



MARYLAND COASTAL BAYS PROGRAM

8219 Stephen Decatur Highway

Berlin, Maryland 21811

(410) 213-2297 - PHONE

(410) 213-2574 – FAX

ctoulan@mdcoastalbays.org

www.mdcoastalbays.org

2021 Horseshoe Crab Spawning Survey Results

Carly Toulan, Maryland Coastal Bays Program

Steve Doctor, Maryland Department of Natural Resources,

Fisheries and Boating Services

The 2021 horseshoe crab spawning survey was the 20th annual survey to track Atlantic horseshoe crab (*Limulus polyphemus*) spawning population abundance and critical habitat availability in the Maryland Coastal Bays. Horseshoe crabs are an integral component of Mid-Atlantic estuaries. Their eggs are a vital source of protein to migratory shorebirds returning from over wintering areas. Eggs and larvae are also a source of food for numerous Coastal Bays' species like eels, catfish, juvenile striped bass, white perch, killifish, weakfish, Atlantic silversides, bluefish, sand shrimp, blue crabs, spider crabs, and hermit crabs (ASMFC, 2019). The adults are a food source for sea turtles, conch and even sharks. Horseshoe crabs are commercially harvested for bait in whelk and eel pots. In addition, their blood is used in the biomedical industry to test for the presence of bacterial toxins. Survey results are used by the Maryland Coastal Bays Program (MCBP) and the Maryland Department of Natural Resources (MDNR) to monitor abundance trends in the local population. The data collected from the surveys is also used to delineate areas of critical spawning habitat for horseshoe crabs as well as preferred spawning temperatures. Results are submitted to the Atlantic States Marine Fisheries Commission (ASMFC) and are used to inform management of horseshoe crabs. The status of horseshoe crab populations along the Atlantic coast is investigated through surveys, research, and harvest records. The 2019 ASMFC stock assessment indicated the population in the Delaware Bay area that also includes the Maryland Coastal Bays is stable (ASMFC, 2019). Results from this survey supports the stock assessment in that the local population abundance appears to be stable.



Horseshoe crabs spawning at the Oceanic Motel by MCBP's Carly Toulan

Methods

Surveys were conducted between late-May and early-July at six sites in the Maryland Coastal Bays in 2021 (Figure 1). At the time of the survey the water temperature was measured with a handheld

thermometer or YSI Pro 2030 SCT meter. A survey consisted of walking along a 100-m beach transect and counting all the horseshoe crabs within a 1-m transect, extending into the water from the high tide waterline. Any dead horseshoe crabs were tallied regardless of whether they fell within the 1-m transect. Since male horseshoe crabs are about 25% smaller than female horseshoe crabs, we were able to differentiate and tally both sexes. Research done in the Delaware Bay has shown that peak migration and spawning occurs during evening high tides (Walls et al., 2002). For each site, surveys were scheduled to be conducted at least twice per lunar period, at high tide. For our survey, the lunar period is defined as two days before, the day of, and two days after a new and full moon.

Three surveying dates are scheduled for each phase of the survey since weather conditions and availability of personnel can vary. Horseshoe crab surveys are conducted around the new and full moon lunar cycles since high tides are amplified during this time. Because sampling can be uneven from year to year due to volunteer availability and weather, the counts have been standardized using a variable called count per unit effort (CPUE) to report relative abundance from year to year. Effort is defined as the number of surveys per year, and count per unit effort is the number of horseshoe crabs counted divided by the number of surveys.

MDNR and MCBP staff conducted surveys with volunteers in accordance with COVID-19 social distancing protocols and safety guidelines.

