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Lagoonal Back Bay Beaches as Spawning Habitat for Horseshoe Crabs

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Abstract *Horseshoe crabs (Limulus polyphemus) are valued for bait, their blue blood, and as a critical food resource for the endangered Red Knot. While there are large scale surveys for spawning adults and egg densities in expansive coastal beaches, one critical missing habitat which may greatly support the regional Horseshoe Crab populations is lagoonal back bay beaches. Data from our samples collected in 2024 from Barnegat Bay, New Jersey found an average egg density of 152,006m^{-2}, with some samples exceeding 500,000m^{-2}. Additionally, data demonstrated Horseshoe Crab eggs present in over 50% of the samples, indicating these regions are valuable spawning habitat for Horseshoe Crabs.*

Keywords *horseshoe crab • Limulus polyphemus • Barnegat Bay*

Introduction

Horseshoe crabs (*Limulus polyphemus*) are a widely distributed coastal species and valued for their use as bait (Munson 1988), biomedical research (Levin et al. 1970, Krisfalusi-Gannon, et al. 2018), and as a critical food resource for migrating birds, including the endangered Red Knot (Dunne et al. 1982; Botton et al. 1994). While there are large scale surveys for spawning adults and egg densities in expansive coastal beaches (Smith et al. 2009, 2017), one critical missing habitat which may greatly support the regional horseshoe crab populations is lagoonal back-bay beaches. While these beach areas are not as expansive as many of the known spawning sites, the lack of investigation into their potential as habitat may limit our ability to fully understand horseshoe crab populations. Many coastal regions with substantial barrier islands have large lagoonal estuaries with varied habitats including salt marshes, mud flats and beaches which could act as alternate spawning habitats (sensu Sasson et al. 2024), but they also are greatly influenced by anthropogenic stressors (Chacón Abarca et al. 2021).

Regionally, evaluations of egg densities have been reported from Connecticut (Beekey et al. 2013), Massachusetts (James-Pirri et al. 2005), Delaware (Pooler et al. 2003), Jamaica Bay, New York (Botton et al. 2021), and from Delaware Bay, New Jersey (Botton et al. 2021), but these are wide and expansive beach regions. Unfortunately, Smith et al. (2022) documented dramatic declines in surface egg densities over the last 20 years, potentially impacting both horseshoe crab populations and shore birds. While lagoonal back-bay beaches may be narrow in comparison to the primary beaches surveyed, they may still provide spawning habitat for horseshoe crabs and contribute to regional populations. This study looked to document whether these regions could support egg laying activity by this critically important species.

Methods

Horseshoe Crab egg densities can vary widely among sites and jointly reflects reproductive effort and losses due to predation. To assess egg densities in lagoonal back-bay beaches, a 5.08cm corer was used to collect samples at two locations in Barnegat Bay, New Jersey: Island Beach State Park (39.87428ºN -74.08754ºW, 6/20/2024, N=9 cores)

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and 'Dredge Island' (39.78762ºN -74.14468ºW, 6/12/2024, N=10). Cores were driven into mid-tidal regions to a depth of 20cm, per the recommendations of Botton et al. (2021). After collection, samples were preserved in 95% ethanol in the field and stained with rose Bengal to assist with sample processing after returning to the laboratory. Samples were processed using a stacked sieve series (4mm, 2mm, 1mm, 0.71mm) to ease identification of egg clusters and individual eggs. All eggs were counted and retained in 95% ethanol.

Results and Discussion

Evaluation of these lagoonal back-bay regions provides insight into alternate spawning habitat for horseshoe crabs. Core samples demonstrated high average horseshoe crab egg densities (Fig. 1) which exceeded 100,000 m^{-2} for both sites, but high variability among individual samples occurred. This is because only 44% of samples from Island Beach State Park had eggs (range 0-427,407 m^{-2}), while 60% of samples from Dredge Island contained eggs (range 0- 749,873 m^{-2}). Regardless, these results demonstrate that these lagoonal beaches are being used by horseshoe crabs as reproductive habitat and corresponds to Sasson et al. (2024) assertion that alternate habitats are available for horseshoe crab spawning.

