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Big Turtles Start Small: Trapping Juvenile Alligator Snapping Turtles in South Mississippi and Implications for Conservation

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Abstract - *Macrochelys* (alligator snapping turtles), the largest freshwater turtles in North America, were recently proposed for threatened status under the US Endangered Species Act. Many previous surveys have focused on catching these large turtles in large river systems, but few surveys have focused on targeting hatchlings and juveniles, particularly in smaller rivers and creeks. I trapped extensively within the Pascagoula River drainage using small, baited crayfish traps, and a considerable focus of the study was in small rivers and streams. Juvenile *Macrochelys temminckii* (Alligator Snapping Turtle; 42.2–192 mm) were detected in small streams and large rivers (30.4 km^2–22,000 km^2), and the small traps were effective at capturing young alligator snapping turtles. Smaller streams are logistically harder to trap from a boat, but small streams should not be overlooked when sampling for this species, as these streams may have served as refugia during commercial harvest over the past century.

Introduction

Macrochelys (alligator snapping turtles) are very large freshwater turtles found in Gulf Coast drainages in the southeastern and midwestern United States (Ernst and Lovich 2009). There are 3 proposed species in the genus: *M. temminckii* (Troost in Harlan) (Alligator Snapping Turtle, hereafter distinguished from the common name of the genus by the use of capitalization), *M. suwanniensis* Thomas, Granatosky, Bourque, Krysko, Moler, Gamble, Suarez, Leone, Enge and Roman (Suwannee Alligator Snapping Turtle), and *M. apalachicolae* Thomas, Granatosky, Bourque, Krysko, Moler, Gamble, Suarez, Leone, Enge and Roman (Apalachicola Alligator Snapping Turtle). Because these species can attain such large sizes, alligator snapping turtles were heavily exploited for the turtle soup industry as well as opportunistically for local consumption (Pritchard 1989). This exploitation along with habitat alteration and degradation has threatened the persistence of these species across much of their range where they have experienced significant declines (King et al. 2016, Moll and Moll 2004, Pritchard 1989, Sloan and Lovich 1995). Turtles are characterized by life histories that exhibit delayed sexual maturity, long lifespans, and high adult survivorship to maintain stable populations (Congdon et al. 1994, Folt et al. 2016, Reed et al. 2002).

The historical harvest, contemporary legal harvest (e.g., Mississippi and Louisiana), and incidental mortality from recreational fishing have warranted the proposal of *M. temminckii* for threatened status under the US Endangered Species

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Act (USFWS 2021). While there have been many surveys for alligator snapping turtles across their range (Baxley et al. 2014, Bluett et al. 2011, Boundy and Kennedy 2006, Folt et al. 2016, Huntzinger et al. 2019, Jensen and Birkhead 2003, Riedle et al 2005, Shipman and Riedle 2008), most surveys involved the use of large, baited hoopnets (>1 m in diameter), with only 1 study incorporating the use of slightly smaller hoops for capturing *M. suwanniensis* (60 cm diameter; Johnston et al. 2015). Indeed, large hoopnets with large mesh sizes seem to be more adept at catching snapping turtle (Chelydridae) species (Ennen et al. 2021, Gulette et al 2019). However, large traps preclude the capture of smaller turtles, or at least allow smaller turtles to enter and exit the trap without being detected (Gulette et al. 2019). Larger traps can also be more cumbersome, and usually require the use of a johnboat to transport and deploy. Furthermore, larger traps often necessitate larger and deeper bodies of water to be set effectively, which limits researchers' abilities to sample smaller, non-navigable waterways where recreational and commercial fishing practices would also be more limited, and hence where turtle populations may have experienced lower harvest pressures and/or incidental loss. While these studies have laid the foundations of our understanding of the status of alligator snapping turtles across their range, there are still gaps in our knowledge of the hatchling, yearling, and other juvenile age classes that are not well-represented in previous studies, as well as the breadth of habitat conditions used by these species.

This lack of data on younger age classes is not unique to alligator snapping turtles. Coined the "lost years" by Carr (1952), hatchling turtles are cryptic out of necessity because they make easy prey for a multitude of predators. However, these missing data are important pieces to understand the life history and ecology of many turtle species, particularly those that may be declining or that may warrant federal protection. Alligator Snapping Turtles were originally denied protection under the Endangered Species Act (1973) due in part to gaps in the knowledge of its life history (Riedle et al. 2008, Spangler et al. 2021). A case-in-point, Folt et al. (2016) had to infer demographic parameters for the hatchling and juvenile age classes of *M. temmincki* from data published on *Chelydra serpentina* (L.) (Common Snapping Turtle; Congdon et al. 1994) to model the population demographics.