Results

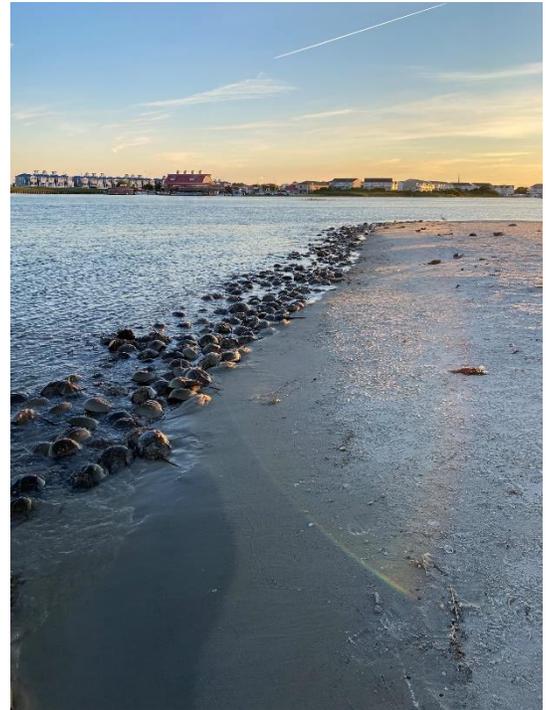
In 2021, volunteers and staff completed 46 surveys and counted 14,036 crabs that equaled 305.13 CPUE (Table 1). Starting in late May, sampling lasted four lunar periods that occurred during the new and full moon. Survey locations were sampled twice per lunar period, except for two sites at Skimmer Island that were missed due to inclement weather. The 2021 CPUE was 305.13 which was similar to the average for all years (272.79). Even though it was at the low end of the range since 2009, it was an increase over 2019 and 2020. There were large numbers of dead horseshoe crabs found in 2019 in Assawoman Bay which corresponded to a low abundance that year and we have not been able to come up with a reasonable explanation for this event.

There were also several hundred dead horseshoe crabs found in 2021 in a north-south facing dead-end canal near 94th St in Assawoman Bay. It is suspected that dead crabs floated into the canal from tide and wind currents, since dead crabs were observed in windrows outside of the canal. To remediate mass horseshoe crab casualties caused by strandings, MCBP and MDNR are working towards organizing a volunteer group to help rescue stranded horseshoe crabs for the upcoming spawning season. Special attention will be given to monitoring horseshoe crab mortality in 2022.

Table 1. Count Per Unit Effort of Horseshoe Crabs by Year.

Year	# of surveys	Total # of crabs	CPUE
2002	19	105	5.53
2003	13	523	40.23
2004	53	689	13.00
2005	46	309	6.72
*2006	57	3,918	68.74
2007	115	7,617	66.23
2008	86	10,690	124.30
2009	63	21,846	346.76
2010	42	23,438	558.05
2011	58	23,105	398.36
2012	60	21,127	352.12
2013	83	31,873	384.01
2014	66	35,278	534.52
2015	30	14,238	474.60
2016	31	9,095	293.39
2017	29	14,554	501.52
2018	41	22,140	540.00
2019	44	6,663	151.43
2020	42	12,228	291.14
2021	46	14,036	305.13

*Surveys began on northern Assateague Island and Skimmer Island in 2006 and effort was increased in these areas in 2008.



Spawning horseshoe crabs on Skimmer Island by MCBP's Carly Toulan.

