

## Horseshoe Crabs – Special Feature (SOOE Extended)

### Question:

Where and when do horseshoe crabs spawn in the Great Bay Estuary? How have numbers of crabs changed over time?

### Short Answer

Since 2012, the number of horseshoe crabs counted in spring surveys has remained stable with notable increase in 2022. The ratio of male to females has increased steadily since 2012, though the reasons for this are not known. Recent spawning surveys indicate that spawning usually peaks in May with a smaller peak approximately two weeks later. Spawning takes place primarily on small beaches in the Great Bay Estuary but also on marshes and in tributaries.

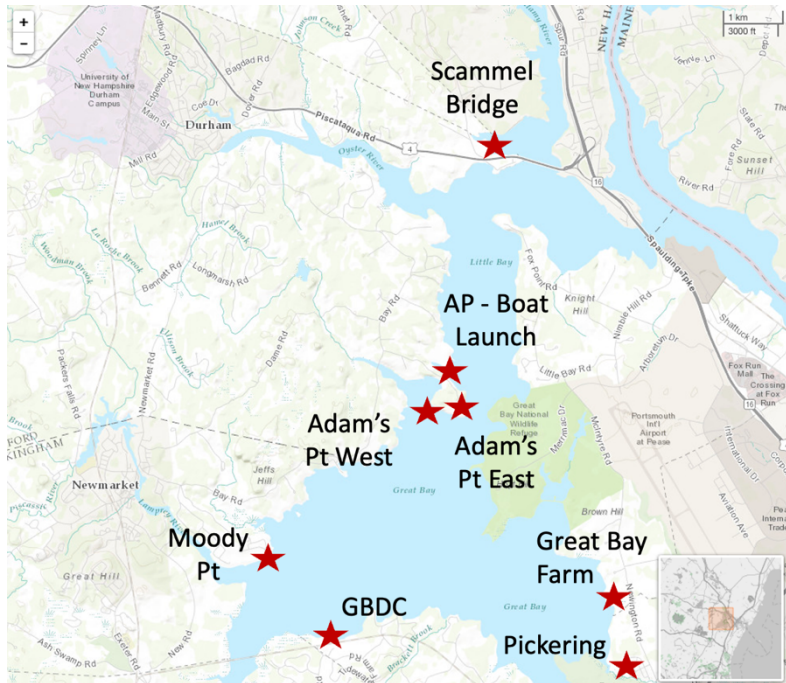
### Why Monitor Horseshoe Crabs?

Horseshoe crabs (Figure HC-1) are important for a number of reasons ranging from economic to ecological. While they are not fished in New Hampshire, more than 600,000 of them are captured and bled to obtain *Limulus* amoebocyte lysate, a valuable substance used by the biomedical industry to detect contamination of medicines. A large number of horseshoe crabs are also captured and used as bait by the whelk fishery. As a result of harvesting for both these purposes their population has declined, and there is concern for the survival of this species. Ecologically, horseshoe crabs are considered a keystone estuarine species primarily because they are key “bioturbators” as they forage in the marine mud for prey, they “turn-over” nearly all of the intertidal mud and bring nutrients to the surface (Lee 2010).



**Figure HC-1. Female (larger, at left) and male horseshoe crab during spawning season in Great Bay Estuary. (Photo credit: Elizabeth Carroll)**

In addition, horseshoe crabs, like many other species, might also be impacted by climate change. There is concern that warming waters and rising sea levels might impact both when and where these crabs are able to spawn. In locations like estuaries, these impacts might occur even sooner than along the coastline, and thus serve as early indicators that steps need to be taken to protect this species.



**Figure HC-2. Map showing locations of horseshoe crab monitoring sites in the Great Bay Estuary.**

## Results

Horseshoe crab abundance and spawning is tracked at sites shown in Figure HC-2. Male to female ratios and abundance counts from 2012 to 2022 are shown in Figures HC-3 and HC-4. The ratio of males to females has increased steadily since 2012 while overall abundances have remained somewhat stable with a notable uptick in 2022. It is unclear why the male to female ratio is increasing. In states such as Massachusetts, females are preferentially harvested, which would impact the ratio, but harvesting is not allowed in New Hampshire.

