2024 Horseshoe Crab Spawning Report

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MARYLAND COASTAL BAYS PROGRAM

MARYLAND DEPARTMENT OF NATURAL RESOURCES

Introduction

There are four different species of horseshoe crabs, but only one, the Atlantic horseshoe crab (*Limulus polyphemus*) is found in North America along the Atlantic and Gulf coasts. Horseshoe crabs are incredibly important species that have scurried along the ocean floor for over 445 million years. They have survived five mass extinctions and many believe it is due to their incredible ability to adapt to a variety of environmental conditions and their amazing immune systems. The success of migratory birds like the threatened red knot (*Calidris canutus*) is dependent on sustainable horseshoe crab populations. Each year, thousands of red knots use the beaches of Maryland, Delaware, and New Jersey as their final stopover site to fatten up on horseshoe crab eggs. Without this critical food source, the red knot would not be able to complete their migration to the Arctic Circle to breed, threatening the success of this species. Other species enjoy the taste of horseshoe crabs, which is why they are commercially harvested and used as bait in American eel and whelk fisheries. In addition to their ecological value, for over 40 years, horseshoe crab blood has been used to ensure the safe production of vaccines and injectable drugs (Maloney et al., 2018). Their blue blood contains a unique protein called Limulus Amoebocyte Lysate (LAL) which is able to easily detect the presence of endotoxins, making their blood extremely valuable to the biomedical industry.

Since 1998 the Atlantic States Marine Fisheries Commission (ASMFC) has been monitoring horseshoe crabs annually to ensure populations remain stable so they can continue to provide their ecosystem services to both fish and wildlife, and humans (ASMFC, 2024). The ASMFC relies on three data sources: bait landings, biomedical harvest and mortality, and commercial discards from other fisheries, to obtain annual population estimates from each region (ASMFC, 2024). The data collected by the ASMFC is used to regulate regional horseshoe crab fisheries and sustainably manage populations. The Maryland Coastal Bays watershed (Figure 2) falls within the ASMFC's Delaware Bay region (Figure 1), which has the largest horseshoe crab population and harvest out of all the regions. Since 2002 the Maryland Coastal Bays Program (MCBP) in partnership with the Maryland Department of Natural Resources (MDNR) have been conducting annual spawning surveys to document trends in relative abundance of horseshoe crabs in the Coastal Bays watershed. The most recent ASMFC stock assessment for horseshoe crabs was released in 2024 and states that horseshoe crab populations in the Delaware Bay region are "good". This is an improvement from the previous benchmark assessment in 2019, that listed the region as "neutral".

Figure 1. Map of regional stock populations of horseshoe crabs (ASFMC, 2024)

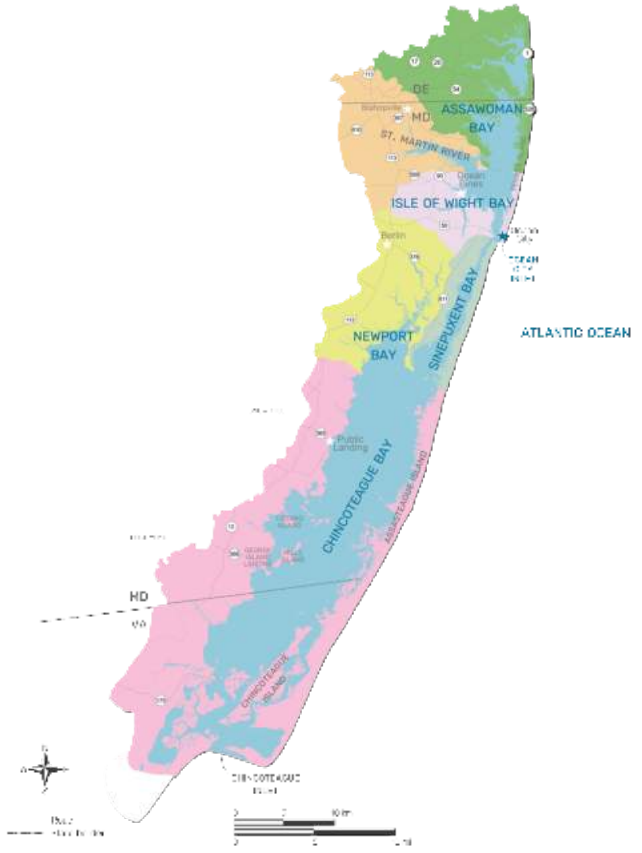
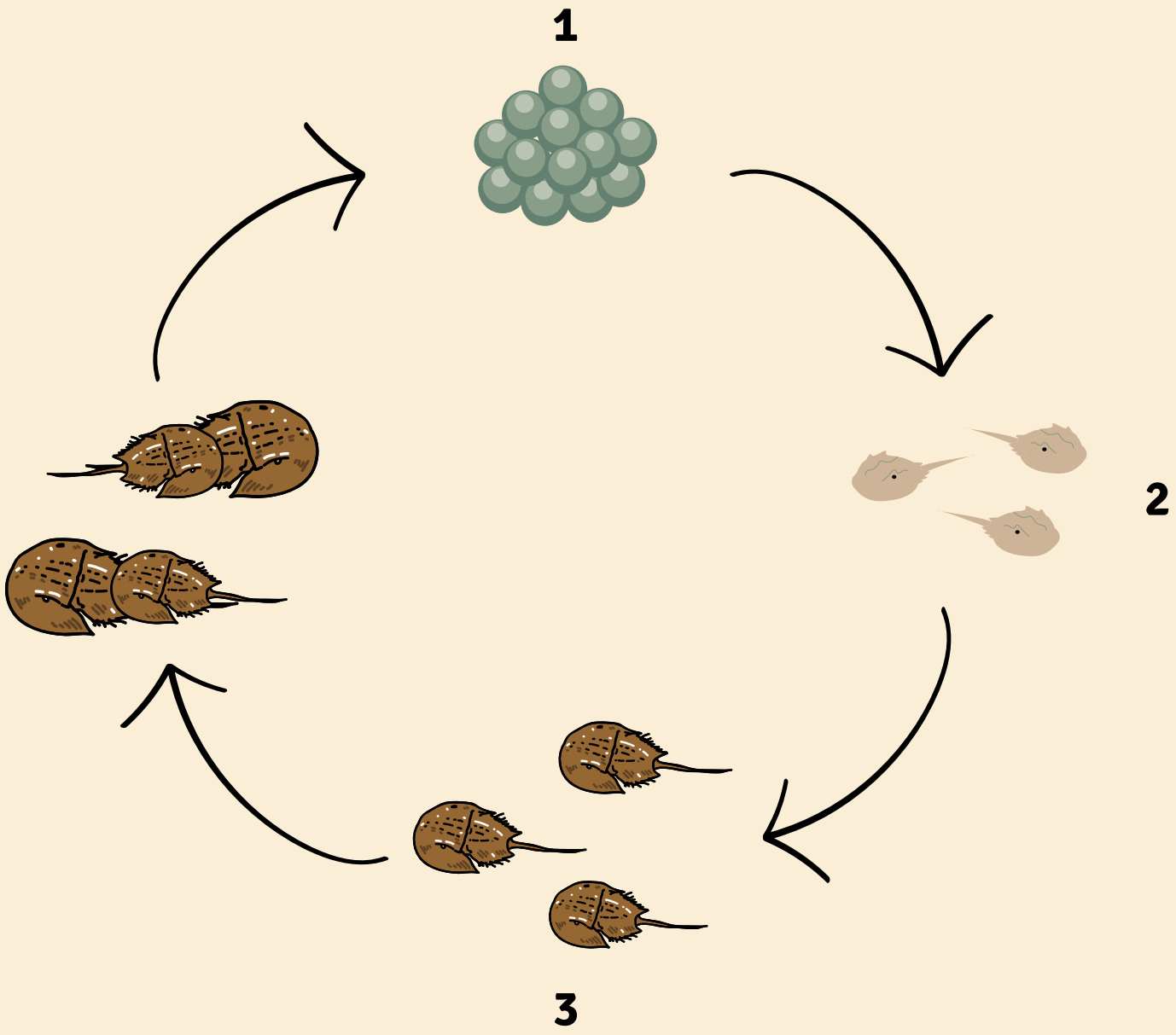


Figure 2. Map of Coastal Bays Watershed

Migration and Life Cycle



1 Horseshoe crab eggs are laid and buried in the sand where they incubate for approximately 2 - 4 weeks. Larvae are hatched from the eggs after incubation and are approximately 2-3 millimeters long.

