Herpetology Notes, Volume 18: 667–670 (published online on 25 July 2025)

Use of a handheld metal detector to evaluate metal ingestion in the Alligator Snapping Turtle, *Macrochelys temminckii* (Troost, 1835)

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The extent and impact of anthropogenic disturbances, such as ecosystem degradation, illegal hunting, water quality, and hook ingestion, among many others, are wholly unknown for many aquatic turtle species. Hook ingestion due to commercial and recreational fishing has been identified as a threat to aquatic turtles, potentially causing injury and obstruction within the digestive tract leading to distress or death (Pritchard, 1989; Steen and Robinson, 2017; Huntzinger et al., 2019). Recreational fishing is widespread throughout the geographic range of the Alligator Snapping Turtle (*Macrochelys temminckii*) in the form of hook-and-line fishing, trotlines, and juglines, among others, which poses risks of hook ingestion in the species (USFWS, 2021).

Hook ingestion has been projected to cause some *M. temminckii* populations to decline at a rate of over 50% (Steen and Robinson, 2017), but the rate of ingestion is not clear across the species' range. Previous studies have used metal detectors to detect hooks in Loggerhead Sea Turtles (*Caretta caretta*; Eckert et al., 2008), White Sturgeon (*Acipenser transmontanus*; Bowersox et al., 2016), and Yellow-Bellied Sliders (*Trachemys scripta scripta*; Lane et al., 2023). Other methods of detection involve larger equipment, require removal of the turtle from the site of capture, and/or can cause distress. Here, we have adapted a non-invasive method similar to that described by Lane et al. (2023) for metal detection in *M. temminckii*, using a portable, hand-held metal detector as a tool for resource managers to evaluate the rate of hook ingestion in wild-captured individuals.

Materials and Methods

Upon capture via baited hoop traps, individuals were visually inspected along all extremities (including dorsal and ventral surfaces) and within the mouth for evidence of hooks or fishing lines. Prior to scanning the individual with the metal detector, all metals were removed from the user's hands and body, as well as any visible within the scanner's range. Additionally, the ground, or the area on which the individual would be placed, was thoroughly scanned for any residual metallic objects that could affect the results of the body scan. Then, a handheld metal detector (Garrett Pro-Pointer AT, Model No. 1140900, Garrett Electronics, Garland, Texas, USA) was held parallel to body surfaces for a broad-detection scan. The metal detector was waved in a slow sweeping motion no more than 2 cm away from the legs, tail, cloacal region, carapace, plastron, inguinal cavity, neck, and head. Point-detection, where the metal detector is held perpendicular to body surfaces, was applied to soft tissue such as the inguinal cavity, cloaca, limbs, and neck (Fig. 1A). Point detection was also used after a broad-detection assessment resulted in metal detection to determine the precise location of the metallic object.

Results

Since development of this protocol in 2022, a total of 71 wild-captured *M. temminckii* have been evaluated across 12 sample sites (Fig. 2), of which 12 (16.9%) individuals yielded positive detections of foreign metallic objects within the digestive system, with one individual yielding an additional detection located in a forelimb (Table 1). Midline carapace lengths of scanned individuals with positive detections averaged

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441.2 mm (n = 12) and 294.2 mm in those with negative detections (n = 59). Evidence of fishing-related activity was documented within or near the trapping area at each site that yielded metal detections.

Presence and identity of ingested metallic objects were visually confirmed for 50% (n = 6) of detections, and the objects were removed, when possible, before the individual was released at the capture location. These included fishing hooks within the mouth (Fig. 1B; n = 3), upper throat (n = 2), and lower throat (n = 1). All individuals with visually identified objects originated from Buffalo Bayou (n = 4) and Little Cypress Creek (n = 2), both of which pass through Harris County and are impacted by recreational fishing and urban stormwater runoff, among other potential sources of foreign metal objects.

The remaining 50% (n = 6) of metal detections occurred within the lower throat or neck (n = 5) or abdominal regions (n = 1) and could not be visually observed or identified. Two turtles from Buffalo Bayou (lower throat and neck) and one from Little Cypress Creek (lower throat) yielded positive metal detections that could not be visually identified. One turtle from Spring Creek (Harris County) yielded metal detections within the right ventral portion of the neck. Four active recreational fishers were observed within the trapping area at Spring Creek, as well as additional recreational fishers and juglines en route to and from the boat ramp. One turtle from Turtle Bayou (Chambers County) had a metal detection within the right, ventral, cranial-distal region of the neck. Two active and one derelict limb lines were observed within the trapping area with additional active and derelict fishing gear observed enroute to and from the boat ramp, including recreational fishing, limblines, and juglines. One turtle from Kimball Lake (Hardin County), a residential lake which is frequently fished by residents, had a metal detection in the lower abdominal region under the plastron that could not be precisely located as it may have been actively moving through or lodged within the digestive tract.

