PC: Elise Perry

Horseshoe crab (*Limulus polyphemus*) spawning surveys collected with participatory science in Great Bay Estuary, NH

Lauren E White[1], Christopher C. Chabot[2] , Christopher R. Peter[1], Melissa R. Brogle[1], and Winsor H. Watson III[3]

Great Bay National Estuarine Research Reserve[1], Plymouth State University[2], University of New Hampshire[3]

PC: Christopher Chabot

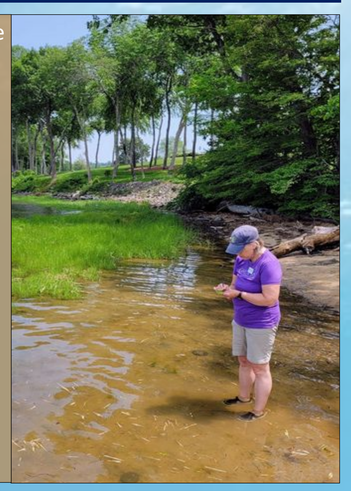
Introduction

American horseshoe crabs are a vital part of estuarine ecosystems, are important to bait fisheries, and a substance in their blood (LAL) is used in the biomedical industry.

Populations across the eastern seaboard are impacted by habitat loss and harvesting (bait, LAL). Recent reports suggest there is a risk of loss at local levels in some northern areas[1,2].

Annual spawning surveys are useful for tracking populations trends to inform conservation actions.

Here, we report on a long-term spawning dataset collected by over 100 participatory scientists in an embayment not subjected to fishing pressures.



Methods

Survey Procedures

- Daily from early May to late June.
- Daytime high tide monitoring for the duration of spawning using volunteers.
- Previous studies showed no difference between day and night counts in Great Bay Estuary[3].
- Survey transcects ranged in length from 50-100m, parallel to shoreline.
- Volunteers counted all pairs and single animals within 2m of high tide along the transect.
- All single animals were recorded as males. We sampled 355 single horseshoe crabs across five sites (both beaches and marshes), and found 97% were male).

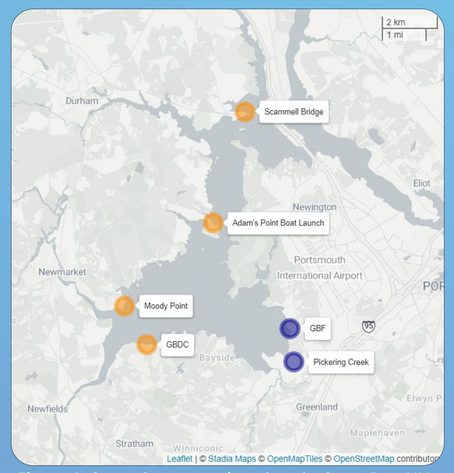


Figure 1: Spawning survey locations in Great Bay, NH. Orange sites are beach habitat and blue sites are marsh. GBDC = Great Bay Discovery Center; GBF = Great Bay Farm.

Data Processing

- Volunteers submitted their findings either electronically or on paper.
- They also noted wave and weather conditions and water clarity.
- The data from each year were processed and compiled by graduate students, faculty, and GBNERR staff.

Spawning Survey Locations

- 3 sites from 2016 - 2022 analyzed for temporal trends (GBDC, Moody Point, AP Boat Launch).
- 6 sites from 2022 - 2025 analyzed for spatial trends.

References:

1. Crosby et al (2025). Regional biodiversity monitoring reveals severe population decline of the Atlantic horseshoe crab (Limulus polyphemus) in Long Island Sound, USA. *Scientific Reports*
2. Smith, D. R., Pooler, P. S., Swan, B. L., Michels, S. F., Hall, W. R., Himchak, P. J., & Millard, M. J. (2002). Spatial and temporal distribution of horseshoe crab (Limulus polyphemus) spawning in Delaware Bay: Implications for monitoring. *Estuaries*, *25*(1), 115–125
3. Cheng et al. 2016. Influence of environmental factors on spawning of the American horseshoe crab (*Limulus polyphemus*) in the Great Bay Estuary, USA. Estuaries and Coasts

Acknowledgements

This study would not be possible without the hundreds of volunteers who participated in our horseshoe crab spawning surveys each spring, over many years. Without their dedication, passion and curiosity study would not have been possible. We also thank NOAA for providing us student support through the Ernest F. Hollings Undergraduate Scholarship Program and our local National Estuaries Program, Piscataqua Region Estuaries Partnership, and Fish and Wildlife Service CSWG Awards F21AP00690 and F25AP00567 for providing additional support. Throughout the years, other students and key partners also provided support including Wellesley Costello and Alyson Eberhardt of NH Sea Grant, Sam Applebaum, Natalie Gravelle, Cole McShane, Tyler Shipley, and Jessica Nitzschke of Plymouth State University and Helen Cheng, Brian Davis and MacKenzie Meier from the University of New Hampshire.

Results

Spawning surveys of the Great Bay Estuary horseshoe crab population have been conducted primarily by a volunteer force since 2016. During this time, we have collected 1,388 surveys during which 46,180 horseshoe crabs have been counted across 6 sites.

Temporal Trends

- It appears that the horseshoe crab population has stayed pretty consistent from 2016 to the present; at least in 2 of the three sites for which we have the longest data sets.
- The M:F sex ratio appears to have slowly increased over the past 10 years (Figure 2).