2 Larvae (< 1 yr) stay in shallow estuarine waters where they molt several times and grow over 25% in size.

3 Juveniles molt several times during the first 2 - 3 years of life and then molt once annually. At this stage they remain in shallow estuarine environments. After about 2 years they an be found within a few miles offshore in deeper ocean waters.

4 At around 10 years old, horseshoe crabs reach maturity. They come from deeper estuarine or oceanic waters and return to shallow estuaries to spawn on the sandy beaches.

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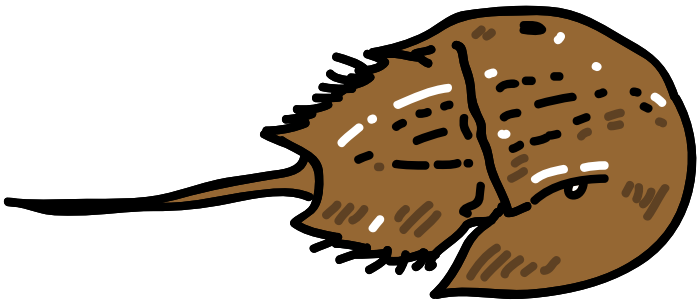
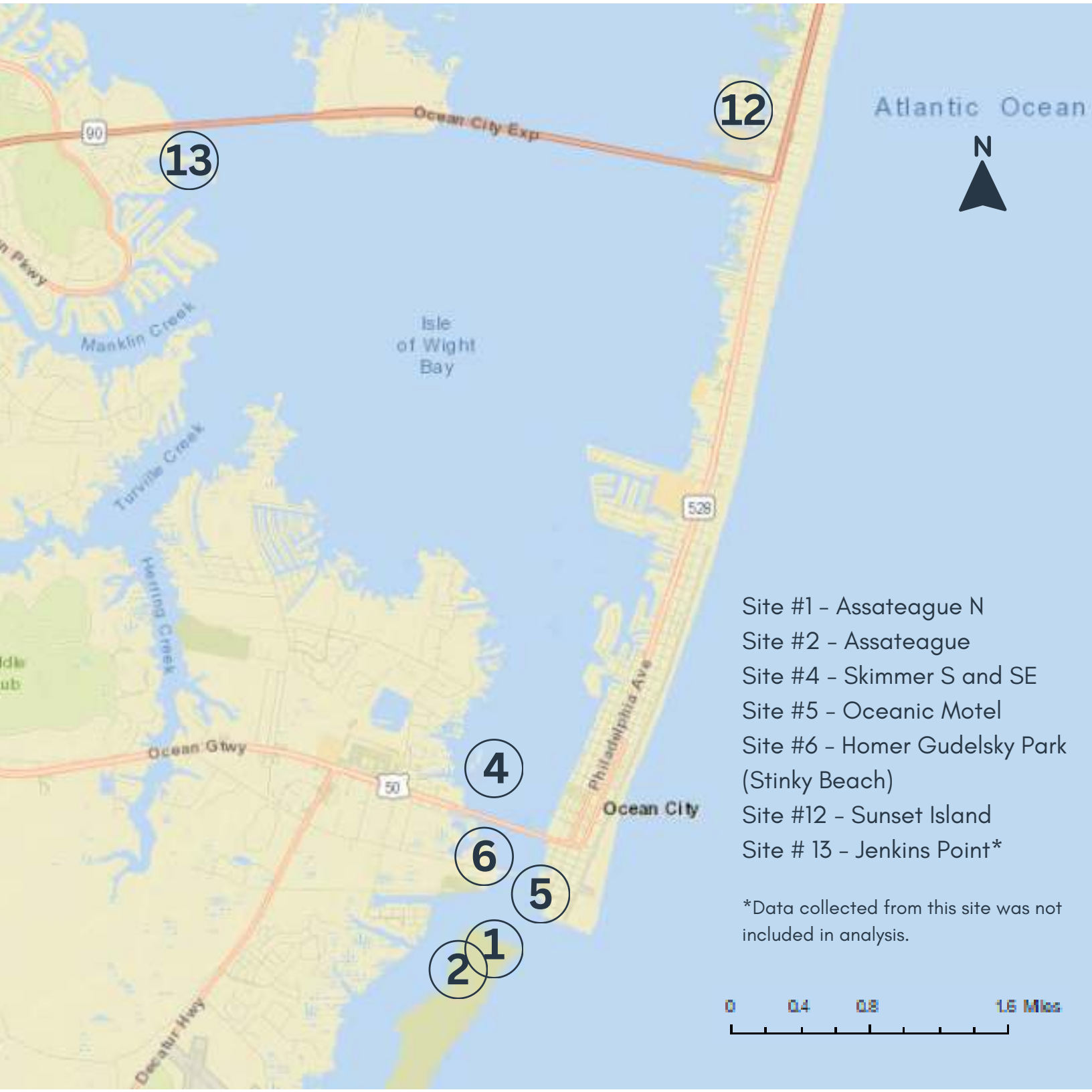


Where do we survey?



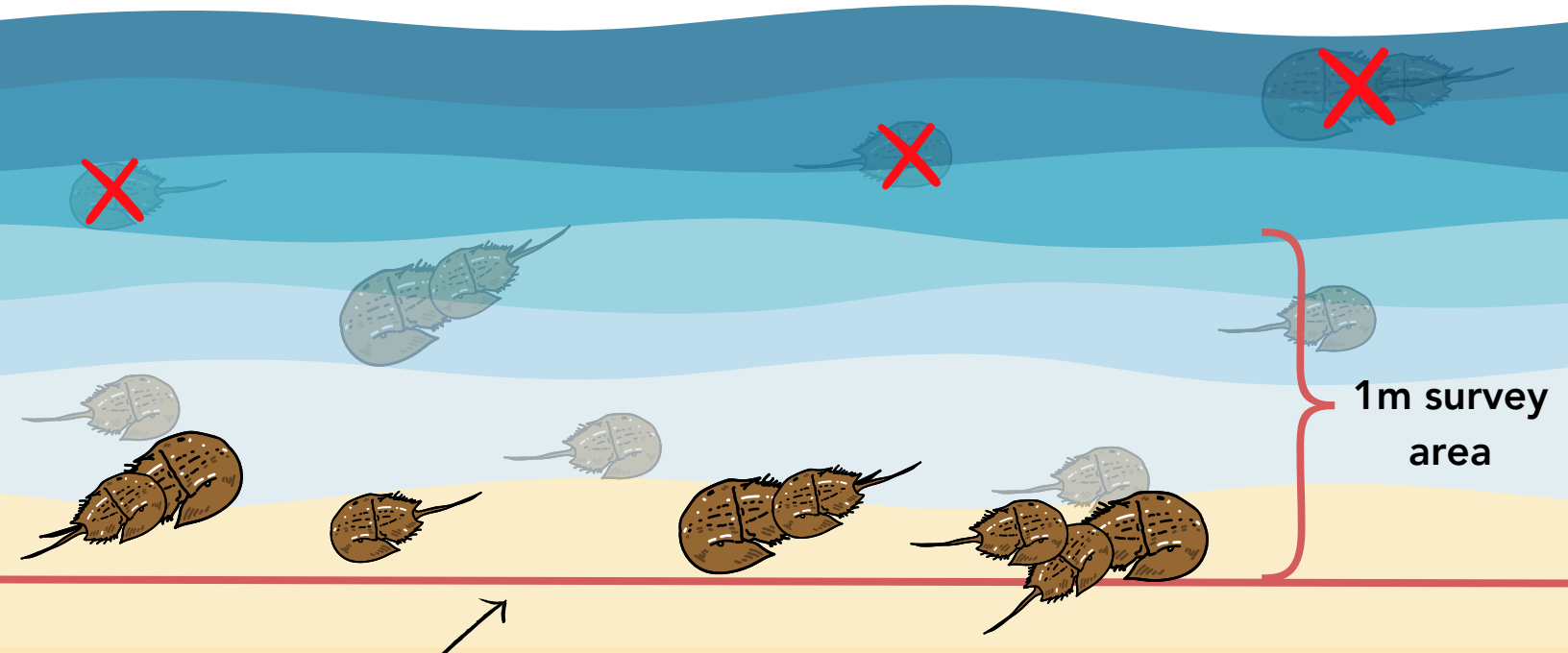
Site #1 - Assateague N
Site #2 - Assateague
Site #4 - Skimmer S and SE
Site #5 - Oceanic Motel
Site #6 - Homer Gudelsky Park (Stinky Beach)
Site #12 - Sunset Island
Site # 13 - Jenkins Point*

*Data collected from this site was not included in analysis.

