2025 Horseshoe Crab Spawning Report

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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, wildlife, and humans (ASMFC, 2025). 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, 2025). 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 2025 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, 2025)

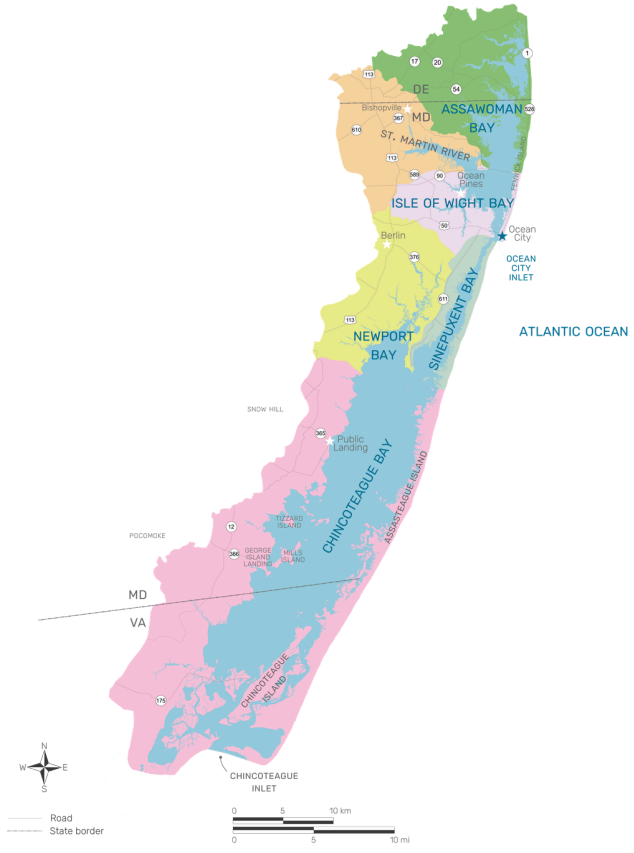


Figure 2. Map of Coastal Bays Watershed

ASMFC ARM Framework

The ASMFC uses the Adaptive Resource Management (ARM) Framework to manage bait harvest of horseshoe crabs in the DE Bay region to maximize harvest but also maintain the ecosystem integrity, provide adequate stopover habitat for migrating shorebirds, and ensure that the abundance of horseshoe crabs is not limiting the red knot stopover population or slowing recovery. The ARM Framework was first developed by a group of experts and scientists in 2009, but was not implemented by the ASMFC until 2012 (ASMFC, 2009). Since then, the model has been updated to better reflect stakeholder values and increase accuracy of outputs. The current model takes into account several technical and values-based components as seen in Figure 3.

These values-based components are utility (U), reward (R), and harvest policy (H). Utility is defined as the level of satisfaction stakeholders have as it relates to science-based numbers like horseshoe crab harvest or red knot stopover abundance. Reward is what the ARM Framework aims to maximize. It is the sum total desirability of a given set of outcomes across objectives. Finally, the harvest policy represents the recommended annual number of male and female horseshoe crabs to harvest. The recommended harvest numbers for both male and female horseshoe crabs is reviewed by several technical committees and the ASMFC Board. The Board can decide whether to follow the models recommendations or implement more conservative harvest specifications. Those harvest numbers can then be limited even further by each individual state in the region. The current maximum annual harvest limits for horseshoe crabs in the DE Bay region (NJ, DE, MD, VA) is 500,000 males and 210,000 females. Although the model indicates that the population could support female harvest, the ASMFC has voted against female harvest since 2013.