As part of a study on the lotic musk turtles (*Sternotherus minor peltifer* Smith and Glass [Stripe-necked Musk Turtle] and *S. carinatus* (Gray) [Razor-backed Musk Turtle]), I used small crayfish traps, as these traps are most adept at catching small kinosternid turtles (McKnight et al. 2015). However, I also caught many juvenile *M. temmincki* across a wide range of habitat types. Thus, the objectives of this study are to address the efficacy of using small traps to capture hatchling and juvenile age classes of *M. temminckii*, as well as document the distribution and the range of habitat types occupied by this species in southern Mississippi.

Field-site Description

The Pascagoula River system is the largest unimpounded river system in the contiguous United States (Dynesius and Nilsson 1994). The Pascagoula Basin is located in southeastern Mississippi and extends into extreme southwestern Alabama

(Fig. 1), draining an area of about 25,000 km^2. The Pascagoula River proper is formed by the confluence of its 2 largest tributaries, the Leaf and Chickasawhay

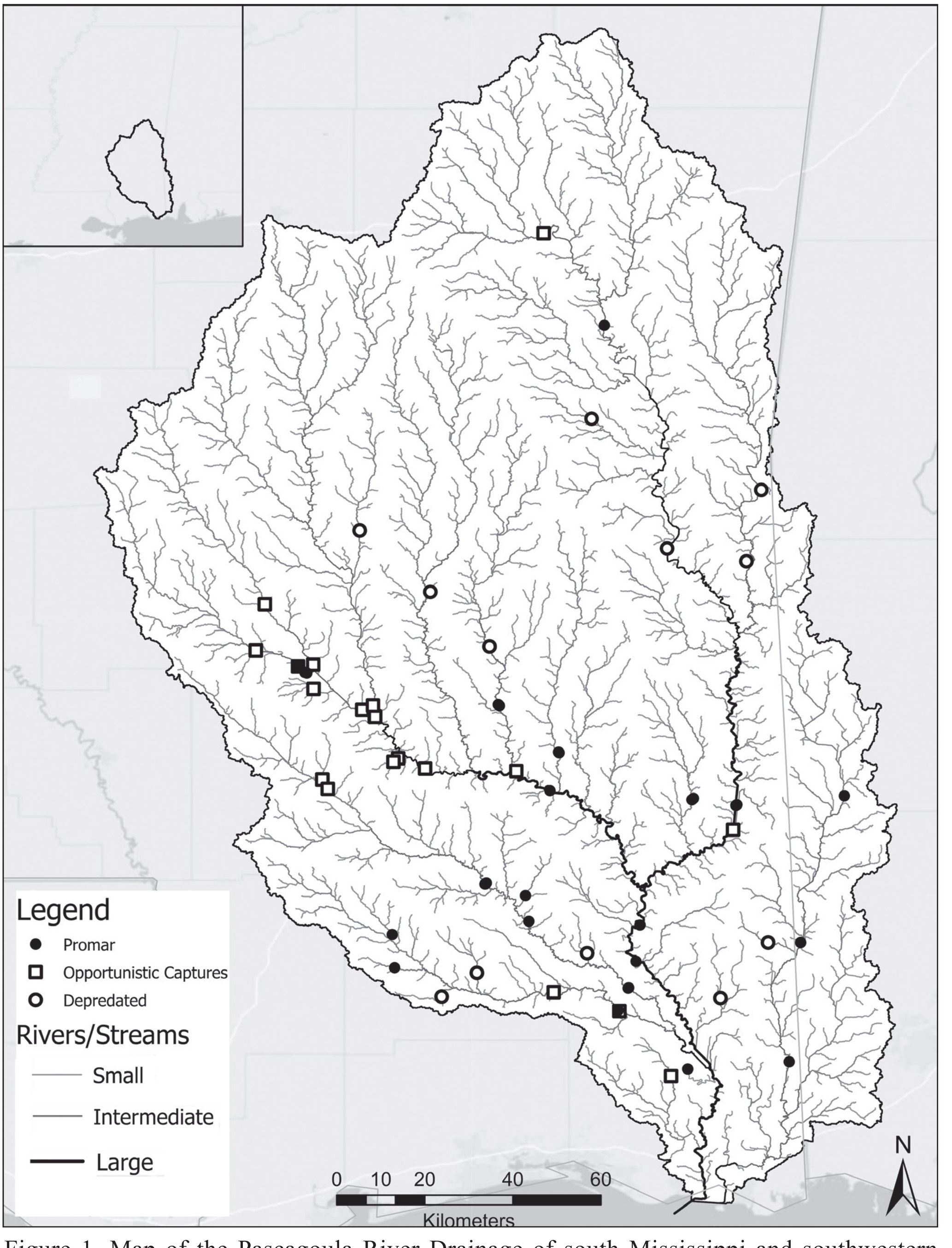

Figure 1. Map of the Pascagoula River Drainage of south Mississippi and southwestern Alabama showing sites with evidence of Alligator Snapping Turtle presence. Closed circles represent sites where juveniles were caught in crayfish traps, open circles indicate traps that were likely raided by adults, and open squares represent opportunistic captures.

rivers, whose headwaters originate near Forest and Meridian, MS, respectively. I used stratified random sampling to select 60 potential trapping locations from points of public access (boat launches, bridge crossings, etc.). I classified sites into 1 of 3 groups based on discharge data from the EDNA watershed layer (USGS 2007): small stream (0.5–10 m^3/sec), intermediate-sized streams (10–100 m^3/sec), and larger rivers (>100 m^3/sec). Sites varied in drainage area from 12.6 km^2 to 22,000 km^2, which corresponded to an average stream width varying from 3.8 m to 140 m. Substrates varied considerably based on locality. Some areas around Meridian were composed of sandstone or limestone bedrock, whereas most streams and rivers were more typical of the coastal plain: sinuous stream stretches with cutbanks and abundant deadwood to one side, and sand or gravel bars on the other. Sites varied in canopy cover, but this was driven by changes along the river continuum (small streams had greater canopy coverage and rivers had less canopy). All sites had intact riparian zones (i.e., no sites had been clear-cut).