Surveys are conducted on sandy beaches that have a history of use by spawning horseshoe crabs. The Jenkins Point site was sampled as a prerequisite for restoration and is not a long-term survey location.

How do we survey?

Generally, horseshoe crabs spawn in the Maryland Coastal Bays from late-May through July. Peak spawning for horseshoe crabs tends to occur around the new and full moon lunar cycles during the evening high tides. Surveys are scheduled to occur during a 5-day window revolving around those peak spawning events to obtain data that represents the population as accurately as possible. Upon arrival, initial notes about the survey location including water temperature, weather and water conditions, and any other important notes regarding the site are recorded. The start time is then recorded and surveyors walk along the transect which marks the high tide water line. All horseshoe crabs that are found within the 1 meter area extending into the water from the transect line are counted and sexed (see next page for sex characteristics). Any live horseshoe crabs that are seen outside of this 1 meter area are not counted (see example below). In addition to sexing and counting the horseshoe crabs, horseshoe crabs are separated based on whether they are live vs dead to get an estimate of mortality that occurs during spawning. All dead horseshoe crabs that are seen during the survey, even if they fall outside the survey area, are counted and recorded. The horseshoe crabs must be freshly dead to avoid double counting and overestimating mortality. Horseshoe crabs that have been dead for longer periods of time usually are missing multiple appendages, have maggots, or are fully hollowed out. The time is recorded to determine time elapsed at the end of the survey to track survey effort and volunteer hours.



*The horseshoe crabs with an "X" over them fall outside of the survey area and are not counted.

Male vs. Female Characteristics

There are three key characteristics that help surveyors determine the difference between male and female horseshoe crabs. The first and most obvious difference, is size. Females on average are about 25% larger than males. If size isn't a good enough indicator of sex, surveyors will carefully pick the horseshoe crab up by the sides of its shell (NOT its tail) and flip it over to look at its claws. Males have two clasping claws shaped like boxing gloves on their first set of legs (top right image) while females have the regular "scissor-shaped" claws throughout (bottom right image).

A final detail that helps determine sex occurs during spawning season. You will almost always see males attached to the abdomen of females, looking like they're hitching a ride from behind. Males use their clasping claws to hold onto the female while she swims or scurries along the sand and lays her eggs (middle image). As the female finishes laying her eggs, she moves away with the male in tow who can then immediately fertilize those eggs. This is why males attach themselves to females.

2024 Results

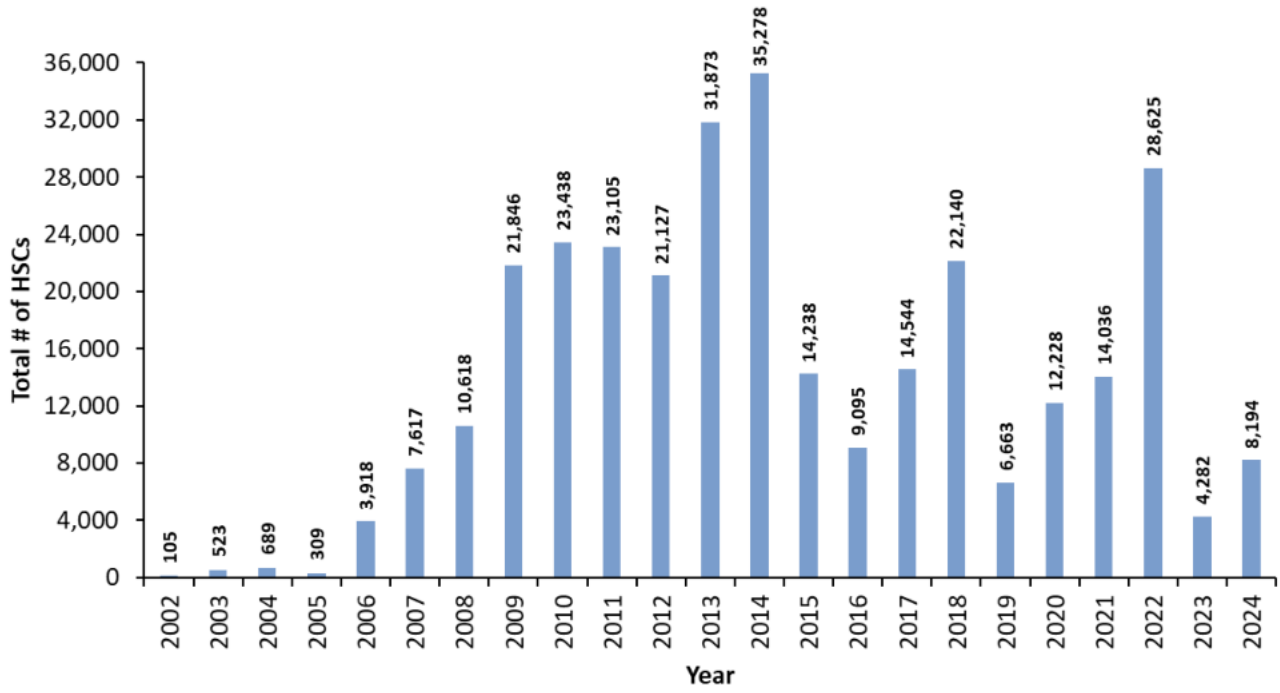


Figure 3: Total number of horseshoe crabs (live & dead) surveyed between 2002 - 2024)

A total of 8,194 horseshoe crabs were counted in 2024 as seen in Figure 3. This was an increase from the low in 2023 but still below the long-term average of 13,673. The total number of horseshoe crabs surveyed includes both live and dead horseshoe crabs. Dead horseshoe crabs typically make up a very small percent of the total number surveyed, but are important to include in the data to understand mortality rates. The percent of dead horseshoe crabs has been under 2% for 19/23 years we have conducted surveys indicating low mortality for spawning horseshoe crabs. The years when mortality was above 2% happened between 2002 - 2005 and ranged between 7 - 11%. As seen in Figure 3, the first four years had low horseshoe crab counts. This could be due to the fact that surveys were only conducted in May and June, or that survey locations were still being determined so many locations surveyed did not have spawning horseshoe crabs present. The average number of dead horseshoe crabs counted between 2002 - 2005 was 34, which is significantly lower than the overall average of 89.

Results of the 2024 survey show an increase from 2023 which is promising. We expect that the total numbers would be even higher for 2024 if two survey nights didn't need to be cut short due to unsafe weather conditions. MCBP and MDNR have determined several potential reasons why horseshoe crab counts have been lower than normal. We don't believe the low counts are indicating a decline in the population, but rather a change in spawning behavior.