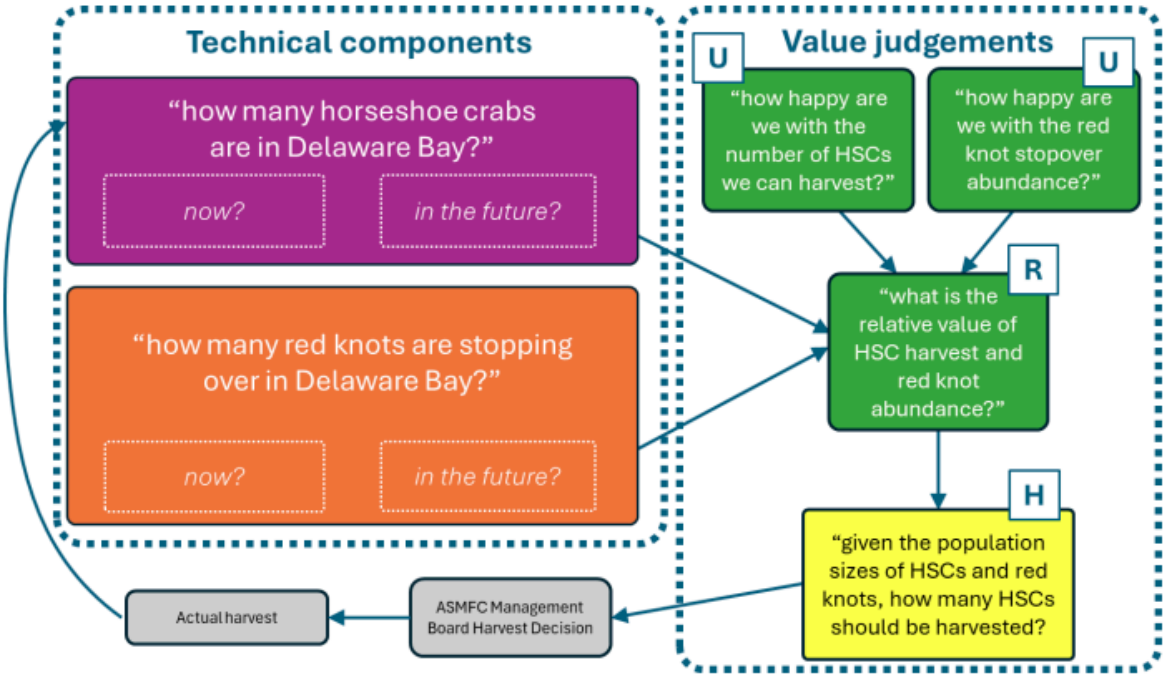
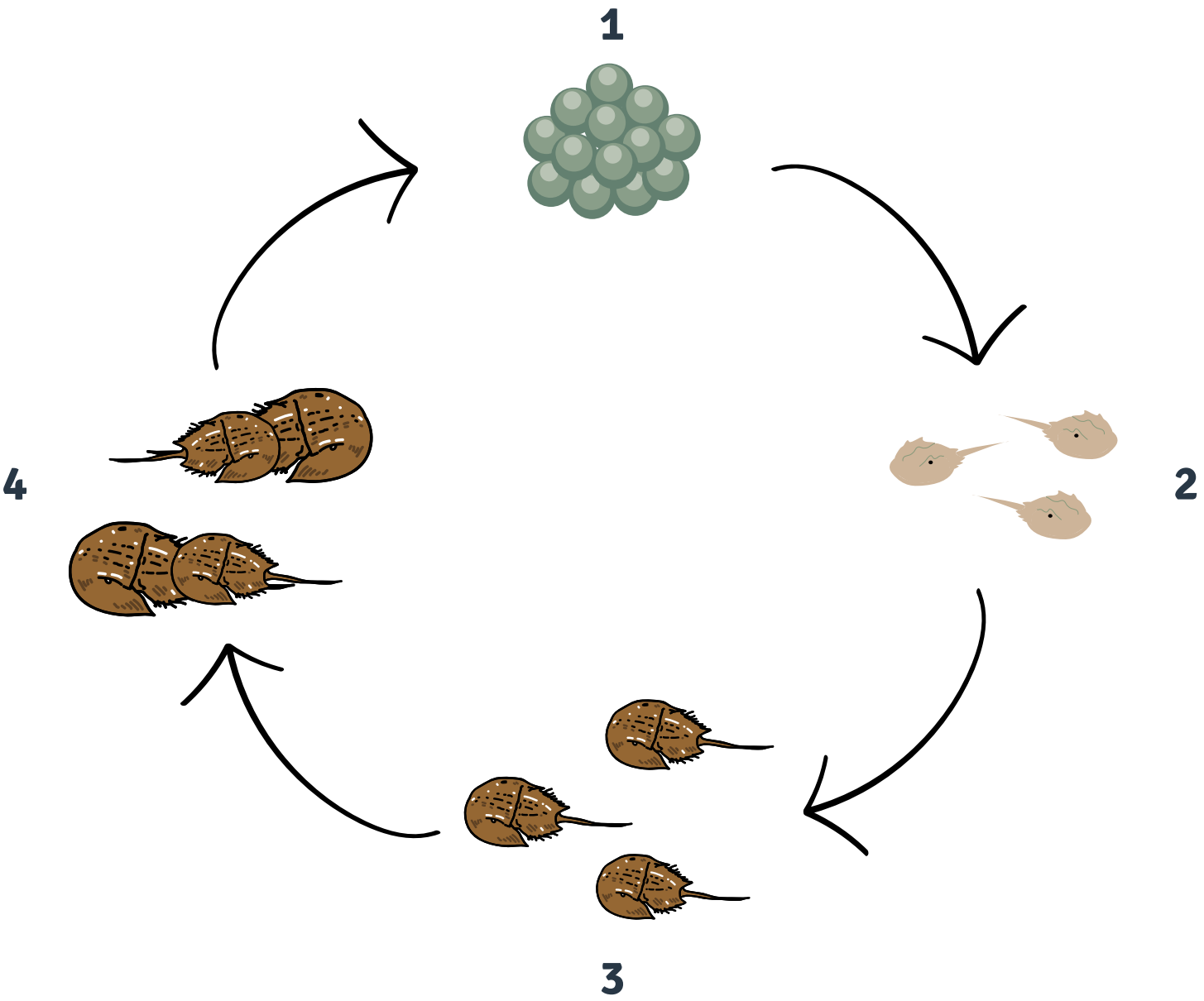


Figure 3. Illustration of the ARM Framework and how the components are related.

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 Males reach maturity around 7-8 years while females reach maturity around 10 years old. They come from deeper estuarine or oceanic waters and return to shallow estuaries to spawn on the sandy beaches.

