Environmental DNA Assessment of the Texas Diamondback Terrapin (*Malaclemys terrapin littoralis*)

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Background

The Diamondback terrapin (*Malaclemys terrapin*) is a small to medium sized (maximum carapace length females = 23.8 cm; male = 14.0 cm) emydid turtle that lives in coastal wetlands and estuaries along the United States Atlantic coast, from Cape Cod, Massachusetts to Corpus Christi, Texas in the Gulf of Mexico (Ernst and Lovich 2009; Roosenburg and Kennedy 2018); their distribution includes a disjunct population found in Bermuda (Brennessel 2006; Ernst and Lovich 2009). Seven subspecies of *Malaclemys terrapin* have been identified and are classified based on their morphological characteristics and geographical distributions. Within Texas, the subspecies *Malaclemys terrapin littoralis* (common name, Texas Diamondback terrapin) is found from Sabine Lake (Orange County) in the north to Baffin Bay (Kleberg County) in the south although only a few records exist beyond Nueces Bay (Dixon and Hibbits 2013). Texas Diamondback terrapins are listed as a 'T3 Vulnerable Subspecies' on the IUCN Red List with declining population trends across much of their range due to human development, transportation, habitat disturbance/loss, pollution, oil and gas drilling, drowning in crab traps, pet trade, invasive species, disease, and climate change (Crawford *et al.* 2014; Roosenburg *et al*. 2019). In Texas, they are listed as 'S2 Imperiled' by the Texas Parks and Wildlife Department (TPWD) and are a Species of Greatest Conservation Need (TPWD 2012). This designation means this species is at high risk of extirpation in the jurisdictional range, has few populations or occurrences, recent and widespread steep declines, and severe threats to their population status. Thus, the clear recommendation was for more research and monitoring of this species. It is also illegal to possess the species without a scientific, educational or zoological permit (Malik 2022).

Knowing the geographic range of a species establishes the foundation for further studies to investigate the species status and requirements so that management and conservation strategies can be developed (Politi *et al.* 2021). Diamondback terrapin surveys along the Texas Gulf Coast over the past decade have been scattered with variable levels of effort (Guillen *et al.* 2015; Baxter 2017). The lack of statewide surveys and a long-term population monitoring program in Texas has resulted in little being known about the distribution, population status, habitat preferences, and general ecology of the Texas Diamondback terrapin (Guillen *et al.* 2015; Baxter 2017; Mohrman 2022). The contemporary range of Diamondback terrapins in the middle Texas Gulf Coast system and the western extent of their range is currently unknown, along with current nesting habitat use and availability (Baxter 2017; Mohrman 2022). Although a few historical records exist west of Nueces Bay in the upper Laguna Madre and into Baffin Bay, no recent observations (*e.g*., iNaturalist) or survey efforts have occurred in the area (Dixon and Hibbits 2013; Guillen *et al.* 2015). The Conservation Action Plan for Diamondback terrapins in the Gulf of Mexico (CAP) specifically recommends filling gaps in the geographic range data in Texas (Mohrman 2022). To address these gaps, my research team has been compiling a database of available Texas Diamondback terrapin distribution data, including historical and contemporary observations from online databases (e.g., VertNet and iNaturalist) and museum collection data.

This project used environmental DNA (eDNA) assay survey methods (recently developed by Dr. David Portnoy with Aaron Baxter at Texas A&M University-Corpus Christi [TAMU-CC] for Diamondback terrapin) to determine the current status of Diamondback terrapin presence/absence in the Coastal Bend region of Texas. These surveys were replicated across multiple seasons in an attempt to provide critical information about the spatial dynamics and habitat requirements for Texas Diamondback terrapins across their range. To understand the extent of estuarine wetland and nesting habitats that

need critical protection for Texas Diamondback terrapins consistent with CAP recommendations (Mohrman 2022), it is imperative to have improved data on the spatial dynamics of this species. Studies of this type may reveal a paradigm shift in our knowledge of Texas Diamondback terrapin habitat use that will require larger areas of conservation and restoration to ensure recovery of this species. Thus, this research will inform vulnerability assessments and adaptive management and conservation strategies to be implemented that help preserve this unique and imperiled species.