CPUE Results

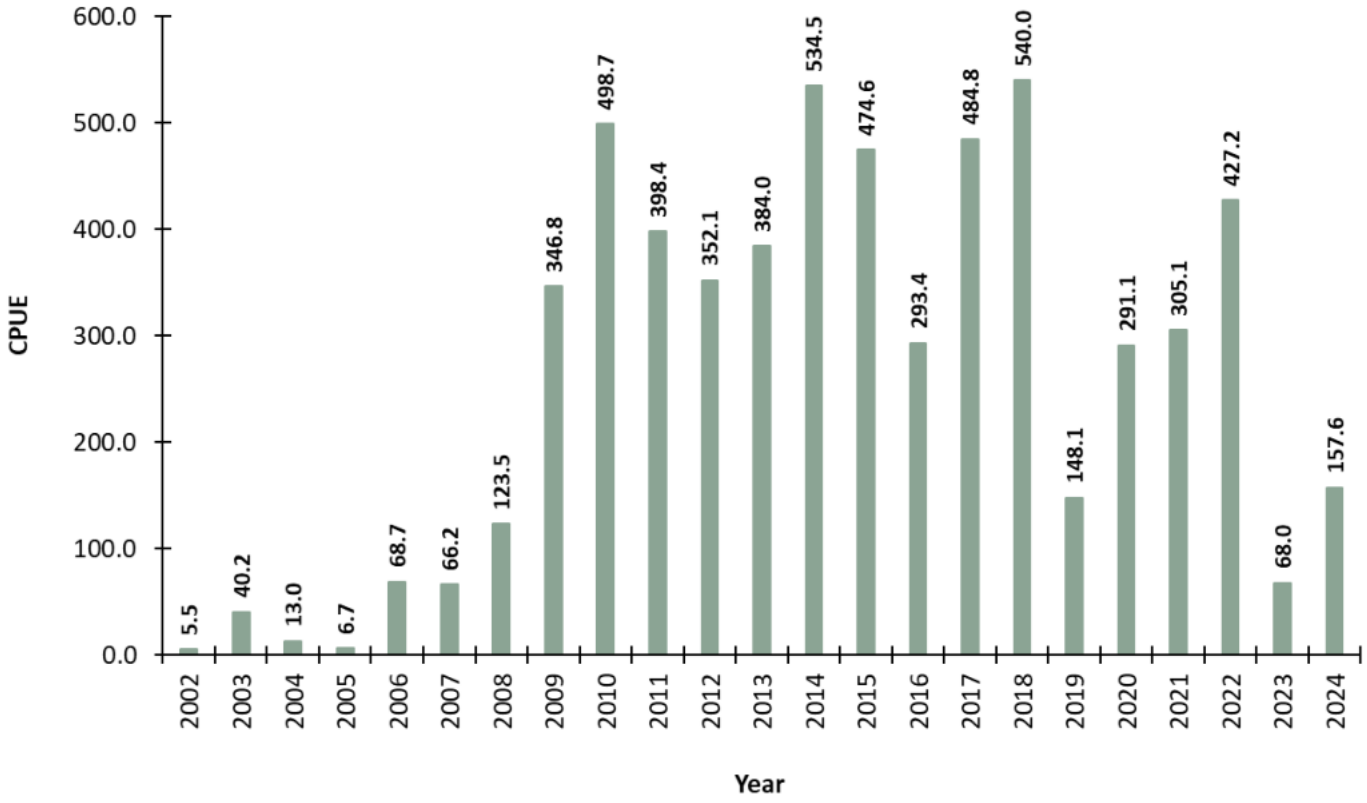


Figure 4: Catch per Unit of Effort (CPUE) based on number of surveys conducted between 2002 - 2024

Catch per unit of effort (CPUE) is a measure of abundance that is useful to assess long-term trends in animal populations. It is calculated by dividing the number of individuals by a measurable unit of effort. CPUE is important because it standardizes our data and provides clearer insight into population abundance. In the Coastal Bays, CPUE is calculated by dividing the number of horseshoe crabs counted (live & dead) by the total number of surveys.

In 2024, 52 surveys were conducted and 8,194 horseshoe crabs were counted resulting in a CPUE of 157.6 (Figure 4). Due to inclement weather, some locations were unable to be surveyed resulting in a lower number of surveys and potentially horseshoe crab numbers. Although we saw a dramatic dip in CPUE in 2023, it seems there has been a rebound with the 2024 CPUE value. We hope that 2023 was an anomaly and CPUE values will continue to increase with survey counts. Consistent declines in CPUE indicate that populations may be overharvested, however Figure 4 does not indicate that there is cause for concern yet.

Since 2002, MCBP and MDNR have conducted anywhere between 13 surveys (2002) to 115 surveys (2007). The number of surveys can change from year to year for several reasons. One of those reasons is due to observing a change in spawning behavior, whether it be spawning location or time of year. In past years, surveys were conducted from the first site of spawning horseshoe crabs until August to determine spawning numbers outside of peak season. Other factors include how many locations are surveyed from year to year and weather conditions.

Lunar Phases

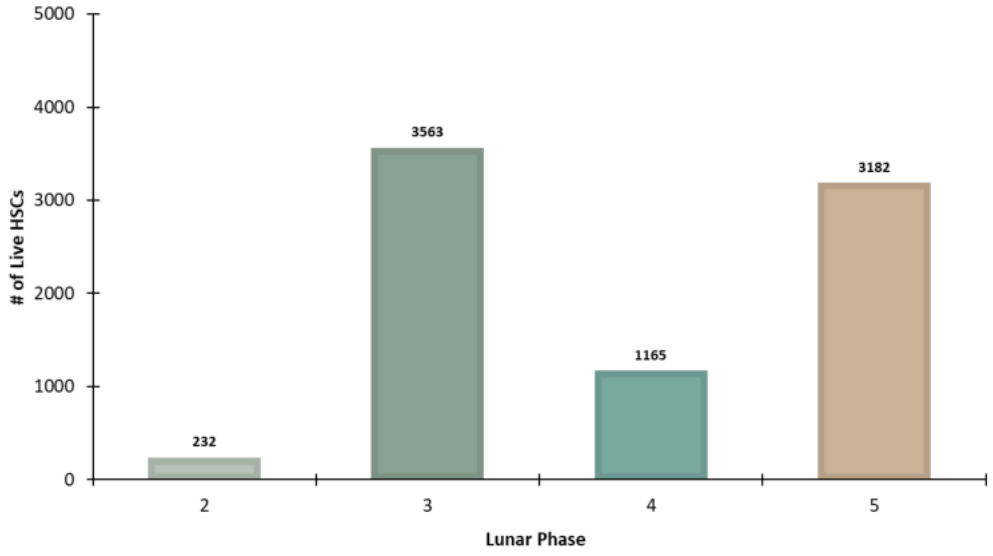


Figure 5: Live horseshoe crabs sampled by lunar phase in 2024

<u>The phases are broken up accordingly:</u>

Phase 1: May 1st - 15th
Phase 2: May 16th - May 30th
Phase 3: May 31st - June 14th
Phase 4: June 15th - June 29th
Phase 5: June 30th - July 14th
Phase 6: July 15th - July 30th
Phase 7: July 31st - August 14th

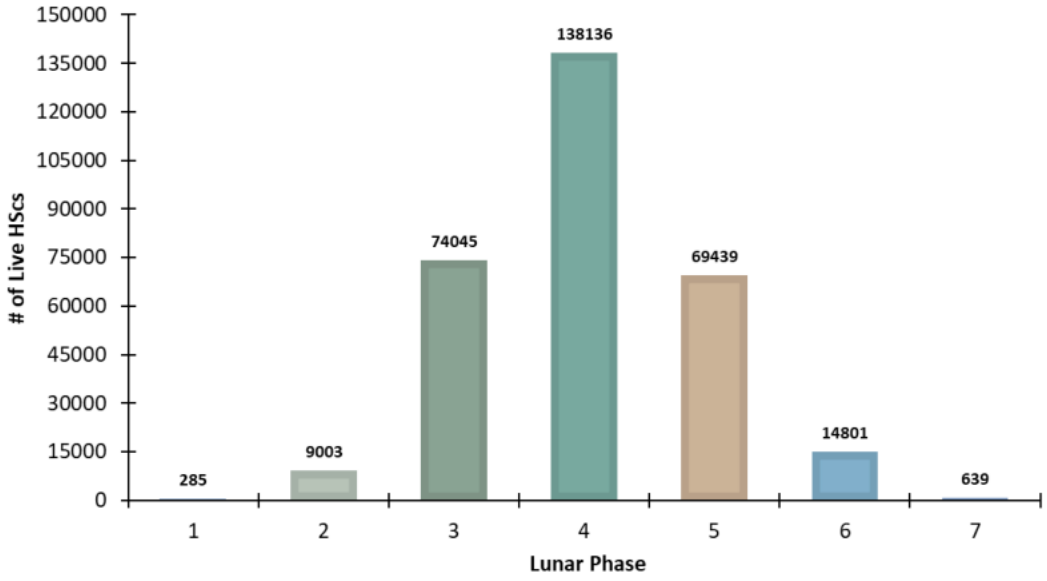


Figure 6: Live horseshoe crabs sampled by lunar phase from 2002 - 2024

Although our surveys revolve around the new and full moon lunar cycles, these cycles fall on different dates annually making it difficult to compare results from year to year. Additionally, over the years we have changed when we start and end surveying based on water temperatures and the spawning behavior of the horseshoe crabs for that specific year. Standardizing the dates and establishing clear lunar phases allows us to be able to compare data collected over the last 23 years. From this standardization, we can understand peak spawning days and if/how those dates change from year to year. The top figure shows that for 2024, no surveys occurred in phases 1, 6, or 7. MCBP and MDNR will typically survey 8 nights over the course of lunar phases 2 - 5 when peak spawning occurs. However, depending on available time and resources additional surveys may take place during other phases. Over the past two years there have been reports of horseshoe crabs spawning in late-April/early-May due to water temperatures warming faster. As a result, we may start surveying in phase 1 again to gain insight on how many horseshoe crabs are spawning early.