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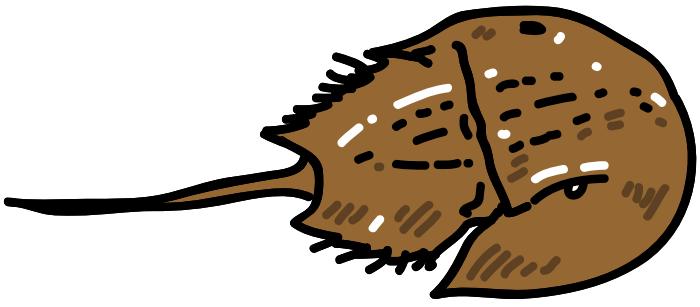
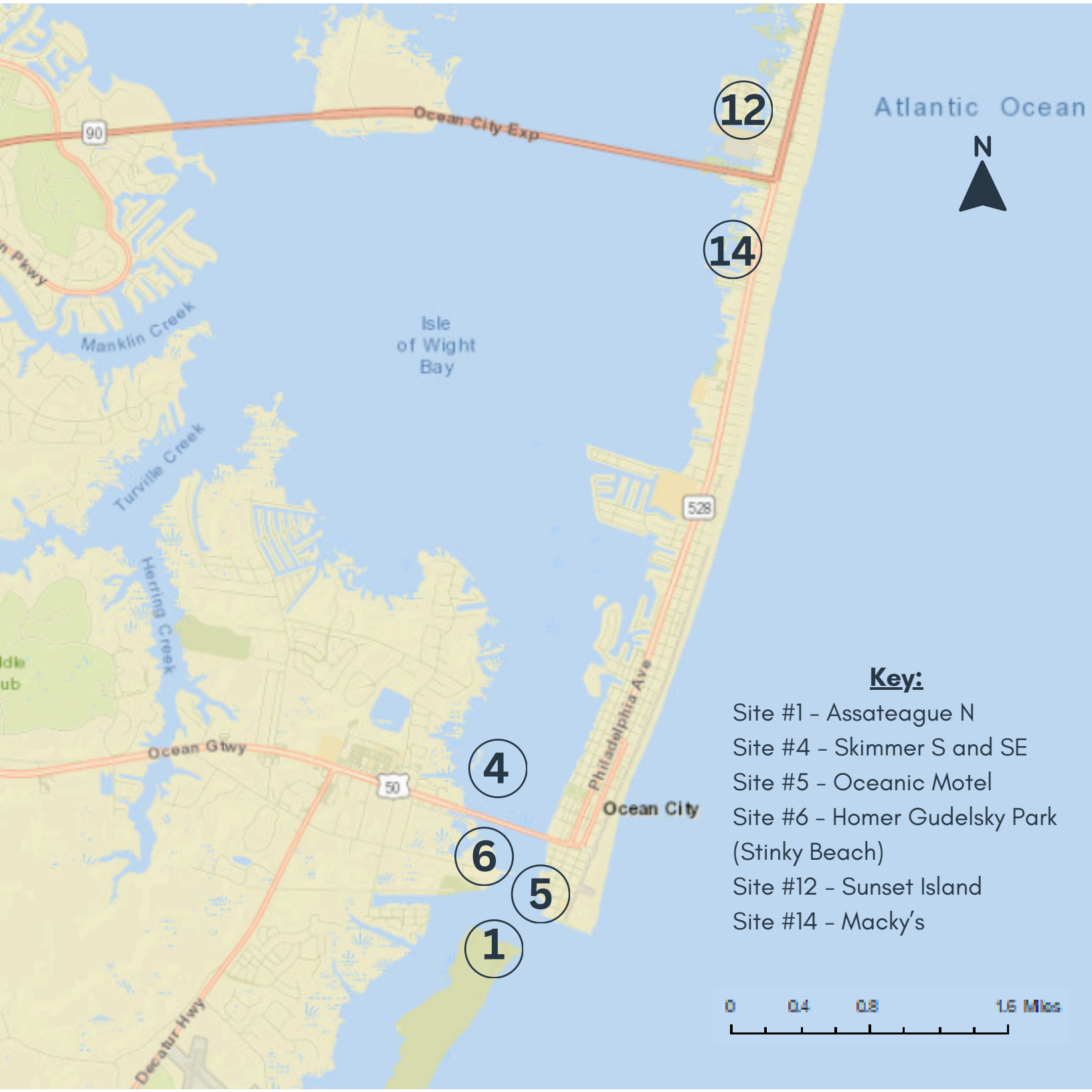


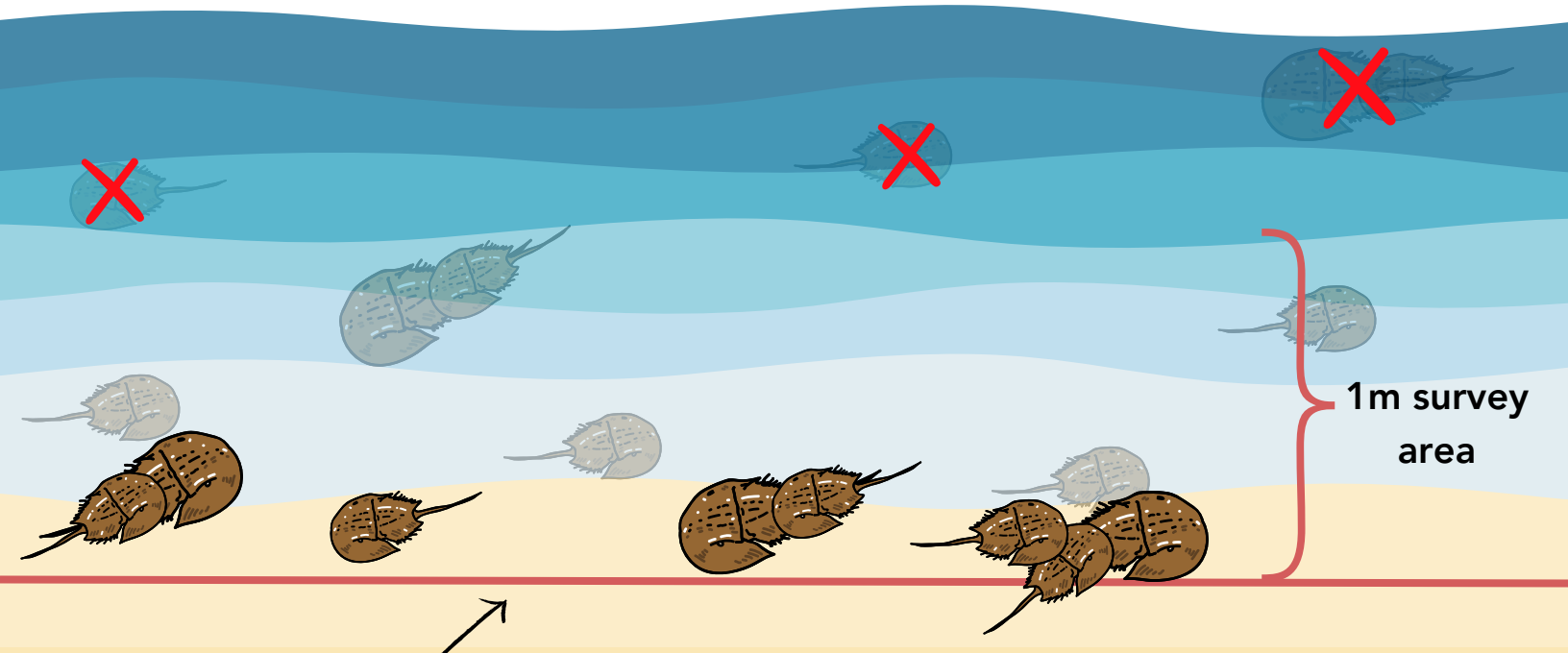
Where do we survey?



