Cove Point Beach Restoration: Utilization of a Spawning Habitat by Horseshoe Crabs (*Limulus polyphemus*)

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Abstract

A survey of horseshoe crab spawning activity was conducted in June and July 2011. Surveys were conducted at night during three high tides. In addition, we conducted beach profiles at 17 locations from the lighthouse to the newly installed riprap. At the same locations we also measured sand pore water hydrogen sulfide levels and the proportion of sand grain size. These beach parameters were previously shown to correlate with spawning activity.

Three AACC students were employed in this work. Bethany Enyeart and Jessica Peterson performed the beach profile measurements, while Deborah Smith collected sand cores and water for hydrogen sulfide measurement. All students participated in at least one nighttime survey.

Based on beach profiles, Cove Point beach can be divided into three areas: northern, middle and southern beach. The northern area, where the restoration occurred, is similar in many ways to the southern beach, where spawning has been observed in earlier years. The middle beach is eroding, and is characterized by short, steep beaches. Sulfide levels were low throughout study area.

Overall, these data suggest that the construction efforts on the northern beach have produced suitable spawning habitat for horseshoe crabs, and physical conditions similar to those found on the southern beach. However, spawning activity was lower than observed in previous years. Further, spawning groups were not found in the northern beach. Either females have not yet moved into the northern area, or there are other unmeasured parameters that continue to make the northern beach unsuitable. The decline in spawning groups is troubling. It is possible that the surveys missed the spawning peaks. A more extensive survey would correct this potential problem. It is also possible that the decline is real. This could reflect a continuing decline in the beach as a suitable spawning area, or a decline in the horseshoe crab population in the mid-Chesapeake region.

Introduction

We have shown in previous studies that horseshoe crabs utilize Cove Point beach for spawning (Bushmann, 2009). Emergence onto the beach for egg laying occurred almost exclusively in the southern portion of the beach. This spawning pattern correlated with several physical beach parameters. The northern beach was eroding, and in many areas underlying vegetation was exposed. This provided less beach area for spawning, while hydrogen sulfide levels were elevated. Very fine sand, while a relatively small portion the total, was present in a greater proportion at the northern beach. The southern beach, where spawning was occurring, was characterized by little erosion, low levels of hydrogen sulfide and a smaller proportion of very fine sand. Fine sand packs tighter, and can produce lower oxygen levels within the beach which can lead to lowered egg survival.

After the 2009 study, restoration began on the northern section of the beach. Stone riprap closed the northernmost portion of the beach, while breakwaters lowered wave energy further south. Sand was replenished in these areas, while beach grasses were planted to stabilize the newly replenished beach. It was possible that this stabilization of the northern beach would result in an expansion of suitable spawning habitat for horseshoe crabs.

The current survey was conducted in Spring and Summer of 2011 to evaluate horseshoe crab utilization of Cove Point beach following restoration. In addition, physical beach characteristics were measured to determine if the restoration program produced a beach habitat more suitable for spawning.

Materials and Methods

<u>Establishment of benchmarks</u>

Benchmarks were re-established prior to the study. This was done using GPS coordinates from the previous benchmarks. When a site was located, a stake was driven into the sand and numbered. Benchmarks were generally sited at the highest visible wave line on the beach. Latitude, longitude and elevation were recorded. The numbers ran from 18 near the lighthouse to 2 at the stone riprap at the northern end of the beach. The numbering stopped there, as there was no useable beach further north beyond that point.

Figure 1. Labeled benchmarks used in this study. Each benchmark was sited using GPS coordinates. The riprap and breakwaters are not shown in this picture. The riprap extends northward from benchmark 2.

<u>Survey Counts</u>

Surveys were performed June 3, June 16, and July 1. The surveyor walked the beach from the lighthouse (mark 18) north to the stone riprap that marks the end of the usable beach. When spawning groups were observed, their position was marked by GPS. The number of males associated with each female was also noted. Single males, if they were on the beach, were also recorded. The June 3 survey occurred between 3 and 5 am, with a high tide at 4:15 am. The June 16 survey occurred between 2 and 4 am, with a high tide at 3:35 am. The July 1 survey occurred between 2 and 4 am, with a high tide at 3:11 am.

Figure 2. AACC students counting spawning groups during the nighttime survey.

