# Validation of trammel netting as a means for monitoring population trends for diamondback terrapins (*Malaclemys terrapin*) in the Charleston harbor estuary

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## BACKGROUND

Diamondback terrapins (*Malaclemys terrapin*) occur from Massachusetts through Texas, and are the only exclusively estuarine turtle in North America (Wood, 1977). Nearly 100 years after the crash of a commercial market (that lasted only a few decades) presumably due to overharvesting (Carr, 1952), the population status of this species in North America is listed as unknown or declining (Hart, 2004). In South Carolina, diamondback terrapins are one of 52 species in the reptile/amphibian guild that is listed as a species of concern.

The South Carolina Department of Natural Resources, Marine Resources Division (SCDNR MRD) has systematically increased efforts to research and monitor diamondback terrapins over time. In the late 1970's, Bishop (1983) reported incidental catch rates in crab pots fished in tributaries and rivers of the lower Charleston harbor. Since 1995, the Inshore Fisheries Group of the SCDNR MRD has recorded capture rates of diamondback terrapins in their trammel net surveys in six estuaries; however, key demographic data (i.e., size and sex) are opportunistically recorded and individual terrapins are not marked or tagged unless part of a separate study. For example, >1200 terrapins captured in this survey near Charleston, SC have been marked (scute notching) or tagged (passive integrated transponder, PIT) in conjunction with six theses (Levesque, 2000; Lee, 2003; Estep, 2005; Schwenter, 2007; Broyles, 2010) and one dissertation (Hauswaldt, 2004). Crab trap excluders have also been evaluated using fishery-dependent and –independent data (Powers et al., 2009a,b).

Because other sampling mandates take precedent over comprehensive work-up of captured diamondback terrapins, and because this survey is conducted in river-edge vs. tidal creek habitats where other long-term studies have been conducted (Gibbons et al., 2001), the analytical value of the trammel net data set for monitoring population trends has received scrutiny. Therefore, in order to determine the extent to which this 18-year data set can be used to assess trends, we have undertaken an acoustic telemetry and capture/marking study to test the following null hypotheses:

1) There is no difference in residence time in river-edge vs. tidal creek habitats overall or by sex
2) There is no difference in residence time in river-edge vs. tidal creek habitats by capture origin
3) Detection frequency does not fluctuate with temperature, salinity, diel, lunar, or tidal changes

## STUDY SITE DESCRIPTION AND SELECTION BASIS

Field research began in April 2013 in the Ashley River and in tidal creeks in the vicinity of Duck Island, a large hummock island located on the south/west side of the river (Figure 1,2). The South Carolina Department of Health and Environmental Control (SCDHEC[5]) reports that there are 3,017.2 acres of estuarine area habitat in the Ashley River watershed. Where our study is being conducted, surface water quality is characterized as SA*, and SCDHEC maintains a water quality monitoring station on the industrially-developed north/east side of the river across from our study area; watershed development on the south/west side is predominantly residential.
[5]https://www.scdhec.gov/environment/water/shed/docs/50202-040.pdf

This study site was selected for the following reasons:
•It is centrally positioned between the freshwater line and the Atlantic Ocean (Figure 1)
•Similar amounts of creek and river-edge habitats surround the island (Figure 2)
•Reliable terrapin capture rates occur in the Ashley River, and in particular this region of the river
•Most terrapins tagged in the aforementioned graduate studies were captured in the Ashley River


*Figure 1: Relative position of Duck Island along the Ashley River (red line).*


*Figure 2: River (yellow) and creek (white) VR2W receiver positions at Duck Island*

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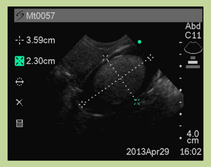
## METHODS

### *Terrapin capture and standard data collection*

Diamondback terrapins were captured predominantly using a 600' section of monofilament trammel net; however, a shorter (100') section of trammel net and a 15' otter trawl were also used. Following capture, terrapins were externally marked with a grease pencil to differentiate among capture locations while they were held in aggregate in a large, ventilated plastic bin.