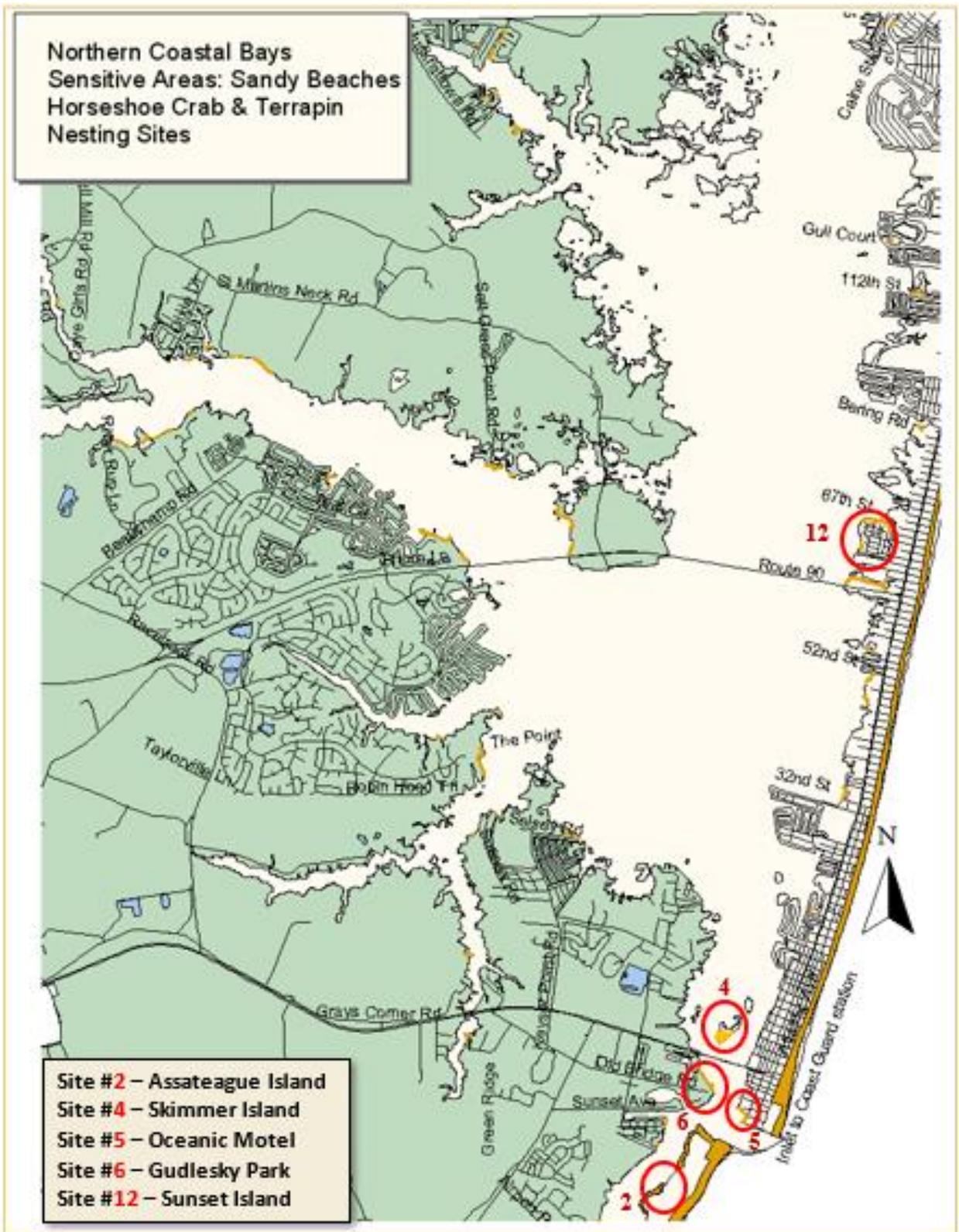


Figure 1. Maryland Coastal Bays Horseshoe Crab Spawning Survey Sites.

Timing of the Horseshoe Crab Spawning

Horseshoe crab spawning varies by latitude, but generally occurs between May and July along the Atlantic coast. The highest number of spawning horseshoe crabs in the Coastal Bays was typically found in June, except for 2008 (Table 2). The peak of spawning in Delaware Bay is in May and June (Michels et al., 2010). These data represent an index of the sample size of the population that is then combined with Virginia, Delaware, and New Jersey survey data to monitor the total population size of the horseshoe crabs in the mid-Atlantic states' region.

Table 2. Horseshoe Crabs Counted by Month.

Year	May	June	July	August	Total # Crabs (live & dead)
2002	0	105			105
2003	2	521			523
2004	57	632			689
2005	48	261			309
2006	125	3,793			3,918
2007	711	6,636	270		7,617
2008	1	4,689	5,928		10,618
2009	10	18,627	3,190	19	21,846
2010	1,205	17,285	4,948		23,438
2011	5	15,166	7,934		23,105
2012	2,032	13,330	5,748	17	21,127
2013	261	22,875	8,737		31,873
2014	560	28,790	5,928		35,278
2015	38	7,262	6,938		14,238
2016	37	5,625	4,369	64	9,095
2017	25	11,040	3,479		14,544
2018	7,462	9,956	4,722		22,140
2019	11	5,766	337		6,663
2020	14	8,050	4,164		12,228
2021	160	11,718	2,158		14,036
Total	12,764	191,127	68,850	100	273,380



Horseshoe crabs spawning on Sunset Island Beach by volunteer Carol Sottili.