Peak Spawning Temps

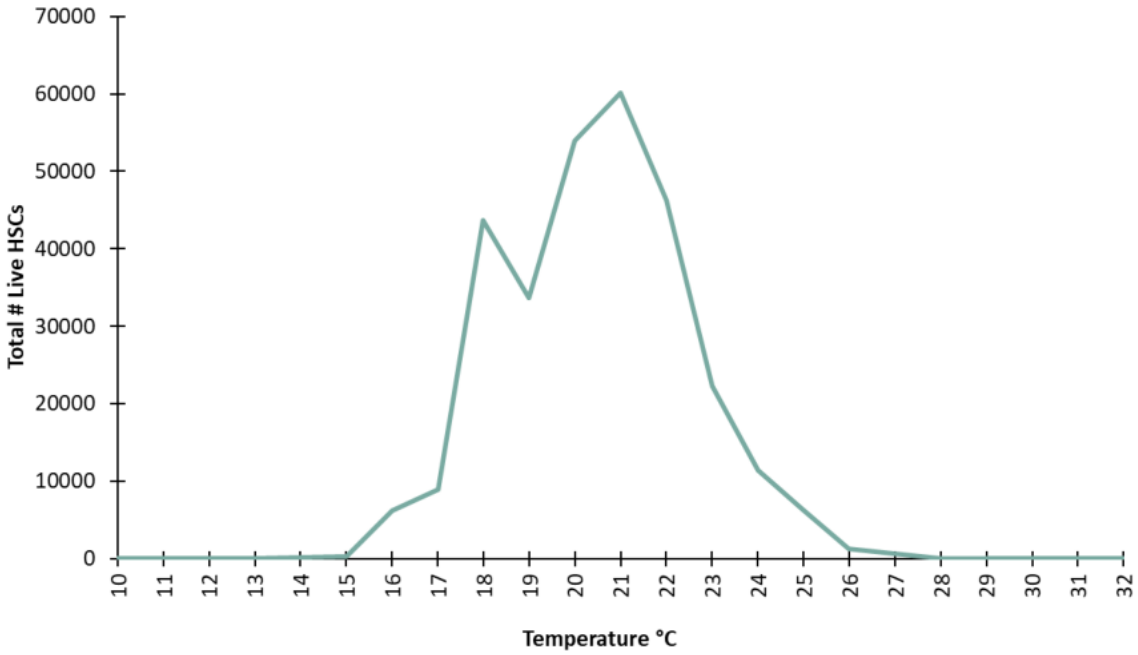


Figure 7. Total counts for (live) horseshoe crabs spawning by water temperature (2007 - 2024).

Water temperature is an environmental factor that triggers spawning in horseshoe crabs. It is important to collect water temperature data to understand how temperatures vary from site to site and how these varying temperatures are impacting spawning behavior. Additionally, water temperature data can provide insight into when we would expect to see peak spawning events. Since 2007, water temperatures have been collected at each survey location before every survey. Our long-term data shows that 95% (279,600) of all horseshoe crabs surveyed between 2007 - 2024 were spawning in waters that had temperatures ranging between 18 - 22°C. Although over the years we have observed horseshoe crabs spawning in water temperatures at or below 15°C, the numbers are so low that they cannot be seen on Figure 6. For 2024, 92.5% of horseshoe crabs were spawning at temperatures at or above 18°C.

Neighboring estuaries use water temperature data taken from a nearby sea buoy instead of collecting the temperature of the water's surface at the spawning locations during the time of the survey. The sea buoy's temperatures may be colder than the water temperatures at the spawning sites. This could explain why other nearby areas state that peak spawning begins at 15°C.

Water temperatures in the Coastal Bays have increased over the last several decades (Brinker et al., 2022). Additionally, milder winters are resulting in water temperatures warming faster and earlier in the season. Over the last two years we have observed spawning events occurring as early as mid-April, something that we had not previously witnessed. This shift in timing could become more prevalent as water temperatures continue to warm due to climate change. One of the ways we are working to understand exactly when water temperatures are hitting peak spawning temperatures is by deploying HOBO data loggers throughout the northern Coastal Bays.

Temperature Variation

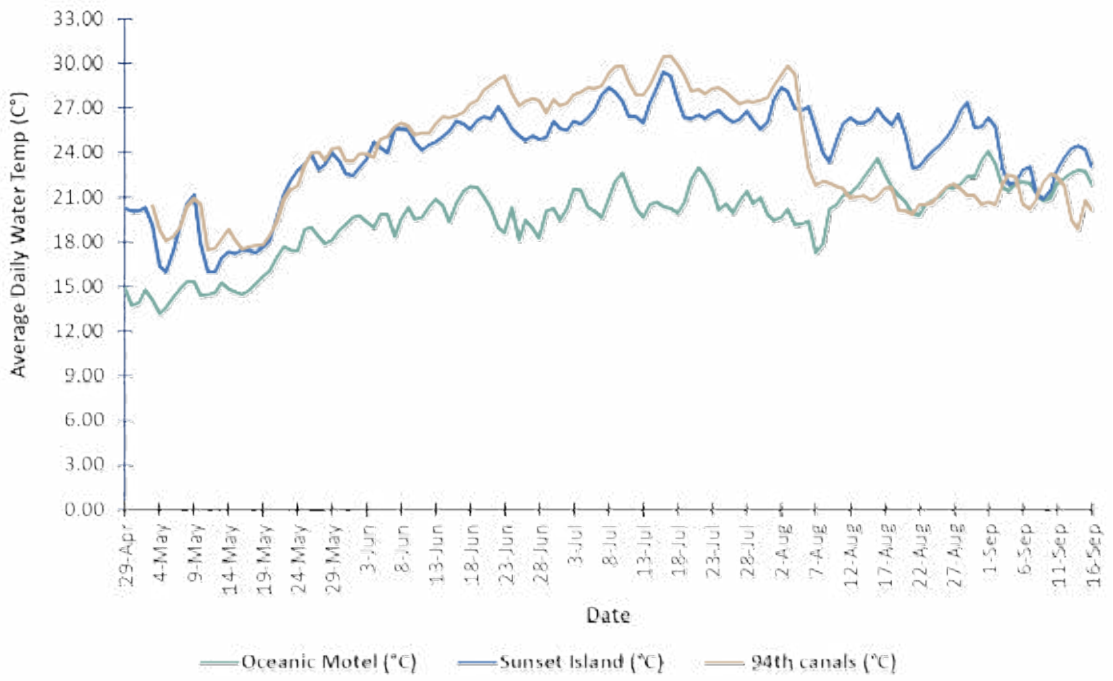


Figure 8. Results of water temperature data loggers.

Through data analysis, we have inferred that spawning begins earlier as you move northward from the OC Inlet due to the shallow water temperatures warming at a faster rate. Survey locations by the inlet typically take longer to reach 18°C due to the influx of cold water from the Atlantic Ocean. For the first time, continuous temperature data was collected at three different locations throughout the Coastal Bays to determine how water temperatures vary on a day-to-day basis as you move from the OC Inlet to Assawoman Bay. Using remote data loggers, we were able to collect water temperature readings at the Oceanic Motel, Sunset Island, and 94th St. dead-end canals every half hour (Figure 8). The loggers at the Oceanic Motel and Sunset Island were installed on April 29th, while the 94th St logger was installed May 3rd. All loggers collected data until September 16th when they were removed.

