productive in traps (Lagler 1943; Tinkle 1958; Legler 1960; Plummer 1977, 1979).

Canned sardines in oil (no flavorings) work well as bait to catch many species of freshwater turtles (Legler 1960) and have been used to capture Western Pond Turtles (Germano and Bury 2001; Lovich and Meyer 2002; Rathbun and others 2002; Germano and Rathbun 2008; Germano 2010). We have also caught many turtles using cat food (salmon, tuna) or canned tuna fish in oil (RB Bury, pers. obs.). Fresh fish such as mackerel has been used successfully to attract Western Pond Turtles (D Holland, pers. comm.). Fidenci (2000, 2005) found that pieces of raw beef were superior to fish as bait in ponds he sampled in central California, but this appears to have been a special case. He pushed a wire through the bait and placed it in shallows, and then waited for turtles to bite the bait. He then grabbed turtles by hand. We have considered using earthworms (crushing a few to increase the smell) or small crayfish, which occur in many of the habitats of Western Pond Turtles. They readily eat these food items in captivity, but we have not used them for bait in the wild. While a number of baits have been successful in luring Western Pond Turtles into traps, there has only been limited testing to identify the preferred baits for Western Pond Turtles in different habitat types and seasons.

Drift Fence Traps ("Fyke" Traps)

Drift fences may be used to increase captures in baited traps or can be used for trapping without bait. Two designs (Fig. 14) are effective under different field conditions. A mesh drift fence (for example, 1 m tall × 10 to 20 m long) with floats on top and sinkers on the bottom can be stretched tight across a pond or bay. Attach the ends of the drift fence to openings of turtle traps at each end of the fence. Pull the fence tight by driving in wood stakes at the rear of each trap. Turtles that encounter the drift fence are guided into the traps. This design was effective for turtles in Nebraska ponds (J Lynch, pers. comm.) and in the upper Midwest (Vogt 1980; Congdon and Gibbons 1996). A variation is a trap with one wing set at an angle from a trap at the edge of stream, river, or pond (Sexton 1959a). Turtles are intercepted as they move along the edgewater and the wing guides them into the trap. This design has been employed successfully for Western Pond Turtles in tributaries of the Sacramento River (G Lubcke, pers. comm.). Lastly, traps with wings can be set in rivers or deep waters. These traps may be 1.0+ m tall and 2+ m wide with long wings or drift fences (Vogt 1980). These have been used effectively to trap turtles in large rivers in the eastern United States (RC Vogt, pers. comm.) but, to our knowledge, have not been tested in western North America. These are likely not the best choice in most situations in western North America because they are expensive, bulky to haul, and require a relatively long time to set up and operate.

Basking Traps

Basking traps have been used with Western Pond Turtles with various degrees of success in California (Reese 1996; Fidenci 2000; Spinks and others 2003). Basking traps can be constructed with a floating frame of wood or PVC pipe and commercial fishnet or hardware cloth (metal) that hangs suspended from the frame (Fig. 15). They require no bait, but turtles need to crawl up ramps. The ramp can be designed as a treadle that can flip inward when a turtle moves over the trap but then drops back to its original position. Others have boards across the center of the trap and turtles fall into the trap when exiting. Often turtles require time to become accustomed to basking traps unless the researcher is able to work the trap around an existing basking site. If the trap relies on creating a new basking site, it may be more effective when the bottom portion is left open or no mesh trap is attached for some time. This allows turtles to become habituated to the presence of the structure. Attach the mesh portion of the trap when ready to catch turtles. Basking traps tend to be fairly large (for example, 1–1.5 m^2), and can be awkward to move.

Several designs of basking traps have been used to catch turtles in other regions (see Carr 1952; MacCulloch and Gordon 1978; Plummer 1979; Browne and Hecnar 2005). One is simply a wire mesh basket attached to the side of a basking station (for example, a log) used by basking turtles. Because the top of the basket is at water level, turtles can leave at will when the trap is unattended. When ready to catch turtles, a person startles or runs towards the basking turtles, which causes turtles to dive off into the mesh trap. Then one boats or wades out to the trap to remove turtles from the basket before they escape.