Horseshoe Crab Spawning Beaches Sex Ratio

In 2021, there were 3.0 males to every female crab which is a typical ratio found in the time series. (Figure 2). The survey counts over the last decade indicate male to female sex ratios have remained relatively stable, except for the 2019 survey that had an historic high M:F ratio due to a low number of females encountered (Figure 2). For horseshoe crabs, high male: female ratio is important for maintaining genetic diversity because more than one male can fertilize a single female's eggs. Generally, the higher the genetic diversity, the healthier the population. The population is not highly skewed toward males, rather the males remain on or near the spawning beaches longer than the females (Walls et al., 2002). This gives the impression that there are more males than females in the population and creates a male-biased sex ratio (Walls et al., 2002). Harvest regulations in Delaware, Maryland, and Virginia have capped the number of horseshoe crabs that can be harvested. In Maryland, beginning in 2013, the harvest of female horseshoe crabs was prohibited (Doctor et al., 2015). Except for 2014 and

2019, these data indicate that male-biased harvest in recent years did not affect the local spawning population's sex ratio.

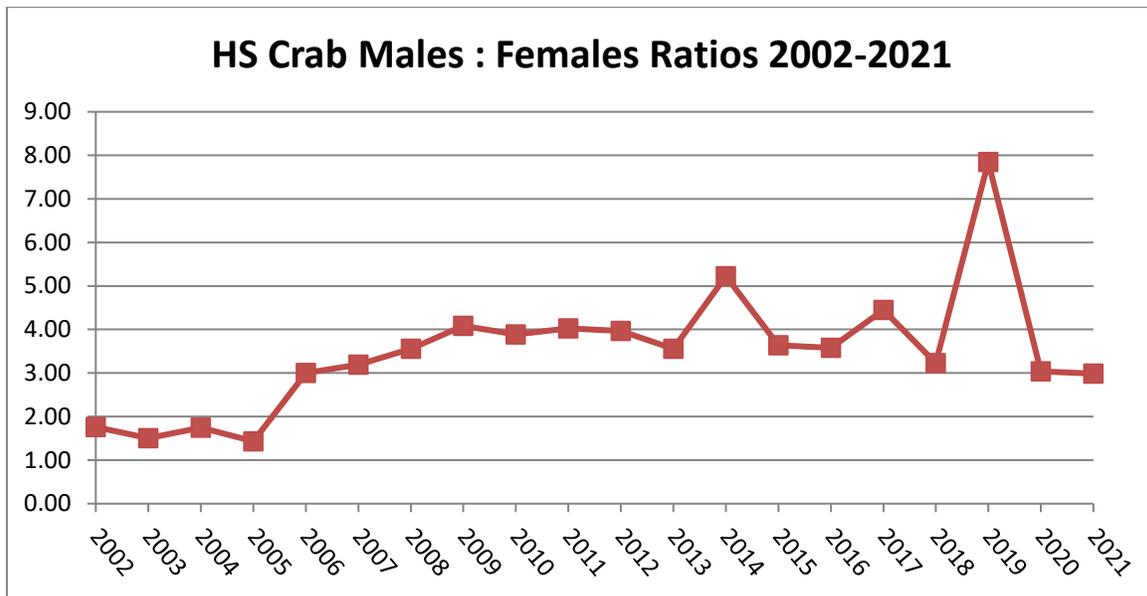


Figure 2. Sex ratios of horseshoe crabs counted in spawning surveys from 2002 through 2021.

Temperature & the Timing of Spawning

Results from 2007 to 2021 reveal spawning activity begins around 15°C in Maryland, and peaks between 21°C and 22°C (Figure 3). Results from the Delaware Bay spawning surveys have supported these findings by showing the critical water temperature for spawning initiation is 15°C (Michels et al., 2010). As shown in Figure 3, active large-scale spawning begins around 18°C and declines once water temperatures exceed 22°C. On June 8, 2021 water temperatures dropped from 18°C to 15°C following a storm which led to only a handful of horseshoe crabs spawning that night at both Skimmer and Assateague Island. Outside of this drastic temperature change, no other weather phenomena seemed to influence spawning horseshoe crab abundance. Based on the past 18 years of data, abundance of horseshoe crabs followed a typical pattern of lunar timing in 2021 (Figure 4). The greatest number of horseshoe crabs were found during the full moon on June 24th which coincided with the third lunar period.