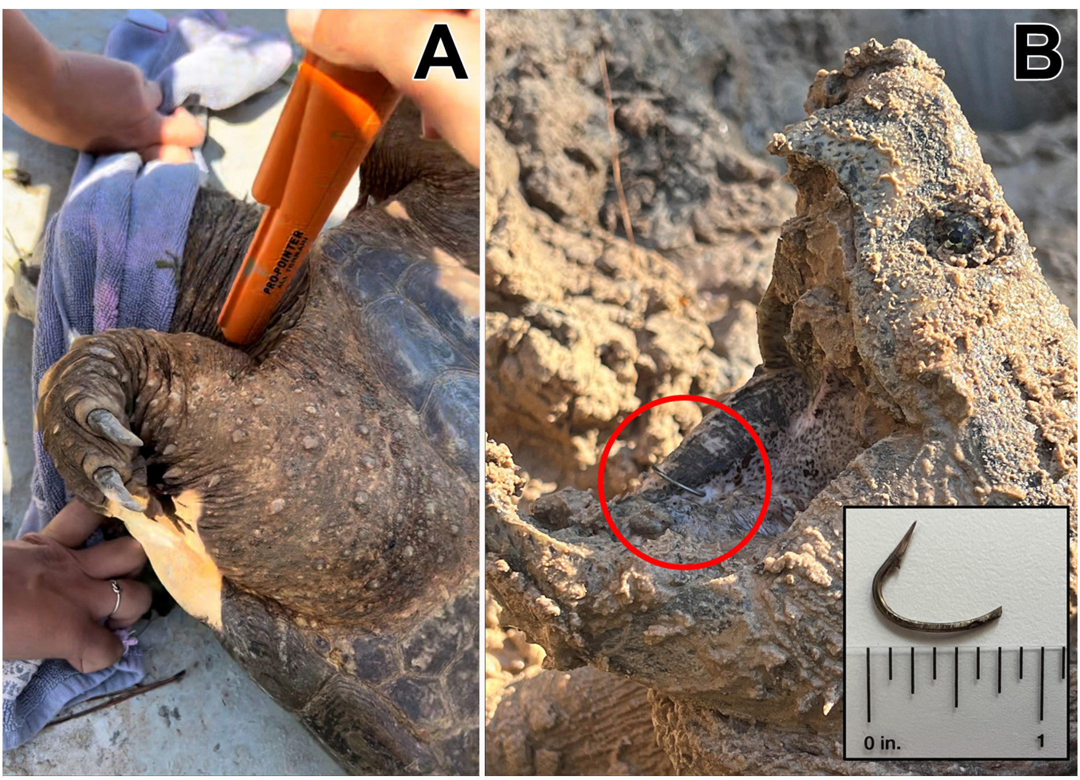

Figure 1. (A) The anterior ventral portion of an Alligator Snapping Turtle (*Macrochelys temminckii*) during a metal detection scan of the neck via point detection. (B) A metal fishing hook (inset) was found via metal detection in the lower right interior portion of the mouth (red circle). Photos by Kelly Garcia.

Discussion

Our rate of positive detections (16.9%) is comparable to the 12% rate of hook ingestion previously documented in *M. suwanniensis* Thomas et al., 2014 using portable radiography (Enge et al., 2014). It also falls within the range documented across multiple species (0–33%) using ultrasonography but is higher than the 5.3% rate observed for Common Snapping Turtles, *Chelydra serpentina* (Linnaeus, 1758) (Steen et al., 2014). A potential positive correlation has been noted between *C. serpentina* carapace length (range = 152–354 mm) and fishing hook presence, likely due to the ability of larger turtles to swallow fishing hooks (Steen et al., 2014). This may explain why the rate of metal ingestion we documented for *M. temminckii* is higher. However, captured *M. temminckii* with carapace lengths ranging 152–354 mm (n = 21) had a 14.3% positive detection rate by comparison, suggesting that *M. temminckii* may be more impacted by hook ingestion in general.