TRAPPING TECHNIQUES

Sample Methods

Selection of sites to trap may include random subsamples of the area that was used for visual encounter surveys, or areas where site-specific presence or demographic data are required. A subsample method is useful in areas where visual surveys indicate concentrations of turtles or where one wants to correlate the number observed with the number captured. It is also useful for the systematic gathering of data where Western Pond Turtles or other species of invasive turtles (for example, Red-eared Sliders, Snapping Turtles) are suspected to occur. The 2nd or site-specific method may be more useful to gauge abundance and trends in Western Pond Turtles. Trapping is also useful to monitor the efficacy of mitigation in project areas (for example, measures of turtles prior to and after a construction project). The trapping protocol here is offered as a consistent and repeatable method that may allow reliable comparisons between sites. We suggest relatively short bursts of trapping (1 or 2 nights minimum) with as many traps as are available. However, investigators need to experiment with methods that work locally or regionally. Instructions and advice provided here are only recommendations. Circumstances can dictate other densities, placements, and duration of time between to trap checks.

Trap Density and Placement

In general, we set traps about 10 m apart along shorelines. Trap spacing may be reduced to 5 m apart in areas of dense cover (for example, root tangles). We set a trap on each side of large objects such as a log or tree in the water, or several large boulders. In lakes or reservoirs, try to trap in 2 to 3 bays. If the number of traps is limited, apply a trap set in each bay in successive time periods and consider the entire effort to be 1 trapping replication (but account for recaptures if turtles move between bays).

Place the traps in or near cover and near basking sites (for example, floating logs, brush piles, vegetated shoals, rocky points) where turtles congregate. We set traps on each side of logs, keeping the trap length parallel to the object in the water. Set or toss traps into vegetated shoals (for example, Cattails, aquatic vegetation). In slow streams or rivers, place the traps upstream from basking sites within pools or in side channels or oxbows. Attempt to locate the trap in slow water near bank overhangs or in cover that creates backwaters. Traps should be securely anchored (as described previously). We make a field map of location of each trap, so that all traps can be relocated rapidly on the return visit and no traps are left behind.

We routinely set 6 traps (4 moderate-sized and 2 large-sized collapsible traps) in a small pond (Germano and Bury 2001; RB Bury and DJ Germano, pers. obs.), but we have not tested what proportion of each type achieves better results. On occasion, we also set out 1 large hoop trap, especially in urban areas where there may be introduced turtles (many are larger sized than Western Pond Turtles). Usually, there is insufficient time to cover large waters or many sites.

Replication

We recommend a minimum trapping effort of at least 1 night with 4 turtle traps (a trap set event) to increase the probability of captures. An additional trapping session is recommended 2 to 4 wk later. In some waters, most of the yield is on the 1st night of trapping. However, turtles may continue to be trapped over 3 d, perhaps longer. In general, we have found reduced yield the longer traps are set in small ponds, but we have seen no pattern in larger waters. Experiment with length of trapping sessions. Some turtles avoid traps once caught or, possibly, may temporarily emigrate from their site of capture. Recapture of these individuals may require a new bait type or different techniques (for example, traps with wings or snorkeling). There is no set protocol at this time for the number of traps or how many nights to set them.

Set and Check Times

Traps should be checked at least every 12 h (overnight set) and more frequently in the day to reduce the chances of turtle escape or mortality. Frazer and others (1990) found that during an experiment turtles escaped from traps much more frequently than anticipated. Over a 24-h period, 16 of 24 Painted Turtles and 2 of 8 Snapping Turtles (*Chelydra serpentina*) placed into traps escaped. Smith and Iverson (2004) reported daily activities based on traps checked every 3 h. Painted Turtles and 2 other species had peaks in midmorning (09:00–12:00) and most had high catch at dawn (06:00–09:00).

We found it best to set traps in late afternoon and evening (for example, between 16:00 and 19:00). We try to check traps 06:00 to 08:00 and this is consistently when most turtles are in traps (RB Bury, pers. obs.). We rarely find turtles after the morning check. In late afternoon or early evening, we check traps again and add a small amount of new bait or rebait traps, if bait is missing. Trapping is also successful with checks just in mornings (DJ Germano, pers. obs.).

To determine the catch per unit effort, record the time when traps are set and pulled. As an example, employment of 6 traps for 2 nights equals 12 trap-nights. Although checking of traps in less than 12 h may disturb turtles and lower the yield (Lagler 1943), traps checked and rebaited at 1- to 2-h intervals had a higher capture rate than did traps left for much longer periods (Legler 1960). However, checking traps this often can be impractical.

Disturbance

Disturbance by observers at sites could affect the capture success of turtle traps. Limit the amount of time spent in the water when setting and checking traps. Avoid having more than 2 people at the site and leave the area promptly once the traps have been set. Areas where recreational use is high should be avoided because traps may be stolen or vandalized. Sometimes recreational use is concentrated on weekends; therefore, trapping during midweek may be desirable at these sites. Attempt to camouflage traps and place them where they will be inconspicuous to humans yet accessible to turtles.