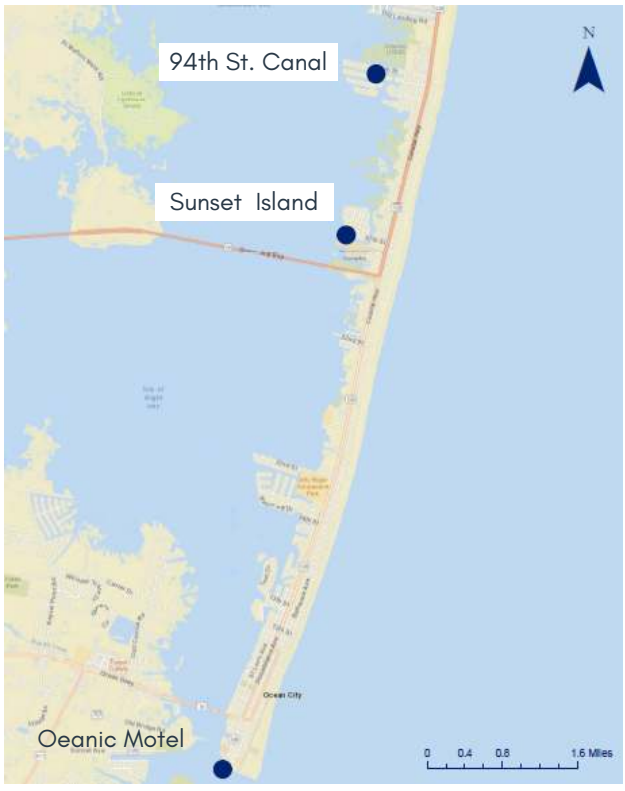


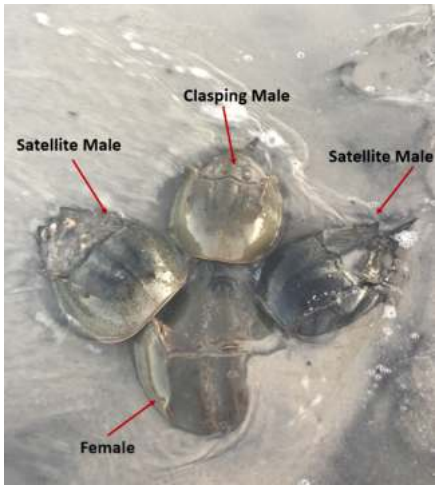
Figure 9. Location of water temperature data loggers

As you can see from Figure 7, water temperatures were well above minimum threshold values for spawning by the time the loggers were installed at Sunset Island and the 94th St. Canal. Average daily water temperatures at the Oceanic did not hit 18°C until May 25th. The average daily water temperatures between the northern sites and the Oceanic Motel were much higher for the entirety of our survey season. With temperature data supporting field observations, we believe spawning surveys may need to start earlier in the Spring for sites in the northern bays to gain a more accurate representation at those sites.

Spawning Ratio

Figure 10. Operational sex ratios for horseshoe crabs counted between 2002 - 2024 surveys.

For data analysis we look at the operational sex ratio, or "the ratio of males to females among adults that are actively spawning" (ASMFC, 2021), as it is an important measure of the population structure. In 2024, there were 4.4 males to every female crab, which is lower than the 2022 Delaware Bay sex ratio of 5.22 (Swan, 2023), but a typical ratio seen for the overall region (ASMFC, 2019). The survey counts over the last two decades indicate male to female sex ratios have remained relatively stable, except for the 2019 survey that had a historic high M:F ratio due to a low number of females encountered. The overall average (2002 - 2024) sex ratio in the Coastal Bays is 3.8.



Spawning Horseshoe Crabs at Skimmer Island

Delaware Bay regional trawl and offshore dredge surveys conducted in MD, DE, NJ indicate male to female ratios for the overall population are around 2.2:1 (ASMFC, 2019). Around our region, it is typical for a female to complete spawning activity over a couple nights during one or two lunar phases (ASMFC, 2019). However, males tend to remain at spawning beaches for longer periods of time, which is why it is normal for the operational sex ratio to be skewed towards males in the mid-Atlantic region (Walls et al., 2002). Since there is such a high density of horseshoe crabs spawning in this region, females tend to have both a clasping male (one that is attached to her), and at least one satellite male surrounding the spawning pair. A single female can lay about 90,000 eggs in one spawning season. Through genetic testing, it is estimated that clasping males fertilize 50%, while satellite males fertilize ~41% of the eggs laid by a female (Brockmann et al., 1994). It is undetermined what happens with the other 9% of eggs (Brockmann et al., 1994). Having multiple males fertilize a female's eggs are beneficial to the overall population as this increases genetic diversity.

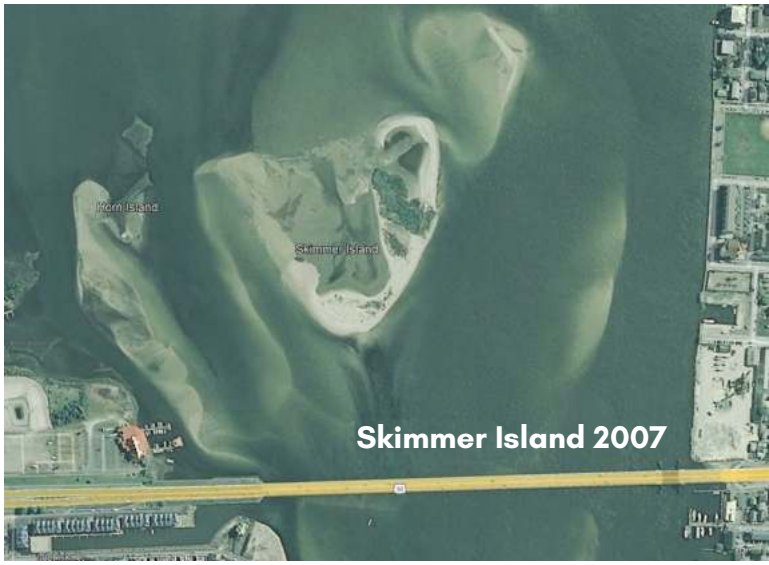
Horseshoe crab eggs on Skimmer Island

Skimmer Island

Skimmer Island is located just north of the route 50 bridge in Isle of Wight Bay. This island historically has had the highest number of spawning horseshoe crabs in the Coastal Bays. As seen in Figure 10, Skimmer Island accounts for 79% of all spawning horseshoe crabs surveyed between 2002 - 2024. The southeast portion of the island has been surveyed since 2006, with the southern transect being added in 2008. From 2011 to 2014, Skimmer Island received about 1,000 cubic yards of dredged sand from a nearby channel to replenish area lost due to erosion. The beneficial dredge material expanded the available area for horseshoe crab spawning. However, since the last replenishment in 2014, the island has been continually eroding. The shape of Skimmer Island is dynamic and constantly changing due to wave energy, sea level rise, and erosion. This can impact where and how many horseshoe crabs are spawning on the island from year to year.

As Skimmer continues to shrink (see aerial photos on right), horseshoe crabs may find other locations like Assateague North to be a more suitable for spawning, even with the increase in human disturbance and obstacles (i.e. riprap) at that location. If sand replenishment does not happen, Skimmer Island will most likely vanish in the near future like so many other islands in the Coastal Bays. It is unknown how our local horseshoe crab population will be impacted if Skimmer Island no longer exists. Hopefully, MCBP will be able to restore this island and maintain the critical habitat it provides to spawning horseshoe crabs.

Although Skimmer Island has remained one of the top spawning locations in the Coastal Bays, the last two years of data have revealed that the site is hosting less than 30% of spawning horseshoe crabs. This shift could be due to erosion and elevation loss impacting the island's habitat quality. We believe that a percent of the horseshoe crabs that once spawned at Skimmer shifted back to Assateague North. This site was previously surveyed between 2006 - 2008 but had not been sampled since due to low spawning activity. That is until thousands of horseshoe crabs were spotted spawning on the beach in 2022. Due to this increase in spawning activity, Assateague North once again became an official survey site. Tracking the movement of horseshoe crabs and ensuring that the hotspot spawning grounds are included in our official surveys is critical to gaining accurate data.