Objectives

1. Determine the distribution of Texas Diamondback terrapin populations in the Coastal Bend bay complexes using environmental DNA surveys.
2. Determine if seasonal patterns of terrapin distribution exist.
3. Identify suitable nesting habitat sites in proximity to identified terrapin populations.

Deliverables

1. Manually classify and map potential nesting sites of Texas Diamondback terrapins using aerial satellite imagery.
2. Conduct proposed eDNA sampling for Texas Diamondback terrapins between the Aransas Bay system and Baffin Bay.
3. Map all locations positive for Texas Diamondback terrapins.
4. Identify seasonal shifts in habitat utilization by Texas Diamondback terrapins.

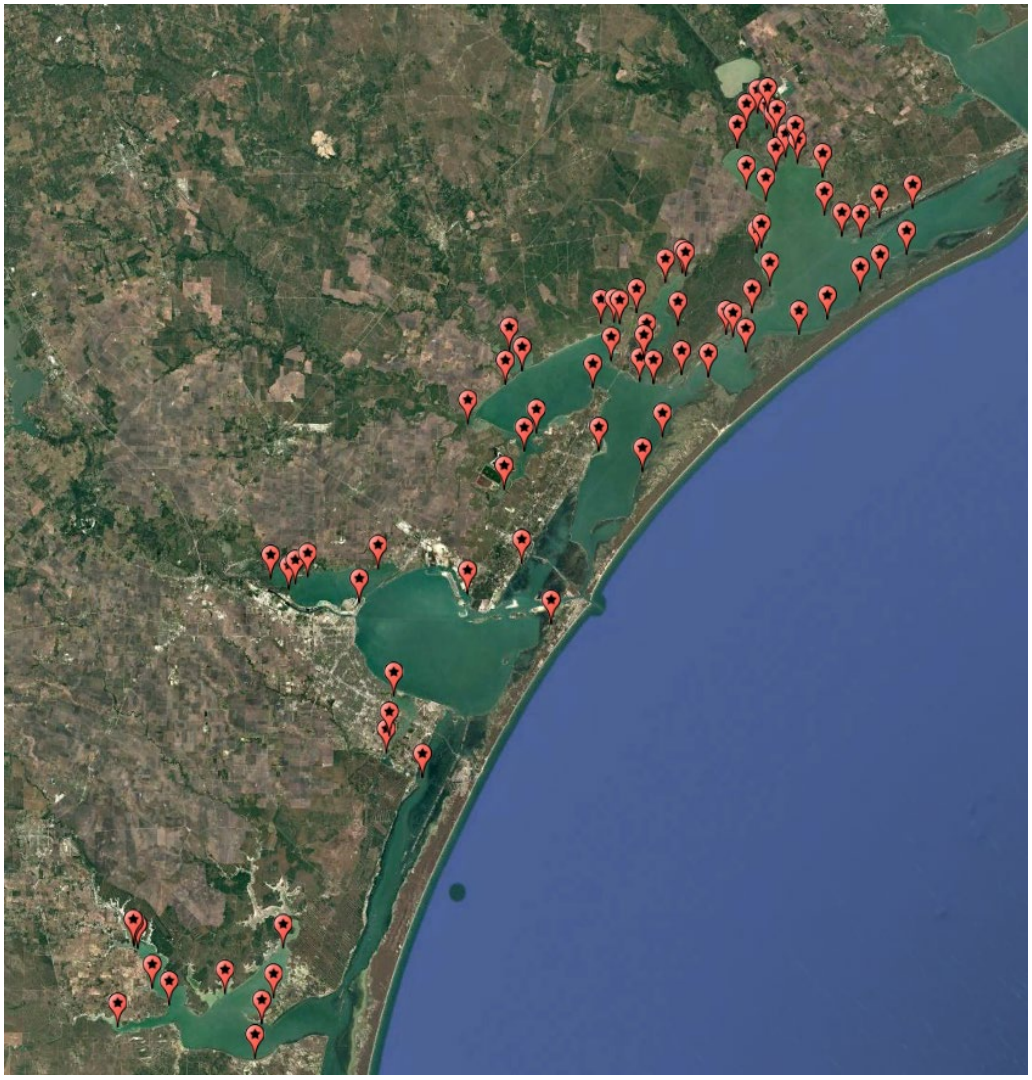

Figure 1: Google Earth Map of eDNA sampling locations

Findings

eDNA sample sites were manually classified from historic sightings, satellite imagery of suitable nesting habitat, and field sampling efforts. To identify the distribution of Texas Diamondback terrapins in Texas, we conducted a comprehensive literature and museum database review to identify the geographic extent of observations in Texas. Historic observation data from unpublished sources (i.e., Baxter et al. data held at TAMU-CC) were processed first. Next, available literature with detailed location data was processed and then compared with records from online databases (Global Biodiversity Information Facility [includes VertNet], Texas Natural Diversity Database, and iNaturalist) to prevent duplication of geographic records. Only location data with GPS coordinates or map figures that could be manually georeferenced were included in our database. We identified a total of 404 site observations for Texas Diamondback terrapins (Figure 2). A total of 32 sites represent terrapin observations between 2016 and 2026, with the remaining 372 sites representing where terrapins were last observed before 2016 (late 1800's through 2015). Locations were scored as high, medium, or low likelihood based on the presence of shell beach, adjacent wetland habitat, and near freshwater outflows, with the presence of all three criteria being the highest likelihood areas. These observation points were used to inform our survey locations in combination with manually classified potential nesting site locations using a combination of geographic data sources, primarily current and historic satellite imagery. Additionally, camera traps were deployed to detect terrapins nesting, as well as limited trapping with modified crab traps, though no terrapins were observed with these methods during the study period.