Theft of traps or contents is possible in areas where human activity is high. In these areas, it may be necessary to set traps and have 1 person watch them continually. Basically, run a trap line and stay in sight of all set traps. Traps occasionally yield turtles in relatively short periods (for example, 1–2 h in the evening or early morning). Sometimes, turtles will be attracted to bait set in shallow water and in relatively short time (Fidenci 2005). There is a trade-off between leaving traps unchecked and having turtles escape (Frazer and others 1990) or of disturbing turtles at the trap and immediate area by frequent checking of traps. Turtles vary in response to presence to people (for example, some turtles in city parks are habituated to our presence). Experiment with times of checking to maximize yield of turtles.

MORTALITY AND BYCATCH IN TRAPS

If a turtle found in a trap appears dead, remove it to a dry bucket and place in the shade. We have found 3 turtles (out of >3000 trapped) that had no movement or responses when removed from traps set overnight. We held the turtle with its head down, and pushed gently on its plastron to force any water out of the lungs. Gently push and pull on the legs to pump air into the lungs. Then, we placed the turtle in a safe area (where no predator can attack it). All of the "dead" turtles recovered in 6–10 h, but one took 20 h. The longest record was an adult female that started to move a little after 8 h but then fell limp again. We kept her overnight, and she was fully recovered when checked the next morning.

Turtles have remarkable ability to recover from anoxia (lack of oxygen). Turtles can remain underwater for extended periods (Ultsch and others 1984). Some species overwinter in ponds, but these areas are cold in winter and turtles slowly adjust to the change. During trapping surveys, however, water and air temperatures are relatively high. Survival of anoxic turtles rapidly decreases with elevated temperature. Still, our preliminary observations suggest high potential of turtles to recover from apparent drowning. If turtles do not recover, they should be kept for later disposition (for example, museum specimens, dissection). Preserve in the field (a task that takes 15 min or longer) or freeze the carcass.

Bycatch may result in mortality of species other than turtles. Although rare, turtle traps will on occasion catch fish. Checking twice a day reduces loss of fish. Few fish die in traps if checked frequently. Crayfish and bullfrog tadpoles may be taken in large numbers in certain situations. Mortality is rare. A caution is catch of belostomatid water bugs (flat body with large front claws) that may reach 90 mm long. These insects attack prey and kill them with a piercing (beak) mouthpart. They can inflict a "bite" that is more painful than that of a hornet or several at once (RB Bury, pers. obs.). They can usually be shaken out of traps.

In some water, a problem is bycatch of semiaquatic mammals (for example, Muskrat [*Ondatra zibethicus*], Nutria [*Ondatra zibethicus*], Mink [*Mustela vison*], River Otter [*Lontra canadensis*], Beaver [*Castor canadensis*]) that could enter a trap and drown. Otter and Beaver likely would destroy the trap while escaping. We have never trapped any of them. The other mammals appear able to chew through the nylon netting and escape, and we have not discovered drowned or hypothermic mammals in any nylon-mesh traps. Sometimes, Nutria and Muskrat drown or die of hypothermia in chicken-wire traps. Although Nutria is an invasive species and considered a pest, as is Muskrat in parts of California, the use of chicken-wire mesh traps was changed to mesh netting and no more were found dead because they chewed out of the mesh. Several traps had large holes that later had to be patched.

Investigators must operate traps in accordance with local, regional, or state fishing regulations (sometimes separate from scientific permits). Be alert to special rules for threatened or endangered species of fish or other aquatic biota in the trapping area. For example, trapping with long drift wings is not allowed in areas with migrating stocks of salmonid fishes. Some waters may be closed to trapping (for example, during runs of spring Chinook Salmon, *Oncorhynchus tshawytscha*).

HAND CAPTURE: "MUDDLING" AND SNORKELING SURVEYS

The purpose of hand capturing turtles is the same as for trapping: to determine population parameters and individual characteristics not measurable with visual surveys. Hand capture is usually employed in flowing waters where trapping would be inefficient or impossible. It can also be useful in standing waters.

To reemphasize, conducting research near, in, or on the water has inherent dangers that may require the use of lifejackets, water safety training, boat handling training, scuba and snorkeling safety, and emergency communication planning. Prior to any activity near, in, or on the water, it is essential to develop a safety plan specific to the conditions. Most federal and state agencies have established safety requirements for conducting field activities near water. It is the responsibility of the investigator to know the safety requirements of the agency they are working for and to develop an approved safety plan before sampling is initiated. Advanced planning is the key to keeping everyone safe during field activities.