Methods

Depending on the size of the stream, I either waded, canoed, or accessed sites with a johnboat. In 2018, I systematically sampled from all major tributaries of the Pascagoula River: Red Creek, Black Creek, Leaf River, Chickasawhay River, Escatawpa River, and the mainstem of the Pascagoula River. At each site, I set 15 collapsible, cylindrical crayfish traps (91 cm long x 30 cm diameter, polyethylene with 2 entrances; TR-502; Promar®, Gardenia, CA) for 2 nights, for a total of 30 trap-nights per site. I set traps like miniature hoopnets in shallow water (25–80 cm in depth) near suitable in-stream structure (e.g., immediately upstream of woody debris, log jams, or rock ledges) and baited with 1 can of sardines in soybean oil (Bumble Bee Foods®, San Diego, CA). All traps were tied to a stationary point (i.e., secure instream deadwood or the bank). I placed an empty water bottle at one end of the trap as a buoy to account for any fluctuations in water level to reduce risk of drowning. A trapping session consisted of 3 days total: 1 day of setting traps followed by 2 consecutive days of checking traps. I also opportunistically hand-captured turtles while setting and checking traps, but these were not included in my catch per unit effort (CPUE) calculation.

As part of separate studies, I also set crayfish traps to catch lotic *Sternotherus* in 2017 and 2019, but did not collect habitat data and number of trap-nights during these less formal surveys despite Alligator Snapping Turtles being detected. At one small stream site in 2017, an aquatic predator tore open many crayfish traps, so I set two 91-cm hoop-traps (3 ring, galvanized steel, #15 gauge 3.81-cm mesh) baited with *Cyprinus carpio* L. (Common Carp) to determine the identity of this predator. Otherwise, no standard-sized hoop nets were used in this study as comparison.

In addition to sampling turtles using crayfish traps, I also conducted wading surveys across all years of this project to supplement data for a genetic study of *Sternotherus,* and Alligator Snapping Turtles were also encountered during these surveys. Wading surveys took place at either dawn or dusk (with aid of flashlights) when many species of turtle are most active (Ernst and Lovich 2009).