For comparative purposes, egg densities and egg presence in cores are used to evaluate the generalized value of regional habitats. Delaware Bay in New Jersey has often been seen as the epicenter of horseshoe crab reproduction (Botton et al. 2021; Smith et al. 2022), especially as its value as a stop over feeding area for migrating birds (Dunne et al. 1982). During early surveys, Delaware Bay egg densities were estimated at 393,000 m^{-2} (Botton et al. 2021), but declines during the last several decades (Smith et al. 2022) have begun to intensify management of horseshoe crabs (Smith et al. 2017). There are several questions which need to be addressed to truly determine the overall value of lagoonal back-bay beaches as reproductive habitat. First, what is the spatial and temporal use of these beaches for egg laying? Since these regions are likely to see greater salinity fluxes due to river input, to what extent are crabs using these regions and does egg density drop off as freshwater inputs increase? Additionally, as these regions are potentially warmer than more exposed beaches, is the spawning timeframe the same or does it become reduced as summer temperatures increase? Second, to what degree are the successful recruits contributing to the regional population(s)? A careful examination of genetic characteristics of both adults and eggs could reveal their relative contributions to these populations (King et al. 2015, Hallerman et al. 2022). Lastly, do differences exist between shallow and deep egg densities? Since horseshoe crab

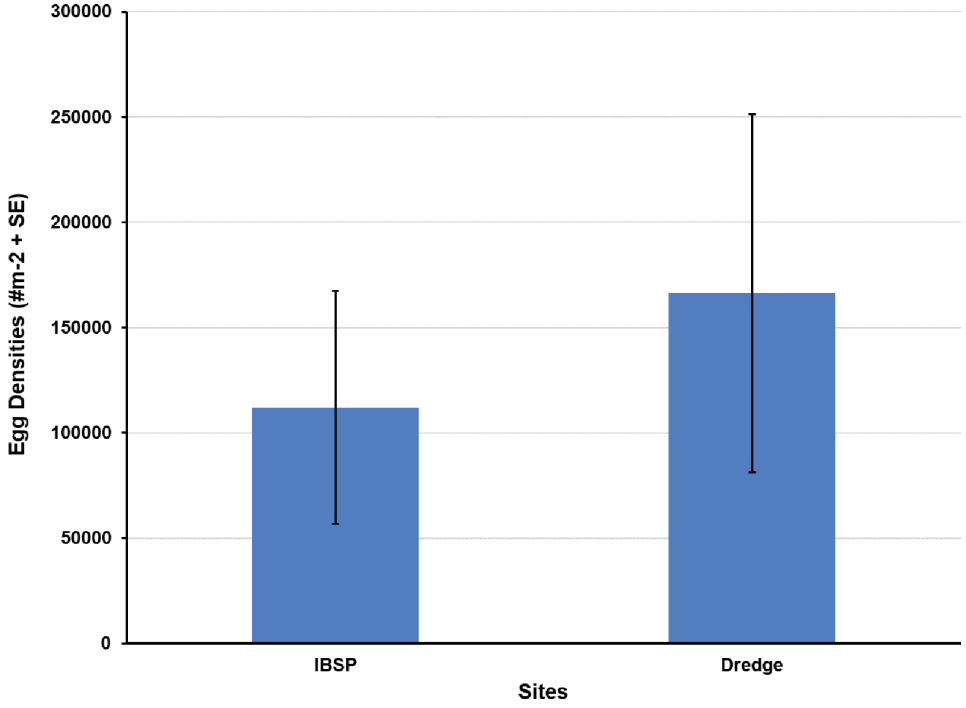

Figure 1. Horseshoe Crab egg density comparison between Island Beach State Park and the Dredge Island sites. Values represent average egg density from cores (mean + SE).

eggs are important food resources for migrating birds, do they suffer similar predation rates in these regions. If they do, then this might impact conservation considerations for threatened bird species. However, if egg predation is minimal, could this reflect the possibility that these regions may be acting as source populations for larger mid-Atlantic meta-population structure.

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