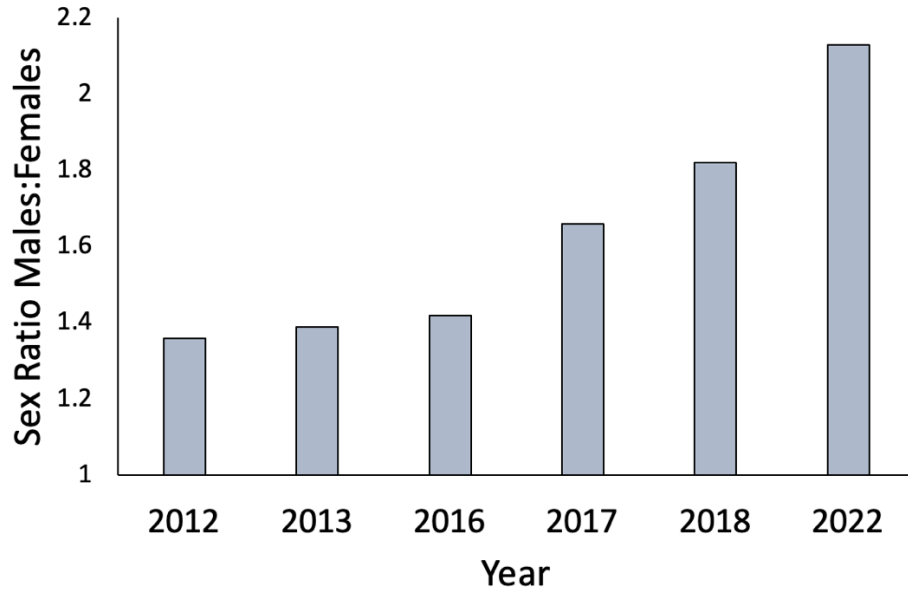


Figure HC-3. Male to female ratios of horseshoe crabs in the Great Bay Estuary.

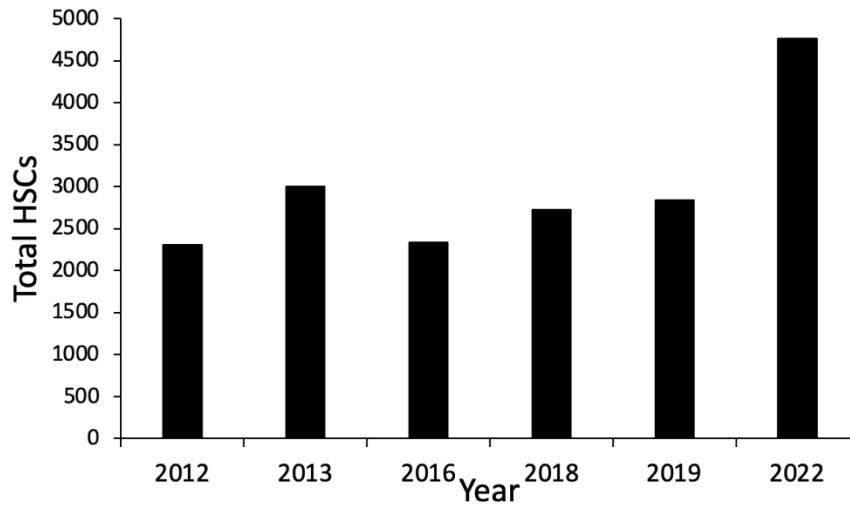


Figure HC-4. Total numbers of horseshoe crabs counted during Great Bay Estuary spring surveys.