Skimmer Island 2007

Skimmer Island 2015

Skimmer Island 2024

Site Summary

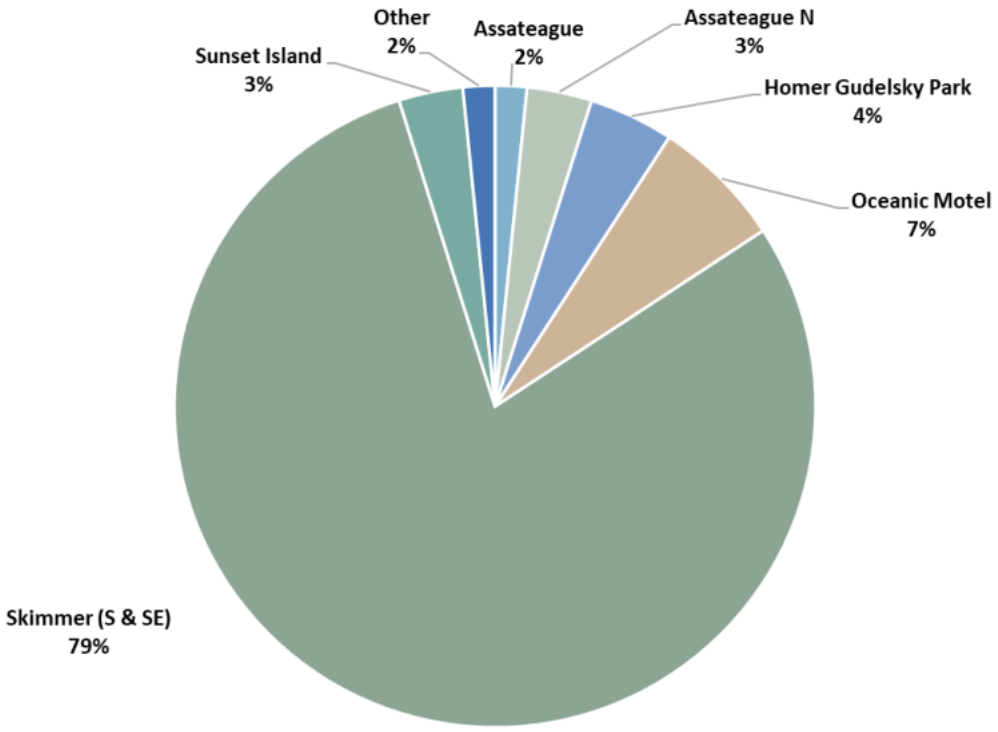


Figure 11. Percent of Skimmer Island's population compared to the total (live & dead) population surveyed in the Coastal Bays from 2002 - 2024. The other sites represent locations that are no longer included in our annual surveys.

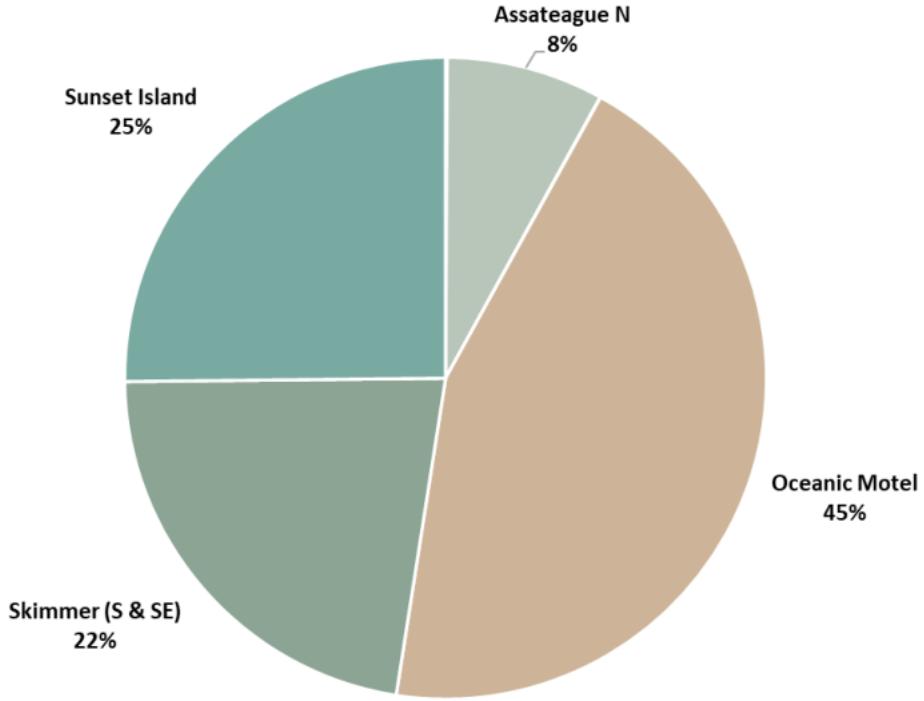


Figure 12. Percent of the total population (live & dead) for each site surveyed in 2024. The horseshoe crab counts for Assateague (7) and Homer Gudelsky Park (2) were too low to be represented in this figure.

Shifts in Spawning

Horseshoe crabs do not have site fidelity, meaning they do not return to the same beach year after year to spawn. However, they do have short-term site fidelity and will remain close to the same spawning grounds throughout a spawning season (ASMFC, 2019). Tracking the movement of horseshoe crabs within the Coastal Bays is important in learning locations that are critical to spawning. This is why we have surveyed various locations over the years. Skimmer Island and Assateague North are not the only survey locations that have seen changes in the number of spawning horseshoe crabs. In fact, survey sites have been added and removed since the survey began in 2002 due to horseshoe crabs moving around from year to year. Locations are added and removed to ensure that surveys include the major spawning beaches in the Coastal Bays. Since 2002, MCBP and MDNR have surveyed 29 different transects throughout the Coastal Bays watershed. Assateague, Homer Gudelsky Park, Oceanic Motel, Skimmer Island, and Sunset Island have been surveyed the most due to consistent spawning activity occurring at these locations. However, over the last few years we have noticed a shift in where horseshoe crabs are spawning. For example, in the last two spawning seasons combined Assateague has had less than 50 horseshoe crabs while Homer Gudelsky Park has only had two horseshoe crabs surveyed. For these two locations, this is a drastic difference compared to previous years that had counts in the hundreds or even thousands.

Exploring New Locations

The changes that we have been observing over the last several years has resulted in the exploration of both new and old survey locations. On May 21st, MDNR and MCBP went to three different locations in Assawoman and Isle of Wight bays to look for spawning horseshoe crabs. These were sandy beaches located on the East and West side of the Rt. 90 bridge and at Keyser Point. Live horseshoe crabs were found spawning at both beaches near the 90 bridge, however none were found at Keyser Point. Although we only conducted one unofficial survey at these locations, the fact that we found spawning horseshoe crabs shows that we are missing a portion of the spawning population in our watershed. The goal for this upcoming year is to survey these locations and others more frequently to see if these sites need to be included in our official surveys. If you know of any locations where horseshoe crabs are spawning, reach out and let us know!