Spawning surveys are conducted on sandy beaches that have a history of use by horseshoe crabs.

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.

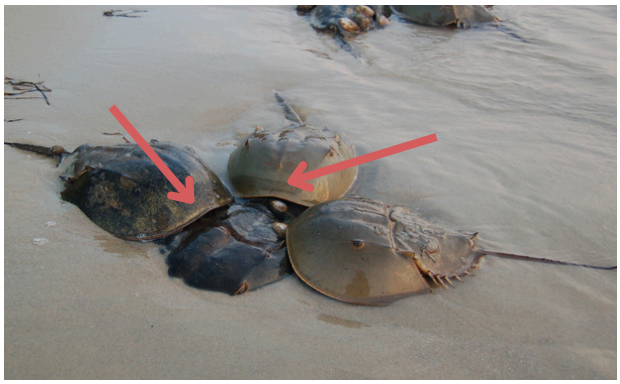


*The horseshoe crabs with an "X" over them fall outside of the survey area and are not counted.

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). Another feature that males have is the front edge of their prosoma (front of their shell) is concave (bottom image). Mature females who have experienced multiple spawning seasons may have markings on the shell of their abdomens from males repeatedly clasping onto to them.

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 makes her way onto the beach to bury into the sand and lay 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.



Concave shape of prosoma on male horseshoe crab.

2025 Results

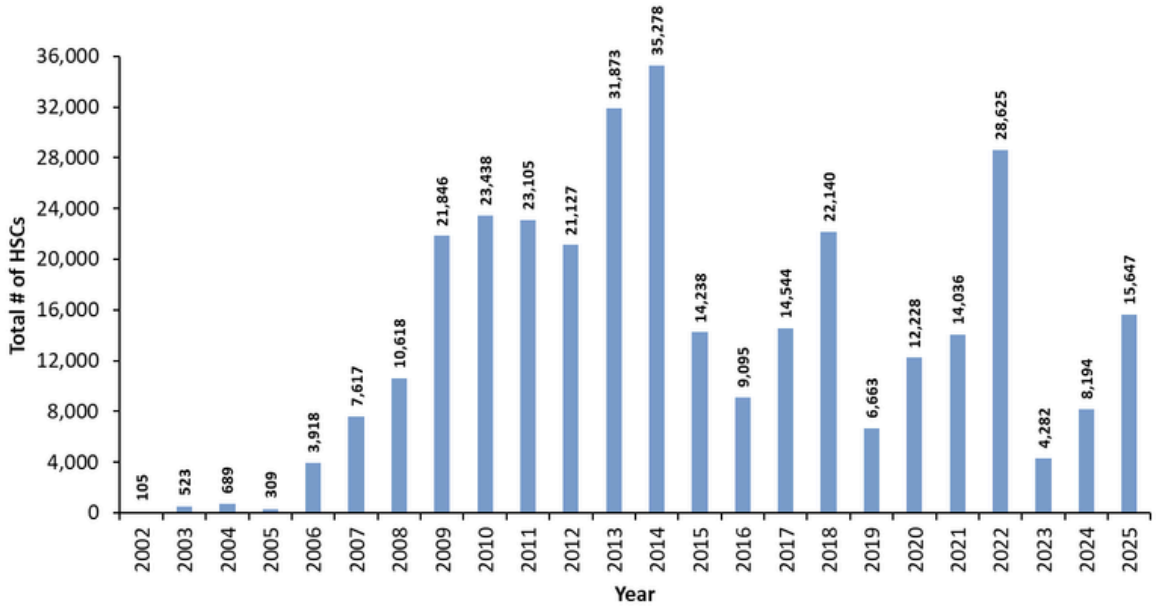


Figure 4. Total number of horseshoe crabs (live & dead) surveyed between 2002 - 2025)

A total of 15,647 horseshoe crabs were counted in 2025 as seen in Figure 4. This was a significant increase from the back to back low spawning counts we had in 2023 and 2024. 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 4, 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.

We expect that the total numbers would be even higher for 2025 if two survey nights didn't need to be cut short due to unsafe weather conditions. MCBP and MDNR have been exploring new survey locations and started surveys earlier this year to try adapt to changes in spawning behavior. We believe that continuing to keep a close eye on where and when horseshoe crabs are spawning will ensure our counts remain accurate in representing our population.