For all Alligator Snapping Turtles, I collected standard measurements using calipers, including straight-midline carapace length (CL). I marked all Alligator Snapping Turtles using a unique combination of notches on the posterior marginal scutes (8–12), based on a modified Ernst et al. (1974) marking scheme. I measured mass, if possible, with a 600-g Pesola scale (Baar, Switzerland). If turtles weighed more than 600 g, I recorded their mass as >600 g. A larger Pesola scale was not necessary when sampling for *Sternotherus* (the original target species for the surveys), which is why masses greater than 600 g were not recorded. Though I collected habitat data in 2018, they were not collected across all years and not analyzed. Instead, I used the National Hydrology Plus database (USGS 2017), as well as StreamStats (USGS 2016), to extract the cumulative upstream drainage area (UDA) at each site as a descriptor of stream size to determine the breadth of stream size used by the species in south Mississippi. Similar to the discharge data used to select streams, I defined streams with UDA less than 100 km^2 as small, UDA of 100–1000 km^2 as intermediate, and UDA greater than >1000 km^2 as large.

Results

In 2018, I trapped 57 (20 small, 19 intermediate, and 18 large) riverine and stream sites. Only the 18 large lotic sites were navigable by johnboat (hereby referred to as navigable); other sites were waded or canoed (non-navigable; Fig. 1). The total effort I accumulated was 1509 trap-nights across the Pascagoula River watershed (520, 523, and 466 trap-nights at small, intermediate, and large lotic sites, respectively). Lost traps, damage to traps, or water-level fluctuations resulted in a loss of 201 trap-nights (12%). I caught a total of 346 turtles at 53 of the 57 sites. The 3 most frequently encountered species were Stripe-necked Musk Turtle (n = 101; catch per unit effort [CPUE] = 0.07), Razor-backed Musk Turtle (n = 88; CPUE = 0.06), and *Trachemys scripta* (Thunberg in Schoepff) (Pond Slider) (n = 64, CPUE = 0.04). Alligator Snapping Turtles were the fourth most frequently encountered species with 26 juvenile Alligator Snapping Turtles (CPUE = 0.02; mean carapace length – 120.7 ± 40.5 mm) caught in crayfish traps at 19 of 57 sites (2 small, 6 intermediate, and 11 large sites). In addition to those trapped, I made 2 hand-captures while setting traps at 2 sites, and I found an additional 3 specimens dead (1 dead female on a trotline, 2 dead males on the bank of the Pascagoula River of unknown causes) at 2 sites.

In 2017 and 2019, during other projects relating to kinosternids, I trapped 5 more Alligator Snapping Turtles in crayfish traps (across 5 sites: 2 small and 3 large lotic sites). Through opportunistic wading surveys, I detected another 17 Alligator Snapping Turtles from 16 additional sites (i.e., different from aforementioned trap sites; 4 small, 7 intermediate, 5 large river sites; Fig. 1). Lastly, one of the two 91-cm hoop-traps set in a small stream (UDA = 67.9 km^2) caught one 18.1-kg male Alligator Snapping Turtle, the other had its bait stolen.

In total, I encountered 54 Alligator Snapping Turtles from 41 sites (9 small, 13 intermediate, 19 large): 31 caught in Promar crayfish traps (including 1 recapture), 1 in a 91 cm hoop-net, 19 found opportunistically (including the 2 found while setting traps), and 3 found dead. From trapping and visual encounters, Alligator Snapping Turtles were detected in lotic systems varying from small feeder streams (UDA = 30.8 km^2) to the mainstream Pascagoula River (UDA = 22,000 km^2). Crayfish traps accounted for the capture of 31 Alligator Snapping Turtles varying from 42.2 mm (15 g; umbilical scar still present) to 192.1 mm CL (unknown mass) (Table 1).

