The Potential Threat to *Malaclemys terrapin* Due to Changing Conditions in Barnegat Bay Assessed Through Dietary and Behavioral Habits

Abstract

The Northern Diamondback Terrapin (*Malaclemys terrapin*) plays an important role in estuaries, like Barnegat Bay, New Jersey, up and down the east coast of the United States as an indicator and keystone species. As sea level rise continues to be seen in estuaries, a greater risk is seen for the Diamondback terrapin due to loss of habitat and loss of their prey species' habitat. With this, it is important to determine exactly where and what species the terrapins are preying on in order to predict future effects sea level rise may have. Dietary habits were determined using a noninvasive, novel stomach purging technique that involves the natural bodily processes a Diamondback terrapin has for switching between different water salinities. The predictions on the effect of sea level rise were estimated using ArcMap GIS software overlaying Diamondback terrapin habitat with current marsh coverage, sea level rise predictions, and prey species habitat.

Introduction

The Northern Diamondback Terrapin (*Malaclemys terrapin*)
- Role as an indicator species and key stone species (Ayers 2010)
- Only species of turtle that lives in brackish water (Avice 2016)
- Brumate overwinter in the marsh mudflats (Hackney 2010)
- Inhabit Barnegat Bay, New Jersey
- Remain in the same area as hatching throughout their life (Muldoon and Burke 2012)
- Nest in accessible, sandy substrate

Sea Level Rise In Estuaries
- Estimated to increase by as much as 1 foot by 2050
- Under normal conditions, estuaries recede back into the coastline
- Economic value lost, $6.417 per Acre (Haas 2014)

Barnegat Bay, New Jersey
- 71% of shoreline developed, 40% to bulkheading or stabilization
- Loss of 238 acres of tidal wetland, no area to recede to
- Supports 156 species of special emphasis (Barnegat Bay Partnership 2019)

Figure 1. A satellite image of the Barnegat Bay of the coast of New Jersey as well as a sub image of the southern region of the Barnegat Bay where this study is focusing.

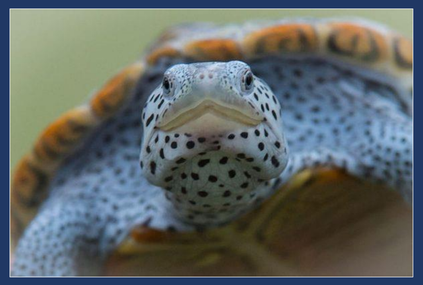

Figure 2. A Female Diamondback terrapin shown from eye level with the front edge of the carapace and plastron showing.

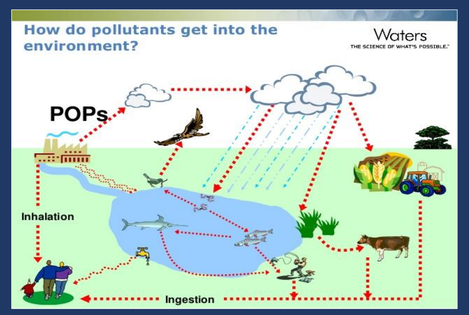

Figure 3. The movement of POPs within the environment, one example of what can be seen through the terrapin due to its' indicator species status.

Objective

To determine the effects of rising sea levels in the Barnegat Bay, New Jersey Estuary on the Diamondback Terrapin through analysis of their diet, behavior, and habitat.

Study Site

Late May to Early August 2019
- subjects from Barnegat Bay area
- regional data and distribution focused in southern Barnegat Bay area
- terrapins highly active in southern region
- subjects processed at school lab Manahawkin, New Jersey
- some sample analysis completed at school lab
- warmer months, some rain

Late August Forward
- sample analysis completed at school lab
- data analysis conducted at home and in lab

Procedure

Subject Collection
- through research capture and release study
- carapace dimensions, gravidity, condition, characteristics
- using hand capture, hoop traps, and a fyke net
- released the following day
- 34 subjects

Novel Purging Method
- natural bodily purge upon fresh to salt water transition
- the process does not stress the individual
- subjects from brackish water placed into 4 in of fresh water
- 24 hours to purge
- stomach contents purged into freshwater holding containers

Sample Analysis
- freshwater filtered for stomach contents with vacuum filtration
- samples dried and massed (g)
- dietary contents analyzed and identified using a compound microscope

Statistical Analysis

Comparative Statistics
- individual prey item abundance to find most prevalent and dependent on marsh
- most commonly captured age range for behavioral analysis
- present prey based on age for behavioral analysis
  percentage of diet consisting of marsh habitat species

ArcGIS
- overlays of
  sea level rise prediction (1ft)
  phragmites distribution
  coffee bean and periwinkle snail distribution
  blue and ribbed mussel distribution

Figure 4. A satellite image of the Barnegat Bay of the coast of New Jersey over lain with data from an estimated 1ft of sea level rise.