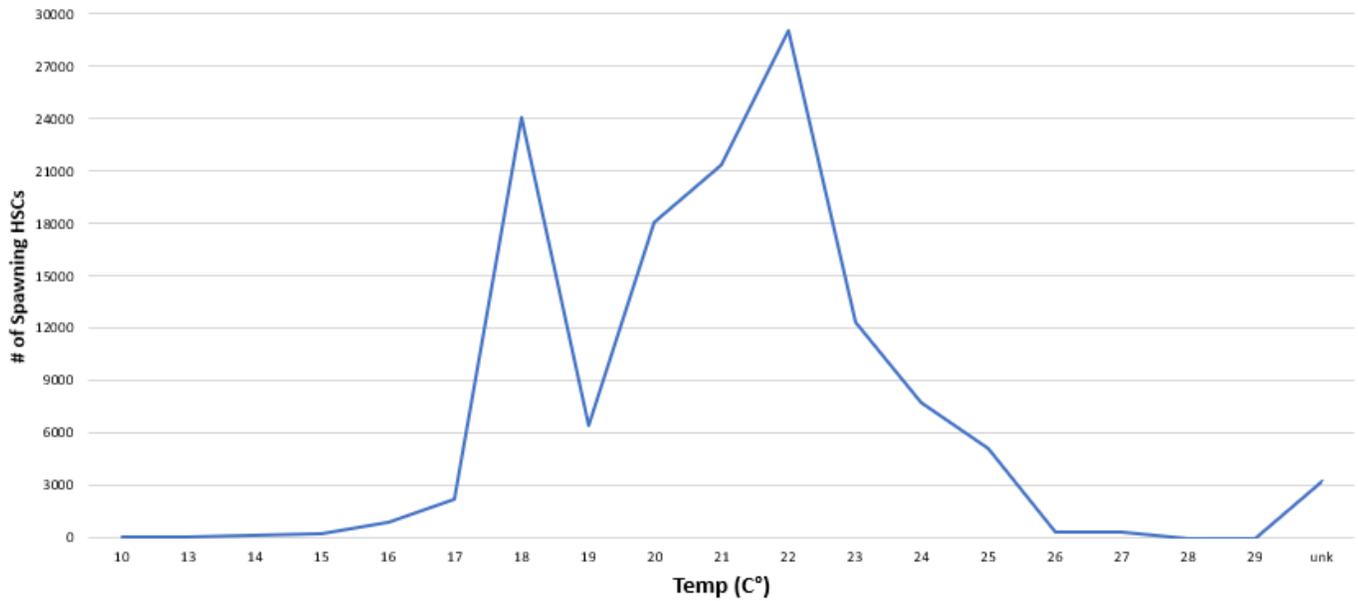


Figure 3. Total number of spawning horseshoe crabs found at various water temperatures from 2007 – 2021. “Unk” stands for unknown temperature to show how many horseshoe crabs were counted when water temperatures were not recorded.