"Muddling"

Turtles can be captured by wading through shallow water and feeling with your hands through algal mats, vegetation, undercut banks, under boulders, or other cover objects with your hands (Cagle and Chaney 1950; Bayliss 1975; Vogt 1981). This is termed "muddling" in the eastern United States (Cagle 1950), and it is usually done in ponds, lakes, or slow rivers. During muddling, your head and upper body are usually above water. Besides an agency-approved safety plan for working near or in water, there are special considerations that should be recognized for those working in eastern North America because of the presence of aggressive turtle species (Snapping Turtles [*Chelydra* spp.], Softshell Turtles [*Apalone* spp.]) and poisonous snakes in the water. This was not of concern in western North America until recent evidence of invasive species of turtles

(Bury 2008a). Besides biting turtles, there is also danger in cutting oneself on trash and debris in waters. Procedures to address hazards associated with muddling must be addressed in the safety plan before sampling is initiated.

Some researchers report this technique may result in a larger proportion of capture of juveniles than mature turtles (Cagle and Chaney 1950; Gibbons 1968; Moll and Legler 1971). Muddling may be useful to locate juveniles of Western Pond Turtles. In northern California, more juveniles were captured by hand searches of shallow areas than by setting traps or diving in deeper pools (Bury 1972a; RB Bury, unpubl. data).

Snorkeling

Free diving using a mask and snorkel is a specialized technique that appears to be the most effective technique to sample Western Pond Turtles in streams and rivers. The technique has been widely used to sample many populations (Bury 1972a; Holland 1994; Reese 1996; Reese and Welsh 1998a, 1998b; Todd 1999). Snorkel surveys depend on experience and skill, which can vary between divers and, thus, introduce bias. Therefore, comparisons between areas should be viewed with caution.

Emphasis on safety is extremely important when using snorkeling as a capture method. Prior to any sampling effort, the surveyors must be aware of the safety requirement of the agency they are working for and must develop an approved safety plan before sampling is initiated. Scuba and snorkeling are inherently dangerous, and most agencies require specialized training before these techniques can be used. Nobody should attempt to use these techniques who has not been properly trained and not met the requirements of the agency they are working for. In developing a safety plan we recommend that in addition to addressing the standard hazards associated with scuba and snorkeling, you also consider some of the potential hazards we discuss below that can be associated with conducting surveys to collect pond turtles. While we will discuss a number of potential hazards, this is not a comprehensive list. It is the responsibility of the investigator to conduct a thorough assessment of potential hazards and include the appropriate safety precautions in the safety plan.

All waters can hide hazards beneath the surface, but streams and rivers have the added danger of moving water. In a strong current, logs, branches, and boulders can form natural strainers able to trap and hold a diver. Many human-produced hazards may also be present, especially near bridges. Beware of barbed wire, broken glass, old cars, and other metal wreckage. Fishhooks and fishing line may be plentiful in some areas. Touch lightly under objects to avoid injury. Rope, wire, or fishing line, or even vegetation in the water can entangle a diver. The type of fins a diver uses can pose additional safety concerns when searching for turtles. Fins with vents or holes in them can hook on branches, trapping the diver by the fin. In even a moderate current, divers trapped by the foot may not be able to reach back and free themselves.

Constituents of the water can also present hazards. Microorganisms can cause ear infections, especially later in the season during algal blooms. Chemical contamination may present a serious hazard in some areas. Just because turtles are present does not mean the water is safe for humans.

There is danger of being bitten while feeling underwater for turtles. Although mammals (for example, River Otter, Beaver) occur in bank undercuts and other refugia. Be extra cautious if there are scat piles on shore (indicates presence of River Otter) or Beaver holes and cut trees and shrubs along waterways. We skip actively used entrance tunnels (for example, Beaver), often marked by fresh cut leaves and twigs.

Be particularly attentive when searching near or under large woody debris or boulders, which could roll or fall, trapping the diver. Before reaching under any object, push firmly against the object to ensure it is secure and will not move. If there is any doubt to the stability of an object or other safety concerns at a site, skip the site. Again, snorkeling should be employed only by skilled personnel and under the strictest of safety guidelines outlined and addressed in an approved safety plan.

Search Techniques

Developing search techniques should go hand in hand with developing the safety plan. The specific methods used to search for turtles may pose additional safety concerns that need to be addressed in the safety plan. In this section we describe some of the techniques we have developed to increase the probability of finding turtles during a survey. It is the responsibility of the investigator to include the safety procedures for implementing these techniques in the safety plan. The search method depends on the depth of the water and whether pools or riffles are being searched. In smaller streams and creeks we generally start at the lower reach of suitable habitat (for example, a pool in a stream) and systematically work upstream. Any stirred-up mud or debris will float downstream and out of your view forward (upstream). In larger rivers with stronger current, it is difficult for surveyors to swim upstream against the current and they may need to search in a downstream direction. Conducting searches in a downstream direction poses additional safety concerns that must be addressed in the safety plan.