The following data were collected:
• Visually inspect terrapins to note pre-existing marks and injuries
• Assess sex based on dimorphism (head/body size, cloaca position/tail length)
• Scan all soft tissue for the presence of a PIT tag
• Measure (straight-line) carapace length, width, and body depth with calipers
• Record body mass using a digital spring-scale
• Photograph dorsal, ventral, and lateral perspectives
• Drill small holes in marginal scutes using a letter combination coding system
• Attach flexible shellfish tags (Floy Tag, Inc.) to carapace using epoxy
• Assess reproductive condition of females using ultrasound
• Opportunistically examine contents of fecal matter to identify forage items
• Opportunistically remove barnacles for a collaborator at the University of Georgia

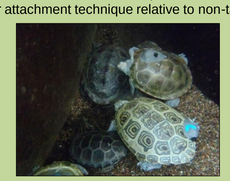

### *Acoustic transmitter attachment*

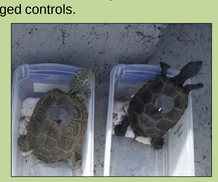
Acoustic transmitters (V9-2H; Amirix Systems, Inc.) that measured 9 mm (diameter) by 29 mm (length) and weighed 4.7 g in air (2.9 g in water) were attached to a subset of captured terrapins. Our goal was to acoustically-tag 12 terrapins captured in each of creek and river-edge habitats, with equal sample sizes for males (>300g) and females.

Transmitters were attached to the carapace using ~9.5 g of a two-part epoxy putty (SonicWeld™; Ed Greene and Company, Sparta, TN). Prior to attachment, barnacles and encrusting bryozoans were gently scraped from the vertebral and costal scutes while fine-scale organic matter such as algae was scrubbed off using alcohol-soaked gauze pads. Loose keratin scutes were carefully peeled away and 100-grit sandpaper was lightly applied to ensure no loose keratin remained.

Transmitters were attached to the second vertebral scute, but offset from center due to the vertical relief associated with vertebral scutes. A base layer of epoxy was first pressed to the carapace across at least three scute seams to minimize the risk of transmitter loss due to detachment of a single scute. The epoxy was molded into a shape that had a centralized dome and resembled a sea biscuit. Next, the transmitter was pressed onto the epoxy dome with the transducer facing aft. In "pig in a blanket" fashion, epoxy was then applied over top of the transmitter and blended evenly.

This attachment technique was first evaluated at the South Carolina Aquarium with two female terrapins. Transmitters were also attached to two female and four male terrapins using a cable-tie reinforced technique, and two non-tagged controls were also included in this tag-retention study. Through 9 Sept 2013 (335 observation days), both epoxy-only attachments remain firmly in place. In contrast, cable-tie attachments have detached from one male and one female terrapin. No change in behavior or body condition was noted for either attachment technique relative to non-tagged controls.





### *Remote data collection systems*

VR2W receivers are deployed near the water surface in a PVC housing that floats, with the hydrophone end of the receiver facing downward. This housing slides up and down a 1.5" diameter galvanized pole. These receivers record acoustic signals emitted (69 kHz) about every four minutes. A CTD (Solinst, Inc.) deployed near receiver #11 records observations every 15 minutes.

VR2W acoustic receivers deployed at seven river-edge and five creek sites (Figure 2) provide continuous monitoring (150 m radius) at water levels when the trammel net survey is conducted, but are exposed at low water due to tidal amplitude.

## SUMMARY AND FUTURE DIRECTION

- **Catch rates substantiate the use of trammel netting for capturing terrapins; need to increase sampling effort/catch of terrapins in creeks**
- **A high degree of mixing occurs between river and creek habitats, especially among creek-captured terrapins**
- **Detections were highly influenced by seasonal, spatial, and all environmental metrics examined thus far**
- **More manual tracking and documentation of seasonal habitat preferences is needed to explain deceased detection in summer**
- **Analyze detections with a multivariate model, evaluate 2013 to 2014 catches with this model, then apply to historical catches at these sites**

## PRELIMINARY RESULTS (data managed in MS Access, statistics performed in Minitab)

### *Sampling effort and catch rates*

• 44 sampling events completed on 7 sampling dates in April (16e,3d), May (22e,2d), July (3e,1d), and August (3e,1d)
•109 terrapins processed in April (63), May (21), July (4), and August (21)
• Superior capture rates were associated with the 600' trammel net, notably when sampling river-edge habitats

| | | # of gear sets | | # of Terrapins | | Gross terrapins/set | |
|---|---|---|---|---|---|---|---|
| Gear type | Set (min) | Creek | River | Creek | River | Creek | River |
| 600' trammel | 20 | 11 | 17 | 21 | 84 | 1.9 | **4.9** |
| 100' trammel | 10 | 5 | n/a | 1 | n/a | 0.2 | n/a |
| 15' otter trawl | 5 | 5 | 6 | 1 | 2 | 0.2 | 0.3 |

### *Recapture events*

• 2 within-study recaptures (1M,1F) occurred on 4/29 and 5/9 after 20–21 days at large, both of which moved between the north creek and the river

• 6 terrapins (4M,2F) tagged in river-edge habitats at this study area in a previous year were recaptured between 4/9 and 5/9, of which two (1M,1F) were recaptured in the north creek