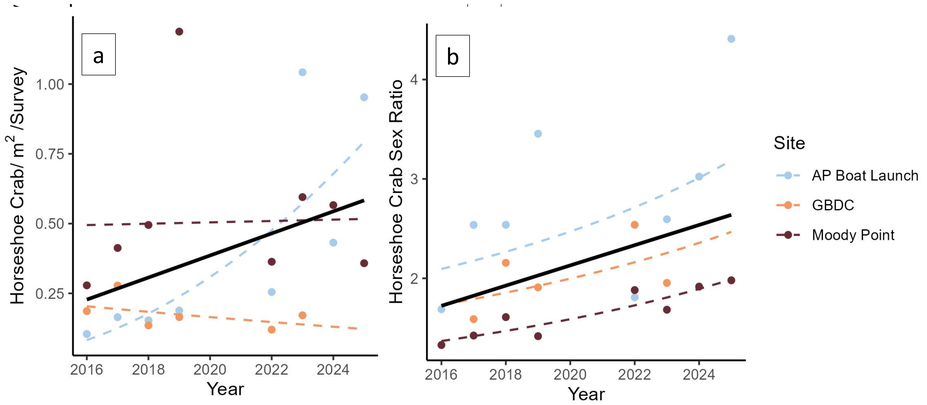


Figure 2. Long-term trends of horseshoe crab (a) density (crab/m2/survey) and (b) sex ratio between 2016-2025 at three sites in GBE. Trends of density varied by site: while the AP Boat Launch site increased, neither Moody nor GBDC changed significantly (p = 0.001, R2 = 0.64). The sex ratio significantly increase throughout GBE (p = 0.03, R = 0.22). Panels depict a linear regression using a Time*Site interaction.

Spatial Trends

- Horseshoe crab sex ratio varies across sites, though there are no discernable differences between habitat types. Sex ratio may vary based on position in the estuary (Figure 3).

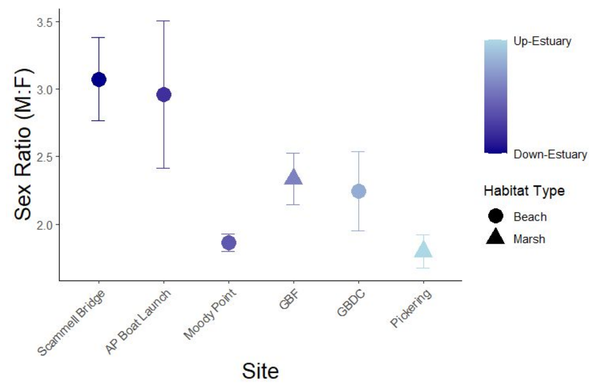


Figure 3: Horseshoe crab sex ratio (M:F) between 2022-2025 is different across sites using an anova (p = 0.047), but but post-hoc Tukey comparisons of means with 95% confidence level showed no significantly different pairs. There is no significant difference across habitat types.

Spawning Season

- We define the spawning season as starting when at least 2 mating pairs are observed and ending the last day two pairs are counted.
- In general, spawning season lasted ~ 1 month; starting between May 10th and May 19th, and ending between June 10th and June 25th (Figure 4).

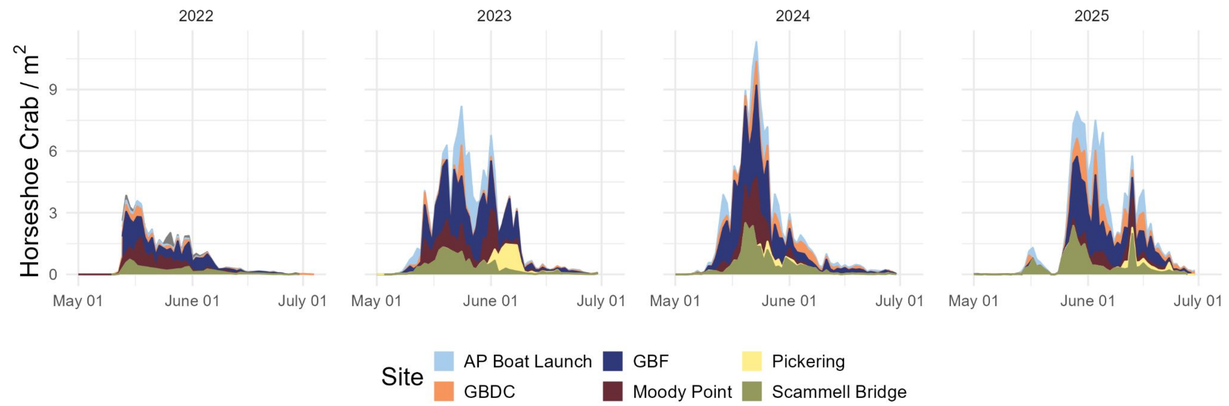


Figure 4: Density of horseshoe crabs/m^2 observed at 6 different spawning locations during each survey day 2022-present.

PC: Pam Perreault

Conclusions

- Overall, in terms of abundance, the horseshoe crab population in the Great Bay Estuary appears to be doing well, and there are no signs of decline.
- The M:F ratio has been gradually increasing, for reasons that are not obvious. While one might expect this to happen in an area where females are preferred for harvesting, horseshoe crabs are not harvested in NH. Therefore, this should be investigated further, alongside reasons for variation between sites.
- The duration of the spawning season is about 1 month, and while spawning typically starts as the water temperature increases in the spring, it is not clear what factors have the greatest impact on when mating season starts in NH.
- This research could not have been carried out without the help of many volunteers and we encourage other states and agencies to also take advantage of all the interested and capable citizens who care about the health of the natural world around us.