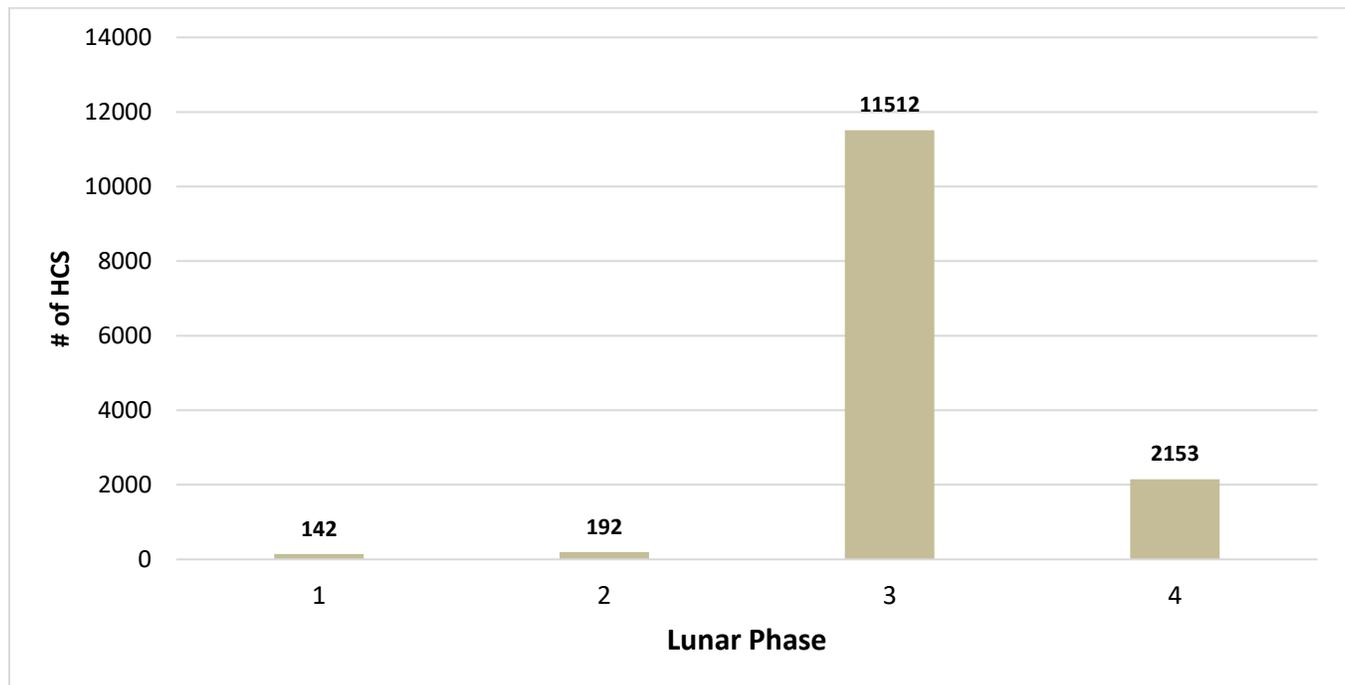


Figure 4. Total number of live horseshoe crabs counted by lunar period in 2021.

Skimmer Island Beach Replenishment Provides Spawning Habitat

Since 2008, the south and southeast portions of Skimmer Island have been surveyed for horseshoe crabs. From 2011 to 2014, Skimmer Island received about 1,000 cubic yards of sand from a

nearby channel that was used as beneficial material on the island. The beneficial dredge material expanded the available area for horseshoe crab spawning. However, the deposition onto the island stopped in 2014 and since then, the island has been continually eroding. The erosion and loss of spawning habitat may explain why the number of horseshoe crabs counted on Skimmer Island at each survey site per year has been trending down since the peak in 2014 (Table 4).

The number of surveys conducted has varied throughout the years with as many as 13 surveys occurring at each Skimmer location in 2009. There was a total of 24 and 22 surveys conducted in 2013 and 2014, respectively, which had the highest total horseshoe crab numbers for Skimmer Island (Table 3). Since 2015, the number of surveys conducted at Skimmer has decreased. Generally, the more surveys conducted, the greater the sample size. This could explain why the horseshoe crab numbers for 2013 and 2014 were so high. In 2021 there were a total of 14 surveys conducted on Skimmer, seven at the south and seven at the southeast location. In total, 10,550 horseshoe crabs were counted at Skimmer Island in 2021, accounting for 75.16% of the total horseshoe crabs counted at all surveying locations (Table 3). The CPUE by survey was calculated for each site to standardize changes in the number of surveys conducted at Skimmer Island's two locations (Table 4). Even though the number of horseshoe crabs counted at the Skimmer locations has decreased over time, these two locations have consistently accounted for over 60% of the total horseshoe crabs counted at all surveying locations since 2007. These data shows the importance of Skimmer Island for the horseshoe crab population.