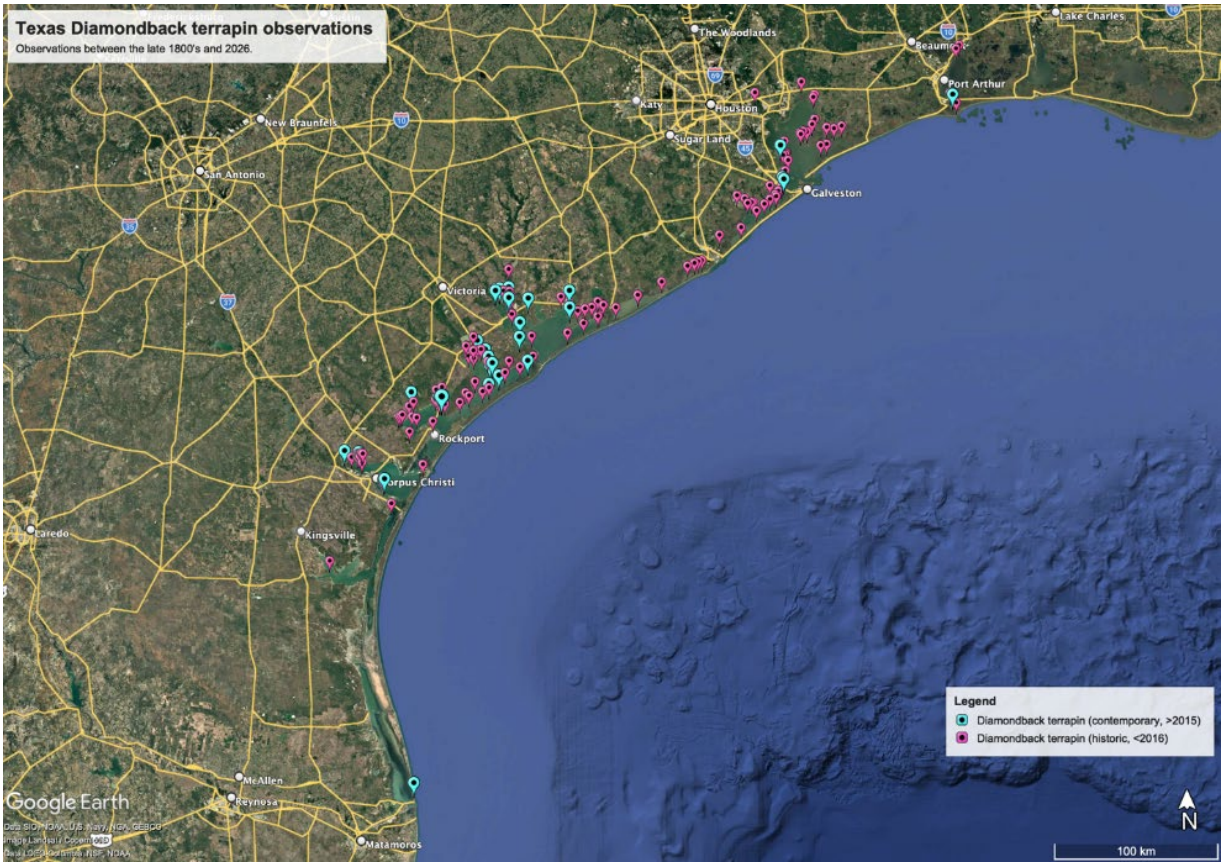

Figure 2. Map of all observation sites for the Texas Diamondback terrapin (*Malaclemys terrapin littoralis*) in Texas. Observations date from the late 1800's-2015 (blue points) through 2016-May 2026 (magenta points).

Sampling began in mid-March 2025 and continued through February 2026. During the summer period, 80 sampling locations were collected. During the fall period, 70 samples were collected; however, the final 11 sites in Baffin Bay could not be sampled due to weather and boat access constraints before water temperatures dropped. Winter sampling was completed in late February, though 7 locations could not be accessed due to low water levels resulting from drought.

The Marine Genomics Core has processed all summer samples, with no positive detections. All 70 fall and 81 Winter samples have been transferred to the Marine Genomics Core; however, processing has been delayed by staff departures, with completion anticipated in Summer 2026. Early in the project, sampling logistics were modified by switching from university vessels with deeper drafts to a contracted airboat guide, which increased access to shallow sites and improved travel speed between locations. The airboat was used for the majority of sites, while kayaks were used for locations inaccessible to the airboat or outside the operator's travel range. Weather conditions (high winds and waves) caused consistent delays throughout the project, and 6 preplanned sampling locations were relocated to the nearest accessible areas due to access limitations. Winter sampling was further hindered by drought conditions, with some sites completely dry.

To date, no positive eDNA detections have been recorded. This may indicate a need to modify the previously established eDNA collection protocol to account for the local rarity of the species. Sampling was paused in October of 2025 to develop a modified sampling protocol that could account for the animals' rarity by filtering increased water volumes at a reduced number of sites. The revised methods were drafted for EPA approval, however due to the prolonged government shutdown from October to November of 2025 approval could not be obtained. The remainder of the project was conducted with the original procedure. Evidence suggests terrapins are sparse in South Texas, with only two individuals observed during head count surveys throughout the project outside of a small group regularly observed feeding on fish carcasses from recreational anglers at the Goose Island State Park boat ramp. The rarity of terrapins in the region is likely driven by multiple factors, including historic take, bycatch from crab pots, destruction of nesting beaches due to shoreline hardening (particularly in San Antonio and Espiritu Santo Bays), and pollution (e.g., plastic nurdles).