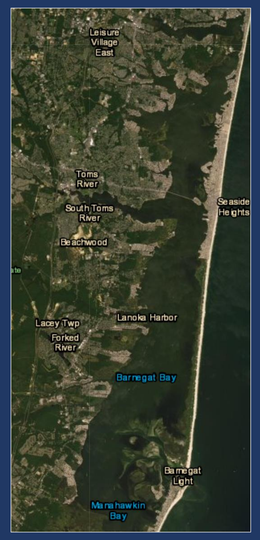

Figure 5. A satellite image of the Barnegat Bay of the coast of New Jersey to serve as a comparison to sea level rise (on the left)

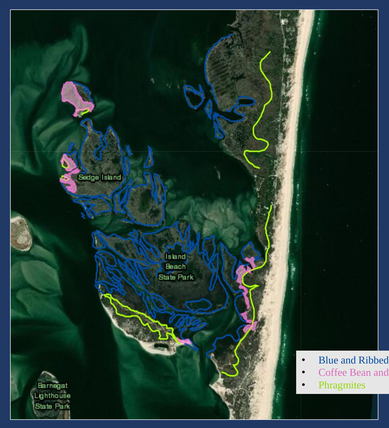

Figure 6. Southern Barnegat Bay Marshland over lain with high density populations of varying species of mussel, snail, and phragmites.

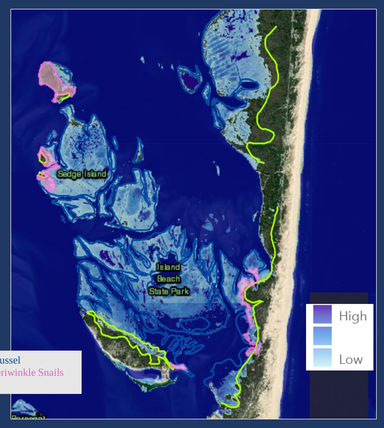

Figure 7. Southern Barnegat Bay Marshland over lain with a 1 foot rise in sea level as well as high density populations of varying species of mussel, snail, and phragmites.

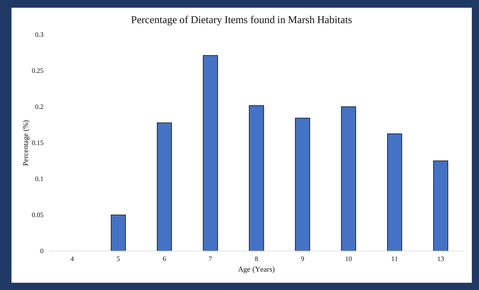

Figure 8. A comparison of the percentage of the total dietary sample that contained species from marsh habitats and age of the terrapins. N = 34

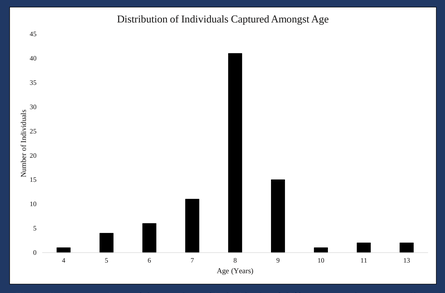

Figure 9. A comparison of the number of individuals of different ages that were collected in a small sample of the capture and release study.

Figure 10. A Diamondback Terrapin, part of the capture and release study,being processed and evaluated

Discussion

Dietary Analysis
- Most prevalent species found in dietary samples that were dependent on marsh habitats included phragmites, coffee bean snail, periwinkle snail, ribbed mussel, and blue mussel.
- The most active age range is 7 to 9 years (most commonly captured and most commonly found on marshes.
- Phragmites reveals time spent along shoreline areas

Mapping Analysis
- Overlay of most densely populated areas of common marsh inhabiting species found in dietary samples with 1 ft sea level rise predictions.
- Revealed the moderate1ft sea level rise by 2050 predicted, would cover almost 80% of the habitat of the dietary species.
- A decrease in prey available will force the terrapins to find new food sources
- A change in the dietary behavior of the Diamondback terrapin, due to its status as a keystone species, will force change amongst species throughout Barnegat Bay.

Figure 11. Examples of the dietary samples collected through a novel stomach purging technique. Labelled with the individual subject's notch code.

Conclusion

Real World Application
- A change in the behavior of the Diamondback terrapin would lead to a major shift in other organisms in Barnegat Bay.
- Barnegat Bay is an area the economy depends upon, so a major change in the Bay would alter the economy.
- Due to the high development of the shoreline, there is no area for marshes to recede to, therefore limiting habitat.

Solutions
- Improve barrier systems, instead of using bulkheading, to help reduce flooding along the shoreline
- More concentration on the conservation of the Diamondback terrapin as well as its prey species and their habitat should be considered.

General
- A larger sample size and area should be evaluated in the future to more completely understand the future of the Diamondback terrapin and its' role in Barnegat Bay.

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