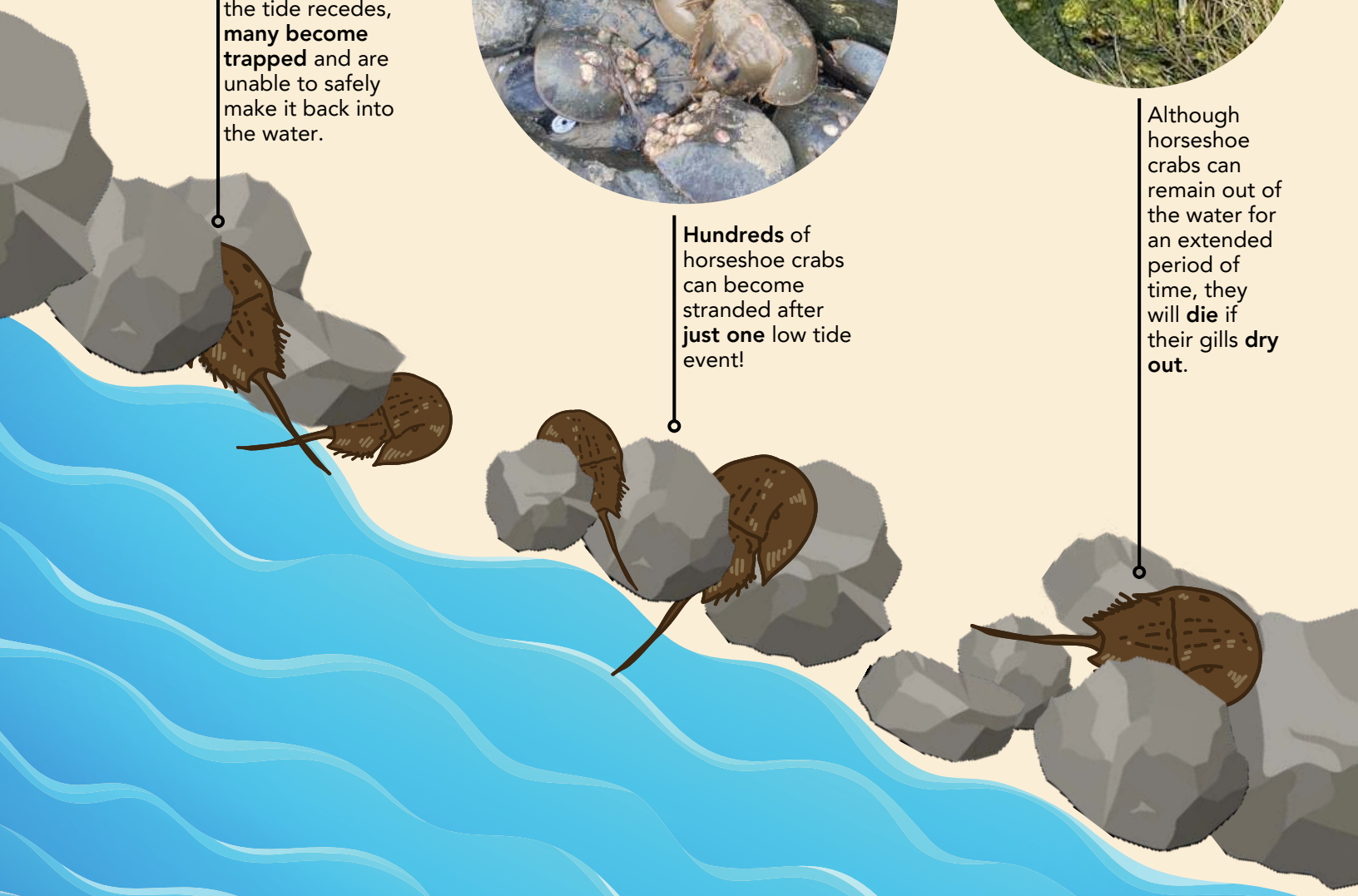
Stranded Spawning Horseshoe Crabs

Horseshoe crabs spend a significant amount of energy spawning, making this one of the greatest natural causes of mortality for adults (ASMFC, 2019). Several hotspot spawning beaches in the Coastal Bays have obstructions (e.g. riprap) that can further increase mortality.

At high tide, horseshoe crabs can easily navigate obstacles. When the tide recedes, **many become trapped** and are unable to safely make it back into the water.

Hundreds of horseshoe crabs can become stranded after **just one** low tide event!

Although horseshoe crabs can remain out of the water for an extended period of time, they will **die** if their gills **dry out**.

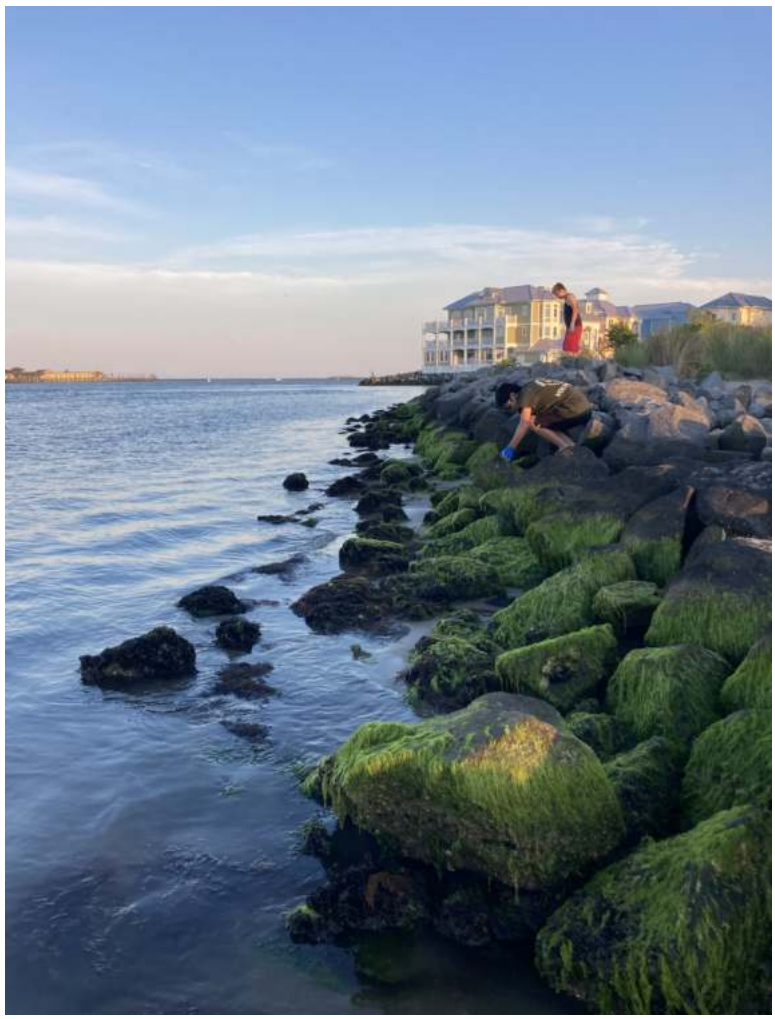


Stranded Spawning Horseshoe Crab Recovery Team

The Stranded Spawning Horseshoe Crab Recovery Team was created in 2022 to address the mass casualties of spawning horseshoe crabs throughout the Coastal Bays. They are trained to recognize stranded crabs, safely remove them from the rocks, and return them to the bay.

In 2024, we trained 39 Stranded Spawning Horseshoe Crab Recovery Team volunteers. They dedicated themselves to rescue efforts and were able to save over 7,900 horseshoe crabs throughout the spawning season!

We are constantly looking for new places to send our volunteers -- if you know a spot where horseshoe crab strandings occur, let us know!



Volunteers rescuing horseshoe crabs from riprap at Homer Guldesky Park (above) and the Oceanic Motel (below).

Thank You!

MCBP and MDNR would like to personally thank the 39 volunteers who participated in our surveys and Stranded Spawning Horseshoe Crab Recovery Team! Thank you for being stewards of our environment. We appreciate your passion and care for our favorite living fossils!

More Resources

Found a tagged horseshoe crab? Scan the QR code to report your tag data!

Add your horseshoe crab observations to the Maryland Department of Natural Resource's map using this QR code:

The Maryland Coastal Bays Program (MCBP) is a 501(c)3 non-profit and National Estuary Program dedicated to enhancing the ecological values and resiliency of the Coastal Bays, the watershed, and their communities through conservation and public engagement. Through education, scientific monitoring, outreach, and restoration, we collaborate with the stewards of our community to have a positive impact on our watershed.
To learn more about who we are or sign up to become a horseshoe crab volunteer, go to our website: www.mdcoastalbays.org

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Literature Cited

Atlantic States Marine Fisheries Commission (ASMFC). (2019). 2019 Horseshoe Crab Benchmark Stock Assessment and Peer Review Report. https://asmfc.org/uploads/file/63d2ed62HSCAssessment_PeerReviewReport_May2019.pdf

Atlantic States Marine Fisheries Commission (ASMFC). (2024). 2024 Horseshoe Crab Stock Assessment and Update. https://www.asmfc.org/uploads/file/663d0fcdHorseshoeCrabStockAssessmentUpdate_April2024.pdf

Brockmann, H. J., Colson, T., & Potts, W. (1994). Sperm competition in horseshoe crabs (limulus polyphemus). Behavioral Ecology and Sociobiology, 35(3), 153–160. https://doi.org/10.1007/bf00167954

Maloney T., Phelan R.,& Simmons, N. (2018). Saving the horseshoe crab: A synthetic alternative to horseshoe crab blood for endotoxin detection. PLoS Biol 16(10): e2006607. https://doi.org/10.1371/journal.pbio.2006607

NOAA. (n.d.). Horseshoe Crab - Limulus polyphemus. https://www.st.nmfs.noaa.gov/Assets/ecosystems/climate/images/species-results/pdfs/Horseshoe_Crab.pdf

State of Maryland Coastal Bays: Building resilience. 2022. Dave Brinker, William Dennison, Steve Farr, Steve Doctor, Roman Jesien, Katherine Munson, Judy O'Neil, Kevin Smith, Mitch Tarnowski, Catherine Wazniak, Jeff White, Craig Wheedon, and Rich Mason. IAN Press. Cambridge, MD 28 pp.

Swan, B. L. (2023, March 15). The 2022 Delaware Bay Horseshoe Crab Spawning Survey. Delaware Bay Horseshoe Crab Survey. https://static1.squarespace.com/static/5a67c452bff2004b42a313d9/t/645c000de6793464b79c56b0/1683750926030/2022HSCSurveyReport.pdf

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