Discussion

This study was originally designed and conducted to study the habitat preferences of *Sternotherus* species across the Pascagoula watershed, but the incidental data collected on juvenile Alligator Snapping Turtles are noteworthy and address serious gaps in our knowledge of the juvenile age class of this species. Boundy and Kennedy (2006) suggested that juvenile Alligator Snapping Turtles were underrepresented in other surveys for this species because juveniles feed by luring and ambush, rather than actively foraging like adults. However, I found that hatchlings as small as 15 g, with umbilical scars still present, will enter a baited trap (Fig. 2). Additionally, on multiple occasions, juvenile Alligator Snapping Turtles were the first turtle in traps, caught <1 hour after traps were set in the middle of the day. What is more likely is that juveniles are able to enter and escape larger commercial hoop nets, or that these large hoop nets cannot be set effectively in the appropriate microhabitats (shallow areas of abundant cover) for juvenile Alligator Snapping Turtles (Spangler et al. 2021). Crayfish traps could be set at a maximum of 80 cm of depth (and a minimum of ~20 cm), a water depth much smaller than the radius of the smallest commercial fishing or turtle traps (Johnston et al. 2015).

In addition to the juvenile Alligator Snapping Turtles caught in crayfish traps, ~90% (174 of 201) of trap-nights lost were due to damage presumably caused by adult Alligator Snapping Turtles. We considered 2 observations to be evidence of this inference: (1) traps were torn open in the water to expose the sardine tin (i.e., not dragged ashore), and/or (2) the tin (if present) would be either obliterated or possess a singular large, triangular and notched hole piercing the aluminum (Fig. 2). I believe most, if not all, raided traps could be attributed to Alligator

Table 1. Morphometric data collected from juvenile Alligator Snapping Turtles caught using Promar Crayfish Traps (not including the 1 recaptured juvenile). UDA = Upstream Drainage Area and is used as a metric for stream size, *n* = number of Alligator Snapping Turtles.

County	State	Carapace length (mm)	Mass (g)	UDA (km^2)	*n*
Clarke	MS	188.8	600+	2392.7	1
Covington	MS	112.3–138.5	600+	527.9–770.9	2
Forrest	MS	123.6–152.6	475–600+	788.1	2
George	MS	76.9–167.1	100–600+	1152.2–17363.7	5
Greene	MS	42.2–161.5	15–600+	342.8–6986.4	4
Jackson	MS	110.8–156.6	330–600+	1694.9–21195	2
Perry	MS	67.3–192.1	70–600+	60.6–7815.6	10
Stone	MS	102.1–145.2	250–600+	37.8–84.4	2
Mobile	AL	47.8	35	1292.4	1
Washington	AL	135.0	Unknown	543.9	1

Snapping Turtles because during the 1509 trap nights, zero *Chelydra serpentina* (L.) (Common Snapping Turtle) were caught in crayfish traps, and only 2 were encountered. Common Snapping Turtles are rare in lotic systems in south Mississippi, and they appear to be outcompeted by Alligator Snapping Turtles within the Pascagoula drainage (L. Pearson, USFWS, Jackson, MS, unpub. data). These notions were further supported when two 91-cm hoop nets baited with carp were set in an area where many crayfish traps had been raided. The following day, an adult male (450 mm CL; 18.1 kg) with recent male–male combat injuries was caught in one of the traps, indicating at least 2 adult turtles inhabited that section of a small, soapstone creek. There were an additional 12 sites (7 small, 1 intermediate, 4 large stream sites) in this study where crayfish traps were likely raided in this manner by suspected Alligator Snapping Turtles, but where the species was not formerly detected, varying in UDA from 25.4 km^2 to 4273 km^2 (Fig. 1).

Figure 2. Clockwise from top left: the diagnostic triangular beak and puncture of an Alligator Snapping Turtle from a depredated trap in South Mississippi; a severely punctured and torn tin of sardines from a raided trap; a patched crayfish trap that has been repeatedly raided by suspected adult Alligator Snapping Turtles; a hatchling Alligator Snapping turtle (15 g) caught in a Promar crayfish trap.

Crayfish traps have been employed to target small turtle species in other studies (Howell et al. 2016, Scott et al. 2018). However, turtles with 200 mm CL seems to be the upper threshold of these traps. Juveniles around this size were often hard to remove from these small traps, and it is unlikely turtles larger than this could enter. Because these traps can be set in shallow water habitats, and because they also seem to exclude larger, generalist species like Pond Sliders from stealing bait (McKnight et al. 2015), it is not too surprising that these traps were effective at catching otherwise elusive sizes and age classes of Alligator Snapping Turtle. These results are consistent with other studies on habitat use by juvenile Alligator Snapping Turtles. Spangler et al. (2021) used radio telemetry to track hatchling Alligator Snapping Turtles in southeastern Oklahoma, and they found that hatchlings settled in shallow water areas with abundant cover after a short dispersal period. Hyder et al. (2021) investigated ontogenetic shifts in habitat use in a juvenile cohort of reintroduced Alligator Snapping Turtles in western Tennessee. Compared to data collected when the juveniles were first released, these turtles were utilizing deeper habitats and had larger home ranges as subadults.