The detection and identification of metals that would have been overlooked in otherwise visible regions of the mouth and the extremities suggest that visual inspections alone are not adequate in quantifying the rate of metal ingestion in *M. temminckii*, as visibility is often dependent on factors such as an individual turtle's temperament and cleanliness. Unidentified metallic objects cannot be assumed to be fishing hooks, with potential objects including other anthropogenic sources, such as construction debris, debris from stormwater runoff, and bullets or shotgun pellets (Shook et al., 2023). Similar to the findings by Shook et al. (2023), pit marks on the carapace that potentially resemble healed wounds from shots fired were observed during this study, though no metal was detected or visualized and the source of the carapace abnormality remains uncertain. Natural sources of ingested metal include iron oxides present in the soil, though the concentration may be too low to induce a positive detection with a metal detector unless a large deposit is ingested. However, the device may be calibrated to the surrounding soil to omit faint positive detections caused by natural sources. Regardless, due to the non-invasive and portable nature of this detection method, it may be preferable compared to traditional methods, which typically include removal and transport of the individual for evaluation via x-rays or other invasive procedures that cause distress.

Lane et al. (2023) found that metal detection in the field using a handheld metal detector resulted in 95% overall accuracy of documenting metallic foreign body ingestion in *T. scripta*, with 0% false negatives and 14% false positives when confirmed on radiographs. While this metal detection method is not intended to aid in the removal of fishing hooks or other metallic objects, it should be used as a guide to evaluate the rate of metal ingestion and extrapolate the potential effects of fish-hook ingestion on *M. temminckii* and other aquatic turtles. Results from these findings may contribute to conservation decisions made at the state and federal levels.

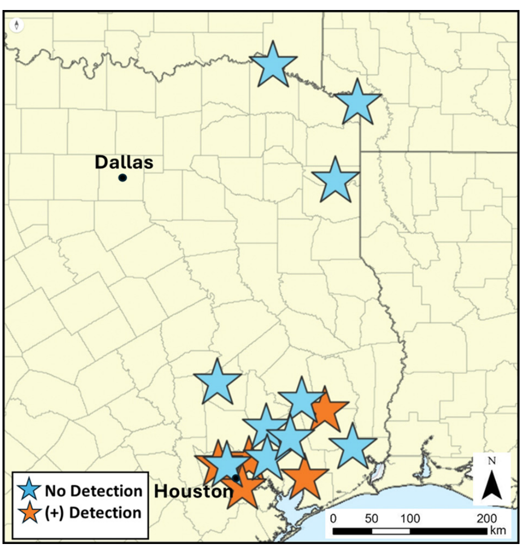

Figure 2. Site map of all locations where the handheld metal detection protocol was used on captured Alligator Snapping Turtle individuals in East Texas, USA. The protocol was used at a total of 15 sites across east Texas, with five locations producing positive detections. Multiple site locations on Little Cypress Creek and Buffalo Bayou in Harris County were collectively referred to as one site, respectively.

Table 1. Waterbodies in East Texas, USA, where trapping and scanning methods yielded Alligator Snapping Turtles (AST; *Macrochelys temminckii*) with positive metal detection scans, with the total number of ASTs with positive detections recorded and their straight carapace length (SCL; mm) ranges.

Location	SCL
Buffalo Bayou (*n* = 6)	298–579
Little Cypress Creek (*n* = 3)	395–527
Turtle Bayou (*n* = 1)	628
Kimball Lake (*n* = 1)	483
Spring Creek (*n* = 1)	449

We recommend future studies utilize this method in their fieldwork to gather data on both stable and at-risk populations across the range of *M. temminckii* to assess the current impacts of hook ingestion to the species and monitor changes over time.

Acknowledgements. We thank the Texas Comptroller of Public Accounts for the funding and support that made this research possible, as well as the Environmental Institute of Houston for the financial support of both the research and publication costs. We also thank the Angelina-Neches River Authority, Brazos River Authority, Harris County Flood Control District, Lower Neches Valley Authority, Northeast Texas Municipal Water District, Tarrant Regional Water District, Trinity River Authority, and Water Monitoring Solutions, Ltd., many state Wildlife Management Area and National Wildlife Refuge or Preserve managers, and all of our private landowners for their support. We thank all the field and lab assistants who endured many hot Texas days and very early mornings. Lastly, we thank Jordan T. Donini for pre-peer reviewing this paper. Sampling was conducted under TPWD Scientific Permit for Research SPR-0321-026 and animals were handled following the UHCL Institutional Animal Care and Usage Committee protocols 0323.001.R0-R3.

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Accepted by Hinrich Kaiser