### *VR2W data: Emigration from the Duck Island study area*

• Two creek-captured terrapins (1M, 1F) emigrated away from the Duck Island study area and were detected by VR2W receivers maintained by another study

Male 25235
a) captured in the north creek on 4/18, acoustically-tagged, released on 4/19
b) detected 5 km upriver on 4/22, but returned to Duck Island the next day
c) through 8/26, this terrapin was detected on 60 of 130 monitoring days; 22 days at Duck Island only, 37 days at the 5 km upriver site only, and once detected at both sites on the same day

Female 25234
a) captured in the north creek on 4/29, acoustically-tagged, released on 4/30
b) detected daily through 5/11, with 95% of detections (462) from river receivers
c) 24 hrs after last detected at receivers 6&7 (Figure 2), this terrapin was briefly and last detected 10 km downriver at two locations in the Charleston harbor

### *VR2W data: Demographic considerations*

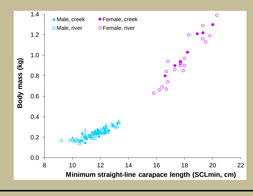
•12 female terrapins (4/10 to 4/30) and 8 male terrapins (4/19 to 7/9) acoustically-tagged
• 48,375 unique detection events in the study area between 4/11 and 8/26
• No significant difference in total detections with regards to terrapin sex and capture habitat ($X^2_3$=0.367, P=0.947)
• No significant difference in the frequency of river detections among males and females tagged in river habitats ($X^2_1$=1.726 P=0.189)
•Significantly more creek detections were recorded for females tagged in the creeks vs. males tagged in the creeks ($X^2_1$=196.392, P<0.001)

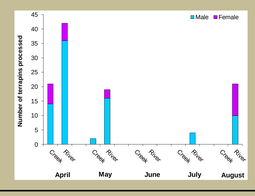
| | | Detected | | |
|---|---|---|---|---|
| Captured | Sex | Creek | River | % River |
| Creek | Male | 1,595 | 2,561 | 61.6 |
| Creek | Female | 3,895 | 10,474 | 72.9 |

| | | Detected | | |
|---|---|---|---|---|
| Captured | Sex | Creek | River | % River |
| River | Male | 334 | 15,884 | 97.9 |
| River | Female | 311 | 13,321 | 97.7 |

### *Demographic overview*

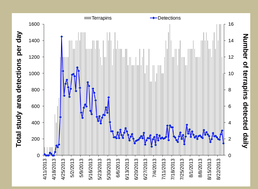
• Overall sex ratio was similar in river-edge (60M, 19F) and creek (22M, 8F) habitats
• Terrapin size ranged from 9.2 to 20.3 cm SCLmin (0.14 to 1.39 kg)
• Size was not significantly different by capture habitats for males (*n*=16,66; T=0.15, P=0.884) or females (*n*=20,7; T=0.89, P=0.392)

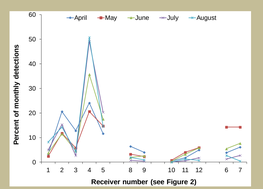


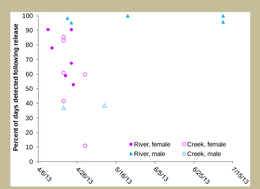




### *VR2W data: Seasonal residence and localized movement patterns*

•Daily detections peaked in late April, declined through May, then stabilized.
•Terrapins were detected by 3 to 12 (median = 7.5) receivers, with 3 to 92% (median = 23%) of detections by the receiver closest to capture location
•All but two terrapins (both river-captured males) were detected in both river and creek habitats, with six terrapins detected in both creek systems
•Detections varied among sites, but also fluctuated seasonally; for example, site 4 accounted for the most detections in every month, but was least dominant in May (24%) vs. August (51%)
•The percent of days detected post-release was significantly greater for river-captured vs. creek-captured terrapins (*n*=12,8; T=3.30, P=0.007)




### *VR2W data: Environmental influences on detections*

• Water temperature was negatively correlated with daily detections per terrapin and accounted for 34% of the sums of squares
• Salinity was positively correlated with daily detections per terrapin and accounted for 19% of the sums of squares
• A parabolic line fit ($R^2$=0.77) was observed between terrapin detections and time of day, with 38% fewer detections between 06:00 and 17:59 hrs local time
• 58% of creek detections occurred during waxing moons, compared to just 47% of river detections during waxing moons ($X^2_3$=229.906, P<0.001)
• Detections were significantly different (P<0.001, $X^2_3$>340 x 4 tests) with respect to habitat and water level/tide stage; indexed values shown below