The changes that we have been observing over the last several years has resulted in the exploration of both new and old survey locations. The small beach located behind Macky's Bayside Bar & Grill in Ocean City was previously surveyed between 2004 - 2006, but was discontinued as a survey location because of low spawning counts. Due to reports of stranded spawning horseshoe crabs, MCBP and MDNR decided to conduct surveys once again at Macky's to monitor spawning activity. Additionally, the site became one of the locations monitored by our Stranded Spawning HSC Recovery Team. Volunteers conducted six surveys in 2025 which resulted in a total of 76 horseshoe crabs counted. This accounted for less than 1% of the total spawning population counted for this year. Even though only 76 horseshoe crabs were counted our volunteers rescued 124 off the rocks at Macky's. This suggests there may be more spawning activity happening then we may be seeing. We may continue to monitor this site to see if spawning activity increases.

CPUE Results

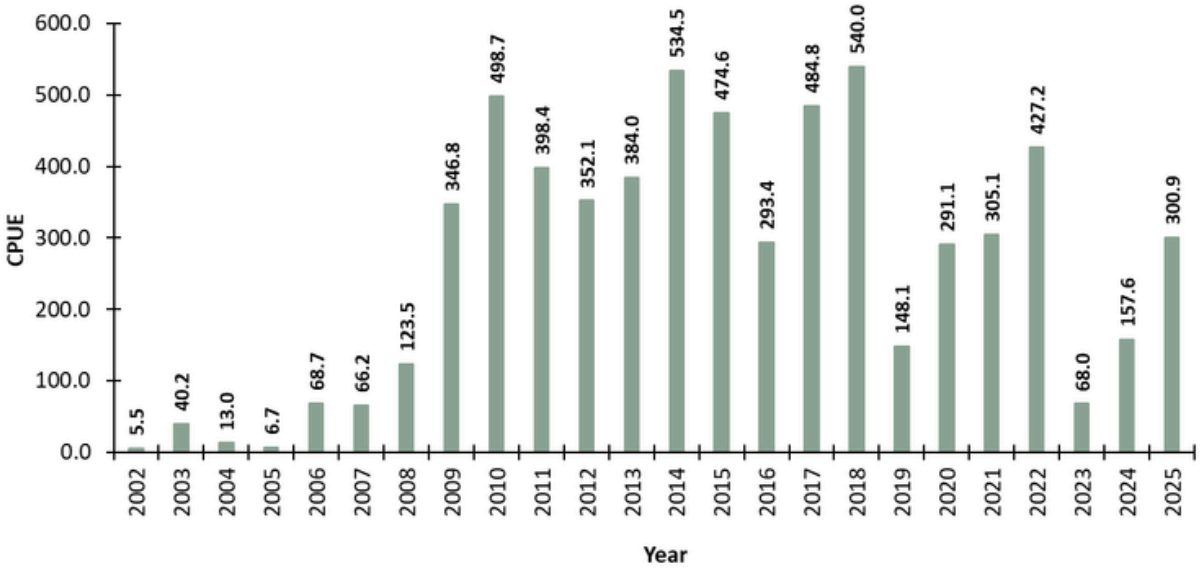
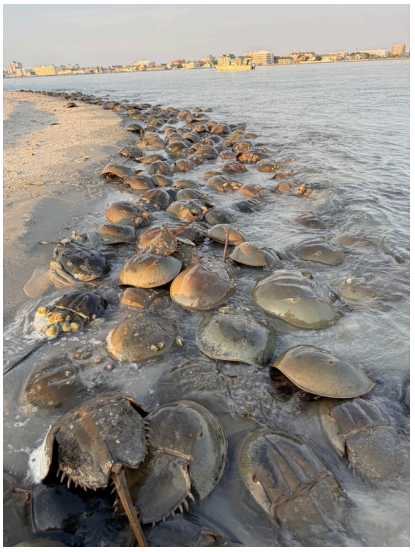


Figure 5. Catch per Unit of Effort (CPUE) based on number of surveys conducted between 2002 - 2025

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 2025, 52 surveys were conducted and 15,647 horseshoe crabs were counted resulting in a CPUE of 300.9 (Figure 5). 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 2025 CPUE value. Consistent declines in CPUE indicate that populations may be overharvested, however our data does not indicate any signs of overharvesting occurring in our watershed.

Since 2002, MCBP and MDNR have conducted anywhere between 13 surveys (2002) to 115 surveys (2007). In past years, surveys were conducted from the first site of spawning horseshoe crabs until August to determine spawning numbers outside of peak season. Once we had enough data to support what phases fell within peak spawning season, we decided to only survey between phases 2 -5. 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. We have enough long-term data to show that our efforts will be best spent surveying between phases 2 - 5 when peak spawning occurs. However, as new data becomes available (like the continuous water temperature data) we can evaluate whether surveys should start earlier in the year.