Regardless of the direction of the search, divers search for turtles using both visual and manual techniques. First, check visually under objects and then do a tactile search with your hands in crevices. For deep pools, search basking sites and the surface of the water for the heads of turtles; if they are observed, dive where the turtle was last seen and feel for the turtle. Search bank undercuts or under large boulders or rocks. You will need to use your hands to search in many places because stirring up sediment will reduce visibility. Use a slow "windshield wiper" arm motion to feel for turtles in vegetation or mud.

Divers can walk shallow riffles and search under hummocks with their hands and visually search into the water. If deep enough, it is usually more effective to float or crawl through riffles and probe with your hands rather than walking upright and bending to reach under objects (RB Bury, pers. obs.). This allows for a longer reach under objects and into crevices. Slowly push your hands into root tangles (for example, Willow [*Salix* sp.] roots) because many turtles hide in these thickets; sometimes the water will be shallow (for example, <0.5 m). Be sure to check side channels, oxbows, and backwater pools because juvenile turtles will often be found in these areas. In rivers or large waters, divers need to scan ahead when underwater looking for turtles in open water; then search crevices, under rocks and logs, in woody debris piles, and through root wads and aquatic vegetation. Turtles congregate in large numbers in some sites, and a population can be underestimated without rigorous search of habitat for these "hideouts." We have found several such hideouts by following radio-tagged turtles.

Surveyors need to use extreme caution when reaching into and searching around debris and undercuts due to the potential of becoming entangled or trapped. The safety plan should address methods to prevent these types of emergencies, as well as procedures that can be implemented if an emergency situation arises. Only properly certified and trained personnel should be involved in these types of surveys.

Above water, turtles appear to have keen senses of hearing and vision. Basking turtles may jump in the water when they spot a person as far as 100 m away (D Reese, pers. obs.). Divers can sneak up on basking turtles by approaching from underwater and then reach up and grab the basking turtle or watch from underwater while creating some disturbance on the surface, causing the turtle to dive off the basking site into the view of the diver. This technique can also be used to help train new divers. By watching underwater while turtles are seeking cover, the diver becomes more aware of the types of places where turtles may hide.

Underwater, turtles appear to be less wary than when basking (D Ashton, RB Bury, pers. obs.). A diver can often approach within a few meters of a turtle without being noticed. When a turtle does notice the diver, it may freeze in place, flee by swimming, or cover itself with sand and silt. When a turtle is first observed, the diver should notice its position and general behavior (such as basking, active, stationary in underwater refugia) before capture. Capture the turtle and hold onto it for a minute, scanning the immediate area for other turtles before taking animals to measure. Often there will be more than 1 turtle in the immediate vicinity, usually within a few meters.

Reese and Welsh (1998b) developed a standardized sampling protocol to compare Western Pond Turtle populations from 2 forks of the Trinity River in northern California. Their method involved divers searching each side of the river and used hand signals to communicate. The teams started upstream of the survey area to avoid disturbing the area prior to diving. Divers moved downstream with the flow, keeping aware of the other team on the opposite shore while searching the underwater area from the bank to about 4 m out (the feasible search area for a diver floating downstream). To avoid biasing the search effort, both dive teams moved at a similar pace, applying a consistent search effort across all habitat types, including backwater pools, islands, side channels, and marshy banks. Once divers captured a turtle, it was given to a team member who recorded the location of capture, time of capture, specific data about the turtle, and other factors that could affect turtle activity, such as weather, water conditions, human disturbance, and evidence of predator activity. The turtles were released at the point of capture after being measured and marked. Several different habitat types may be present in an area, and backtracking may be necessary. For example, when side channels are long, divers may want to return to survey them after surveying the main channel. Reese and Welsh (1998b) also described methods to survey vernal pools, ponds, oxbows, large backwater pools, and wetland habitats for turtles. The number of divers needed depends upon the size of the habitat being surveyed and the number of divers and support personnel to safely conduct the work.

Regardless of capture method (trapping or hand capture), handling of turtles should be limited to that needed for assessment, measurement, photographs, and marking. Minimize time turtles are held and be sure to not crowd them in buckets or totes. All work should be part of a designed and permitted survey or study. Prior to attempting capture, become familiar with the field procedures for proper handling of turtles and standardized measurement techniques (see Chapter 7).