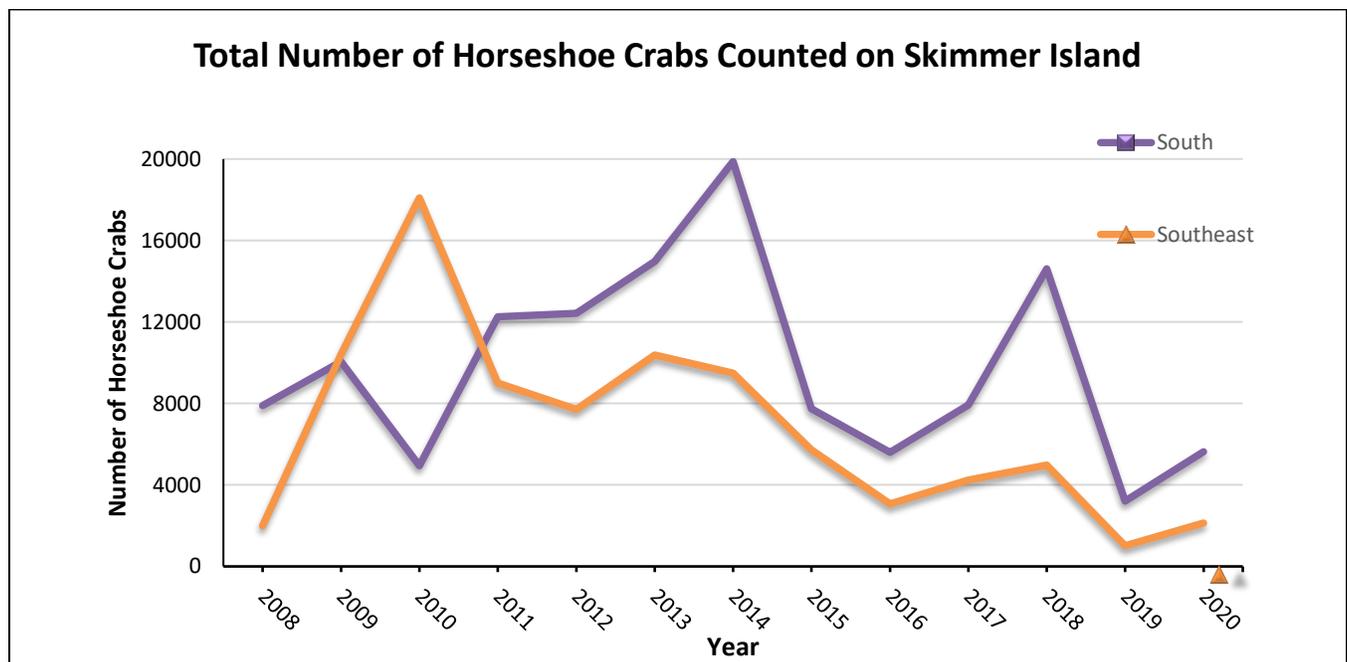


Figure 5. Total number of horseshoe crabs found per year along two 100 square meter transects on Skimmer Island. Note the generally downward trend from 2015 .

Table 3. The percent of Skimmer Island's horseshoe crab counts compared to the total number of horseshoe crabs counted at all surveying locations.

Year	Skimmer S & SE (live & dead)	All Survey Locations (live & dead)	% of Total
2006	764	3918	19.500
2007	4916	7617	64.540
2008	9880	10618	93.050
2009	20467	21846	93.688
2010	23035	23438	98.281
2011	21265	23105	92.036
2012	20138	21127	95.319
2013	25338	31873	79.497
2014	29367	35278	83.245
2015	13474	14238	94.634
2016	8668	9095	95.305
2017	12174	14544	83.705
2018	19591	22140	88.487
2019	4218	6663	63.305
2020	7766	12228	63.510
2021	10550	14036	75.163

Table 4. Count per unit effort of horseshoe crabs for the two sections on Skimmer Island.

Year	Skimmer South	Skimmer SE
2006	N/A	764
2007	492	N/A
2008	1315	153
2009	773	801
2010	412	1508
2011	1114	819
2012	1036	642
2013	1247	864
2014	1807	863
2015	1291	955
2016	933	512
2017	1586	849
2018	1827	622
2019	401	127
2020	939	355
2021	807	700



Photo of MDNR's Steve Doctor holding a large female HSC on Skimmer Island.

References

- Atlantic States Marine Fisheries Commission (ASMFC). (2019). Horseshoe crabs stock assessment and peer review report.
http://www.asmfmc.org/uploads/file/5cd5d6f1HSCAssessment_PeerReviewReport_May2019.pdf.
- Doctor, S. et al. (2015). Maryland FMP Report (August 2016) Section 12. Horseshoe Crab (*Limulus polyphemus*).
- Michels, S., Smith, D., and Bennett, S. (2010). Horseshoe crab spawning activity in Delaware Bay: 1999-2009. Report to the Atlantic States Marine Fisheries Commission's Horseshoe Crab Technical Committee (March 26, 2010).
- Walls, E.A., Berkson, J., & Smith, S.A. (2002). The Horseshoe Crab, *Limulus polyphemus*: 200 Million Years of Existence, 100 Years of Study. *Reviews in Fisheries Science*, 10(1), 39-73.

Acknowledgements: Special thanks to the volunteers, without whose help this survey would not be possible: Carol Sottili, Pam Casagranda, Susie and Ray Smith, Debbie Munford, Laurie Lawton-Smith, and the numerous volunteers who helped with rescuing stranded spawning horseshoe crabs. Also, thanks to Joshua Newhard at US Fish and Wildlife Service for coordinating the tagging program.