Peak spawning on Skimmer Island

Junior volunteer helping count horseshoe crabs. PC: Meg & Gary Laurinaitis

Spawning Ratio

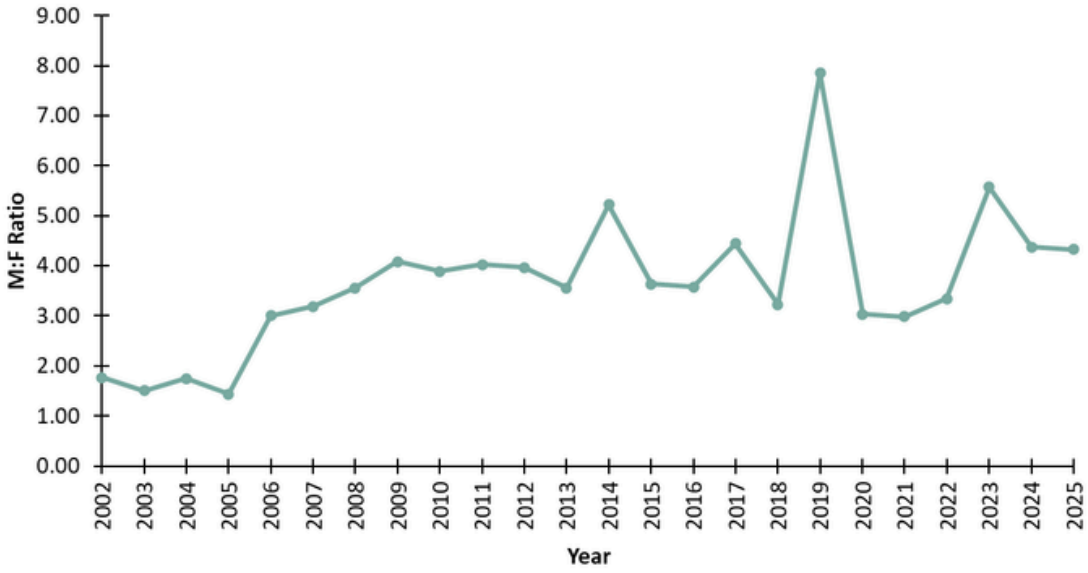
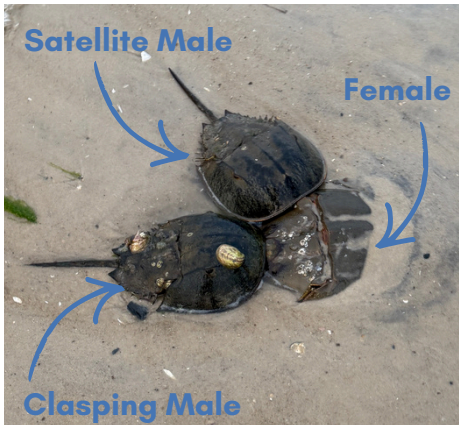


Figure 11. Operational sex ratios for horseshoe crabs counted between 2002 - 2025 surveys.

Delaware Bay regional trawl and offshore dredge surveys conducted in MD, DE, NJ, and VA 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.



Spawning Horseshoe Crabs at Assateague Island

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. Additionally, when there is an abundance of horseshoe crabs spawning on the same beach, the egg density becomes high enough to where females will accidentally dig up previously laid eggs. The eggs dug up are the food source for those migrating shorebirds, along with other important fisheries species.