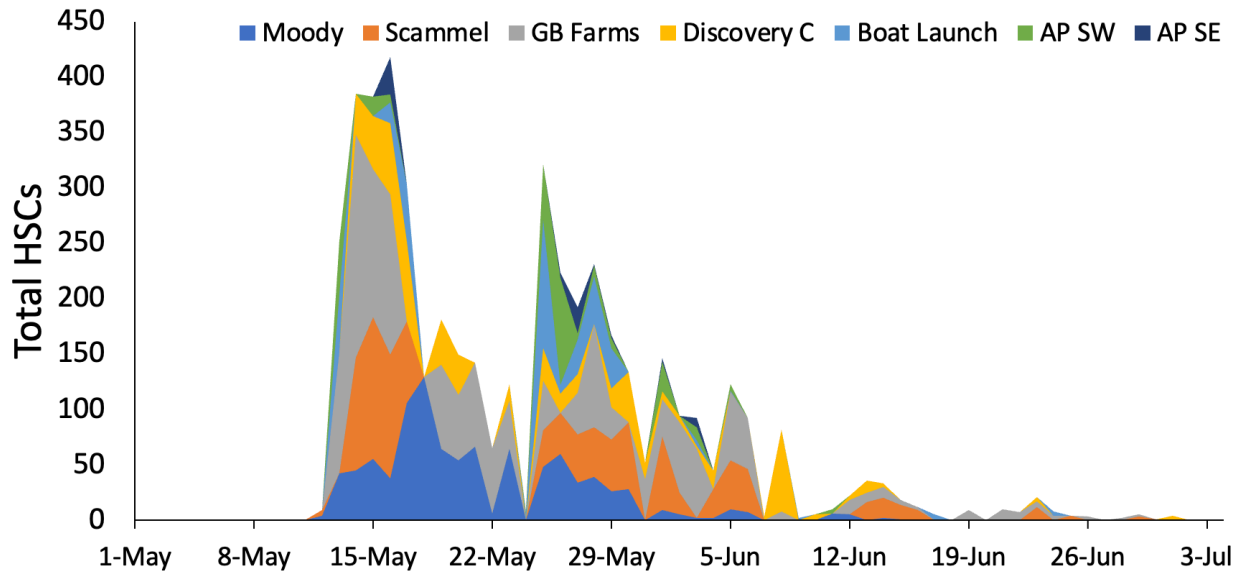


Figure HC-5. Horseshoe crab spawning survey results from 2022 in the Great Bay Estuary.

Volunteer-aided annual horseshoe crab spawning surveys have been conducted since 2016 (Figure HC-5). The goals of the survey are to determine: 1) What factors might coincide with the initiation of *Limulus* mating; 2) How long the mating season lasted and whether mating behavior coincided with the phases of the moon; 3) Where most of the spawning took place and if these locations coincided with the abundance of juvenile horseshoe crabs. Last year, scientists also began to map “alternative” mating locations (marsh grass) throughout the estuary to determine if eggs were laid in these areas and if the eggs survive as well as they do in traditional beaches.

Many of the horseshoe crabs that are present in Great Bay in the summer overwinter in the deeper channels found in Little Bay (Schaller et al. 2010; Watson et al. 2010). Then in the spring, when the water temperature exceeds  $\sim 12^{\circ}\text{C}$ , they move up into Great Bay in preparation for spawning (Watson et al. 2016). Typically, in May, when there are a series of warm days and the water temperature increases rapidly, spawning begins, leading to the first large surge in mating activity (Cheng et al. 2015, 2016). While lunar phase appears to be important in some horseshoe crab populations, breeding in Great Bay horseshoe crabs doesn’t necessarily coincide with new or full moons. A given individual female typically spawns about 2-4 times in a week during the  $\sim 6$ -8 week breeding season (Owings et al. 2019; Watson et al. 2022). A second peak of breeding activity generally occurs 10-14 days after the first one and it is not clear what factors give rise to this second peak. While females often return to the same beach to spawn, they will also mate in several other locations in a given spring/summer. Some of the “most popular” locations in Great Bay appear to be: 1) Moody Point; 2) Great Bay Farm; 3) Pickering Creek and; 4) Adams Point (see Figure 2). While the greatest abundance of mating horseshoe crabs is usually observed on a handful of beaches in the Great Bay proper, mating has also been observed, and now confirmed, in a number of marshes and tributaries as well.

Horseshoe crab eggs hatch after about 3-4 weeks and the trilobite larvae stay in the water column for about 14 days. During this time the combination of currents and their movements up and down in the water column (Chabot et al. 2021), cause many of them to be carried up into Great Bay proper, and into various tributaries, where they settle to the bottom in the soft mud and

metamorphose into 2<sup>nd</sup> instar juveniles. Thus, the greatest abundance of juvenile horseshoe crabs does not necessarily coincide with where spawning takes place (Cheng et al. 2021).

### Methods and Data Sources

Spawning surveys were conducted by students, faculty, and volunteers during each daytime high tide in May and June. In one year, surveys were carried out during night high tides to test the hypothesis that more mating takes place during the night than the day. This turned out to be false and there are similar numbers of animals breeding during the day and the night tides in Great Bay. In most years, surveys were done at: The Great Bay Discovery Center, Moody Point, Adams Point, and the boat launch near JEL. At these locations, 50-100 meter transects were established and people walked the transect at high tide and counted all the horseshoe crabs seen from the edge of the water out to 2m from the edge. They also quantified the number of single males, single females, and pairs, with males attached to females. In 2022, the number of study sites was expanded to six and volunteers were also asked to note the number of male/female pairs that were buried and apparently actively mating.

Additional data outlined above were also obtained using a variety of acoustic telemetry methods and SCUBA diving was employed to survey juveniles throughout Great Bay and Little Bay. These methods are provided in the papers cited below.

### Acknowledgements and Credit

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