Opportunistic captures during wading surveys detected Alligator Snapping Turtles at 16 additional sites. When combined with trapping data, these results show that the Alligator Snapping Turtle can be found in a wide variety of lotic environments in south Mississippi. I was able to detect the species with these small traps in streams with a drainage area as small as 30.4 km^2 and as large as 22,000 km^2. Sites where traps were raided had drainage areas as low as 25.4 km^2, equating to a stream width as small as 6.4 m. These results suggest that the Alligator Snapping Turtle may be more generalist in its lotic tendencies than previously believed. For instance, 2 small streams where I detected this species were shallow, scoured soapstone streams where few other turtles were observed (Fig. 3). Thus, a wide variety of lotic habitats should be considered when surveying for the species.

These trapping data and observations have implications for our understanding and conservation of *Macrochelys* species. Most studies have focused on sampling the species from navigable waterways (i.e., johnboat accessible), where biologists admit that traps may be set sub-optimally to prevent theft by locals (Boundy and Kennedy 2006; L. Pearson, pers. comm.; J. Godwin, Alabama Natural Heritage Program, Auburn, AL, pers. comm.). Navigable waterways are also frequented by sportsmen and fishermen, and Rosenbaum et al. (2023 [this issue]) found a negative correlation between number of trotlines present and *Macrochelys* captured. Likewise, historically these navigable sites likely experienced higher harvest pressures due to their general accessibility (Boundy and Kennedy 2006). Given the dendritic nature of lotic systems, there are many more miles of unnavigable waterways than navigable (Lindeman et al. 2020). These smaller waterways may represent important strongholds for *Macrochelys* species not just in Mississippi, but across their geographic ranges. The use of crayfish-style traps may facilitate the sampling of non-navigable waterways that would otherwise be logistically difficult to sample using traditional methodologies (i.e., large hoopnets from a johnboat). Additionally, these smaller traps are much more affordable than large hoopnets, generally selling for less than $20. Even when raided by larger turtles, these traps can be easily patched with zipties and still capture turtles (Fig. 2).

Because these data were collected unexpectedly and incidentally, I think there are many ways this study could be improved and expanded upon. I think a systematic and rigorous comparison of trapping efficacies (and a cost–benefit analysis) between traditional hoop nets and crayfish traps for juvenile *Macrochelys* would benefit future studies of the species. During this study, I did not collect microhabitat data at each trap, but I did start to notice potential trends and microhabitats for *Macrochelys.* Part way through the 2018 field season, I began to avoid setting traps near emergent cypress knees in an attempt to catch fewer *Macrochelys.* The presence of Alligator Snapping Turtles in a trap seemed to affect the likelihood of catching the target kinosternid species*,* a phenomenon also demonstrated under controlled laboratory conditions by Jackson (1990). If musk turtles and Alligator Snapping Turtles were both present in a trap, the musk turtles could often be found hanging upside down in the trap, sometimes out of the water. Thus, by using crayfish traps and collecting trap-specific microhabitat data, one might be able to study habitat preferences in juvenile *Macrochelys.* Last, I think an additional drainage-wide study investigating the habitat use of the species along a river continuum using traps of various sizes would also add to our knowledge of the species' ecology.

In conclusion, the use and employment of crayfish traps may be an effective, affordable way to sample non-navigable and navigable waterways for Alligator

Figure 3. Two juvenile Alligator Snapping Turtles caught in crayfish traps set in very different habitats in south Mississippi. The individual on the left is from a large, sinuous coastal plain river with cutbanks, abundant deadwood and sandbars, and the individual on the right is from a small, scoured soapstone stream with very little in stream structure. Alligator Snapping Turtles occur in a wide variety of habitat in South Mississippi.

Snapping Turtles, or to sample the juvenile age class which have historically been underrepresented in the *Macrochelys* literature. These methodologies may also be applicable for surveys of juveniles of all *Macrochelys* species. These data help begin to fill important gaps in our understanding of the distribution, natural history, and ecology of the Alligator Snapping Turtle.

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