Dug up horseshoe crab eggs on the beach

Lunar Phases

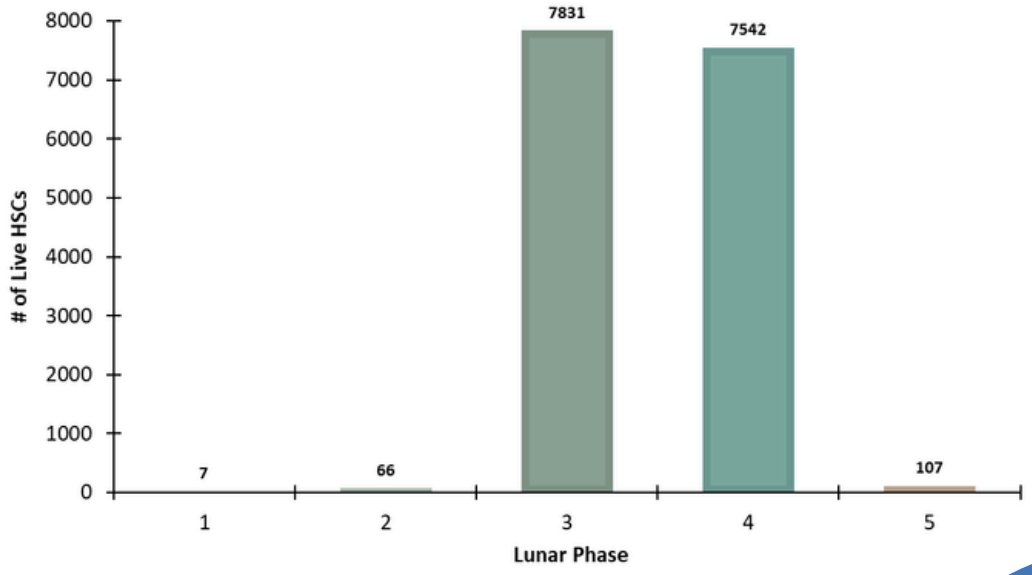


Figure 6. Live horseshoe crabs sampled by lunar phase in 2025

<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

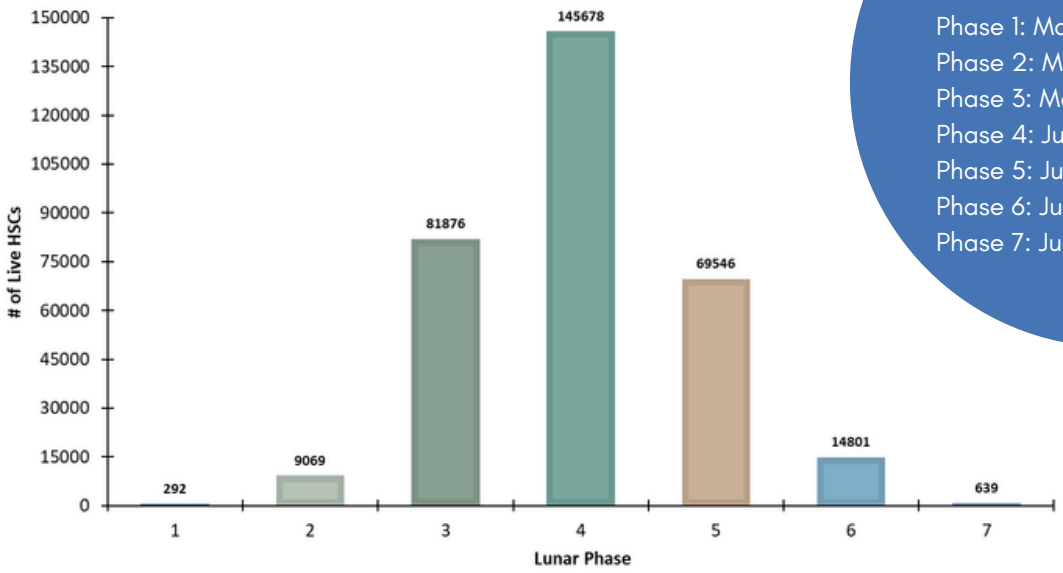


Figure 7. Live horseshoe crabs sampled by lunar phase from 2002 - 2025

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.

Spawning seemed to have dramatically declined after phase 5 based on reports from our volunteers. Therefore, we did not feel surveys needed to continue into phases 6 and 7 for this year. 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 in the northern bays due to water temperatures warming faster. As a result, we had one volunteer at Sunset Island begin surveys during phase 1 since that location tends to warm up faster than the other survey locations. Even though only a small number of horseshoe crabs were counted, it was worth surveying since water temperatures were well above 18°C during phase 1.

Peak Spawning Temps

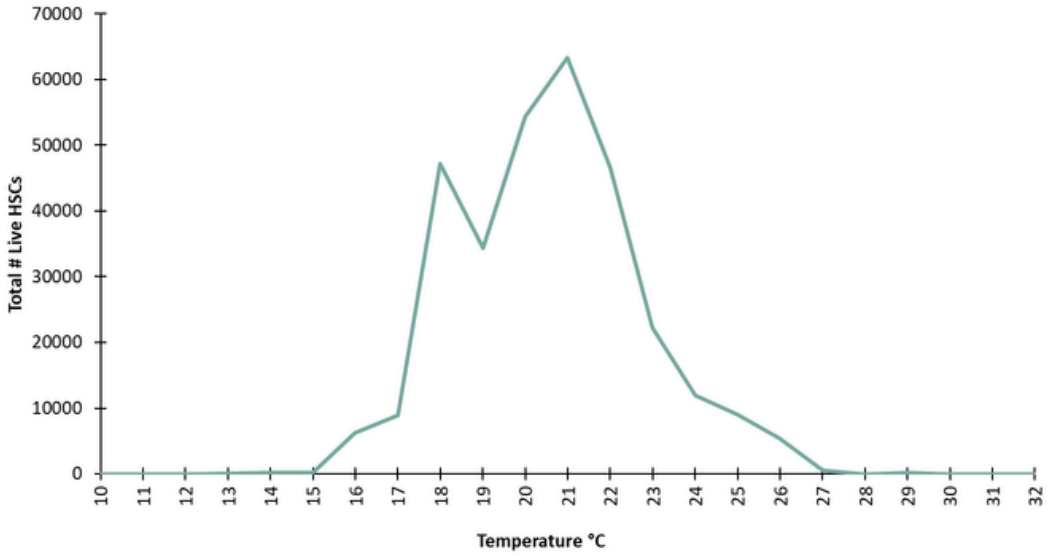


Figure 8. Total counts for (live) horseshoe crabs spawning by water temperature (2007 - 2025).

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, surface water temperatures have been collected at each survey location before every survey. Our long-term data shows that 95% (290,337) of all horseshoe crabs surveyed between 2007 - 2025 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 8. For 2025, less than 1% of the live horseshoe crabs were spawning at water temperatures below 18°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 Coastal Bays.