Once the Marine Genomics Core has completed processing samples, any positive detections will be mapped and provided in a supplementary report and incorporated into a peer-reviewed manuscript.

Figure 3. Location of observed terrapins in November 2025

Public Engagement:

To assist in acquiring contemporary research-grade observations and identify undocumented Diamondback terrapin populations in Texas, we created an iNaturalist project called "Texas Diamondback terrapin Task Force" (link - https://www.inaturalist.org/projects/texas-diamondback-terrapin-task-force). The iNaturalist project now has 174 Research Grade observations, doubling the number of observations since the start of the project. The majority of these observations have come from Goose Island State Park on Aransas Bay near Lamar, TX or from West Bay near Galveston, TX. The project has resulted in five new locations for terrapin observations: 1) in between Magnolia Beach and Indianola on Matagorda Bay; 2) near Oyster Lake Park on Matagorda Bay; 3) Palacios Bay Beach on Tres Palacios Bay; 4) east side of Lavaca Bay Causeway; and 5) two observations on northeast side of Oso Bay. Recently, we created an ArcGIS Survey123 form where we can send citizen observers directly to share their observations and upload photos without needing to register or sign up for an account. This creates an alternative to iNaturalist that requires multiple steps for the user to be able to share unobscured coordinates with our research group. This will be dispersed to the public before the end of July 2026. Link to observation form - https://survey123.arcgis.com/share/4ee4735d499c4817964e640c10135cee.

We have also created outreach media and presented our research to several groups to encourage citizens to report their observations of Diamondback terrapins. Educational outreach has included a formal presentation to the TAMU-CC Anglers Club (2024), which trained participants on terrapin identification and reporting methods. A public presentation was given at the Calallen Public library in the fall of 2024 that highlighted the need for terrapin research and conservation. Specialized PowerPoint slides were also developed for the Texas Sea Turtle Stranding and Salvage Network (STSSN) to help responders identify Texas Diamondback terrapins and submit verified reports to the McCracken Lab or the iNaturalist project. We have also created a flyer that we share opportunistically with boaters, kayakers, and fishing guides that directs them to the iNaturalist project. Project updates, fieldwork

highlights, and educational content have been regularly disseminated through the McCracken Lab and Center for Coastal Studies social media platforms, maintaining continuous public engagement throughout the project.

The project's visibility and professional engagement were further strengthened through conference and invited presentations. In 2025, Dr. Shawn McCracken and postdoctoral researcher Dr. Tyler Bowling presented "Distribution and Movement Ecology of the Texas Diamondback Terrapin (*Malaclemys terrapin littoralis*) and Habitat Use and Environmental Tolerances of Diamondback Terrapins in the Southwestern Gulf of Mexico" at the 10th Triennial Diamondback Terrapin Workshop in Cape May, New Jersey. Earlier that year, PI McCracken presented "Casting a Wide Net: An Array of Techniques to Identify Nesting Habitats of the Texas Diamondback Terrapin" at the Gulf of Mexico Alliance Business Advisory Council Meeting and "Distribution of Diamondback Terrapins in Texas and Identification of Nesting Habitats" at the Gulf of Mexico Alliance All-Hands Meeting.

Future Use:

Given the lack of detections, future eDNA surveys will need to be modified. The extent to which this may necessitate lab-based trials to refine protocols, given the rarity of the animals and the likely lower eDNA concentrations than those for which the method was initially developed. Additionally, we are actively building connections within the commercial and recreational fishing communities to develop avenues for citizen science reporting. We have also initiated research focused on the Goose Island State Park population. We have tagged a large male and installed a cellular trail camera overlooking the main area, where terrapins are observed near the dock. We plan to expand these efforts across the marsh in the immediate area to document terrapin nests, movement, and behavior before, during, and following planned construction/restoration efforts for the local habitat.

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