Temperature Variation

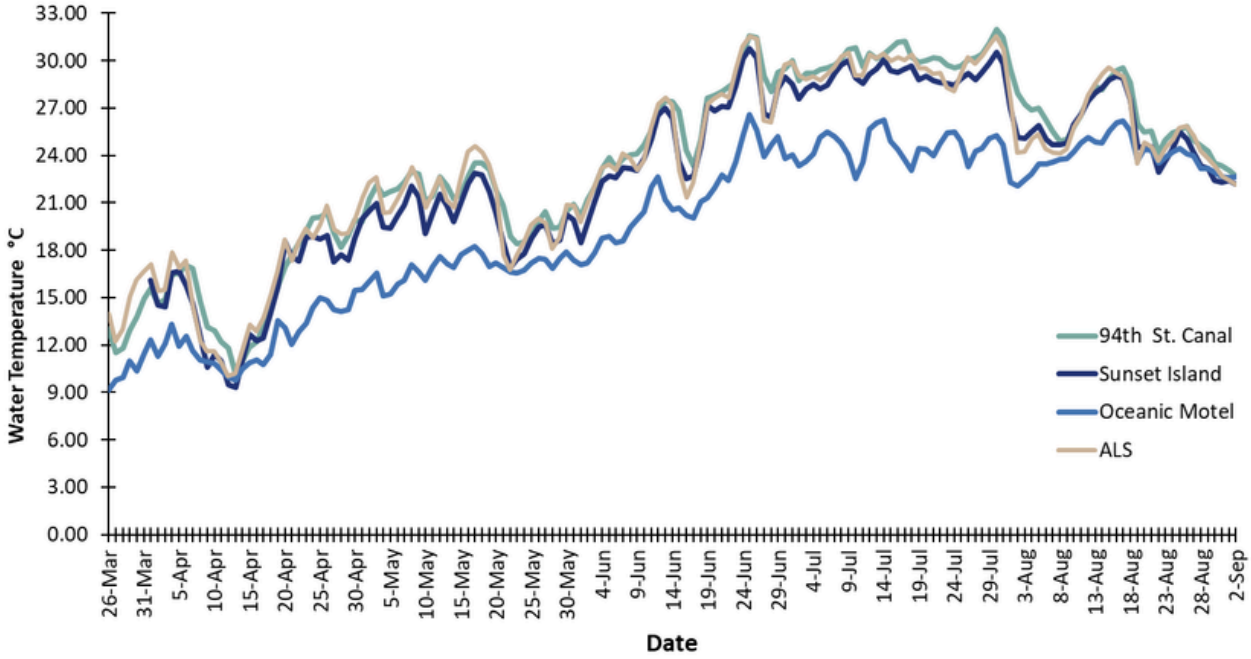


Figure 9. Results of water temperature data loggers.

Through data analysis, we have inferred that spawning begins earlier as you move away 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. This year, we were able to continuously monitor water temperatures at the same three locations as 2024 in addition to a new site located at the Assateague State Park's Living Shoreline (ALS) (see Figure 9).

Loggers were installed roughly a month earlier in 2025 than 2024 to try to capture the first dates at each location where the average temperature reached 18°C. Although the Assateague site is not a survey location, adding a logger at this location provided a southern site to determine if temperatures in the southern bays followed similar trends as the northern bays. Analysis of the data shows that on average, the sites furthest from the inlet had 131 days where the average water temperature was ⩾ 18°C , whereas the Oceanic Motel site located right next to the inlet had 92 days where water temperatures was ⩾ 18°C.

Obtaining this continuous data is critical to understanding variations in spawning throughout an individual season as well as changes in spawning behaviors from year to year. Over time, this data can be used to compare average water temperatures and the number of potential spawning days for horseshoe crabs. It also helps us better anticipate when surveys should start based on previous years' data.

Figure 10. Location of water temperature data loggers

Assateague Island

The shoreline located on the bayside of Assateague Island was first surveyed in 2006 to determine if the site should be included in our official horseshoe crab spawning surveys. The results of that initial survey led to that site being included in our surveys for the next 18 years. Back then, you can see that the northern end of the island was fully connected to the jetties and that the bayside beach was fully in tact with little erosion. Since 2006, the bayside shoreline has suffered from severe erosion which has led to the disappearance of one of our long-term survey locations.

Over the last several years the horseshoe crabs spawning at Assateague have only made up about 1 - 2% of the total spawning population surveyed. This could potentially be due to the erosion of the beach, although we do not have enough evidence to support this idea. Between 2006 - 2008 MCBP and MDNR conducted surveys at the northern end of Assateague Island by the OC Inlet after noticing spawning horseshoe crabs on the beach. The site was discontinued from the surveys until it was brought back in 2022 when we counted over 7,000 horseshoe crabs spawning on the beach. We suspect that the horseshoe crabs shifted away from the eroding bayside beach to the northern end of Assateague that offered better spawning habitat.

Unfortunately, this site is not the only spawning beach that has faced severe erosion over the years. Skimmer Island is another critical spawning location that has severely eroded over the years. It is critical that these habitats are restored to protect these important spawning grounds. Horseshoe crabs are not the only species that depend on bare sand beaches; shorebirds, diamondback terrapins, and other species rely on this habitat for foraging and nesting. Habitat degradation or loss is one of the leading factors that contributes to population declines. In addition to erosion, sea level rise is also contributing to habitat loss. Our data suggests that current populations in both the Coastal Bays and the larger DE Bay region are stable. However, if spawning habitat continues to decline we may start seeing declines in spawning populations in our watershed.

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. Volunteers are trained to recognize stranded crabs, safely handle them, and return them to the bay. In addition to rescuing stranded horseshoe crabs, volunteers provide important data that provides insight into where the largest number of strandings are occurring, number of dead horseshoe crabs found at each location, and whether horseshoe crabs are spawning outside of peak times.

Volunteer rescuing stranded horseshoe crabs PC: Mary Kroll

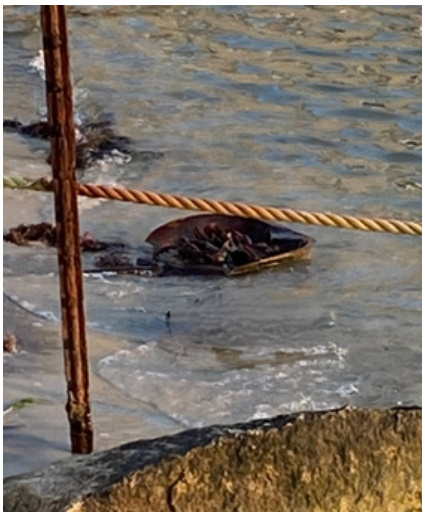
In 2025, we trained 62 Stranded Spawning Horseshoe Crab Recovery Team volunteers. They dedicated themselves to rescue efforts and were able to save over 5,409 horseshoe crabs throughout the spawning season!

If you are unsure about whether a horseshoe crab needs rescuing, use these photos below to help!

Horseshoe crabs stuck in or on rocks or other obstructions need rescuing. ✓

PC: Sue Latour

Horseshoe crabs flipped on their backs need rescuing. Remember to "just flip 'em!" ✓



PC: Meg & Gary Laurinaitis

Horseshoe crabs buried in the sand are most likely actively spawning and do not need rescuing. ✗

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

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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