Beach Profile

Two students used Emery rods to conduct a beach profile at each benchmark (Emery, 1961). Their use is shown in Figure 3. First, the coordinates of each benchmark, including elevation, were recorded to provide a permanent marker. Rod 1 was placed at a benchmark, and rod 2 was stretched 1 meter toward the water. By observing differences between the 1 cm marks on each rod, the elevation change for that meter was determined. Elevation change for each meter from the benchmark to the water's edge was measured in a similar fashion. These measurements were used to construct a profile at each benchmark site, showing vertical elevation change and beach slope.

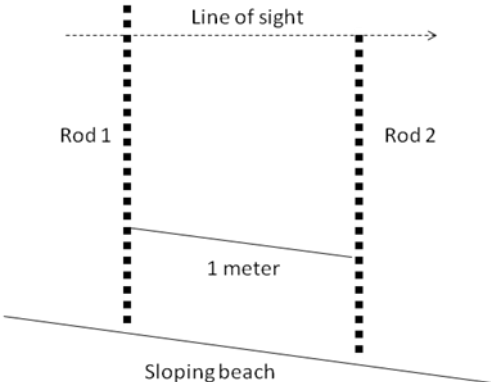

Figure 3. Diagram showing the use of Emery rods on a downward sloping beach.

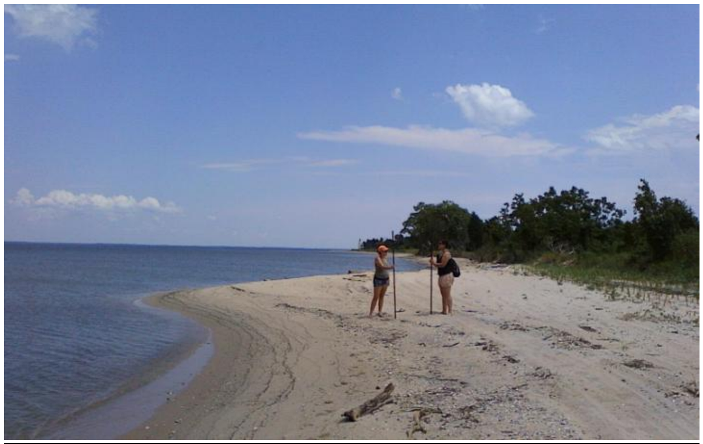

Figure 4. AACC students conducting a beach profile at benchmark 5 during a daytime visit.

Physical Beach Parameters

Hydrogen Sulfide – These measurements were taken 1-2 hours before a daytime low tide. At each benchmark, sand pore water samples were collected by syringe at 15 cm depth, 0.5 m from the waterline. To this sample, 0.5 ml of sulfide reagent was added immediately (van Handel, 1987). A methylene blue reaction product was proportional to the sulfide present in the water sample. Methylene blue concentrations were measured in the laboratory with a visible light spectrophotometer and sulfide concentrations determined (O.D. = 0.17 per microgram sulfide at 650 nm).

Sand Grain Size – Sand core samples were taken 1-2 hours before a daytime low tide, at each benchmark, 0.5 m from the waterline. Cores were 8 cm in diameter and extended 20 cm into the sand. Cores were returned to the laboratory, dried, weighed and poured through a stack of sieves with standard size numbers 5, 35, 60, 120 and 230. These represent mesh sizes of 4, 0.595, 0.250, 0.125 and 0.063 mm, respectively. The fraction retained by each sieve was collected and weighed, allowing us to determine the relative proportion of sand grain size classes in the sample.

Results

Survey Counts

The June 3 survey occurred between 3 and 5 am, with a high tide at 4:15 am. There were high winds, and thus fairly heavy surf. Only one spawning pair was observed, approximately at benchmark 17 near the lighthouse. The June 16 survey occurred between 2 and 4 am, with a high tide at 3:35 am. Seas and wind were calm. We counted 26 spawning pairs. Spawning animals were found primarily on the southern portion of the beach, with a few groups in the middle area, up to benchmark 8.

The July 1 survey occurred between 2 and 4 am, with a high tide at 3:11 am. We counted 16 spawning pairs. As on the June 16 survey, spawning groups were distributed primarily on the southern beach, with a few groups found northward as far as benchmark 10.

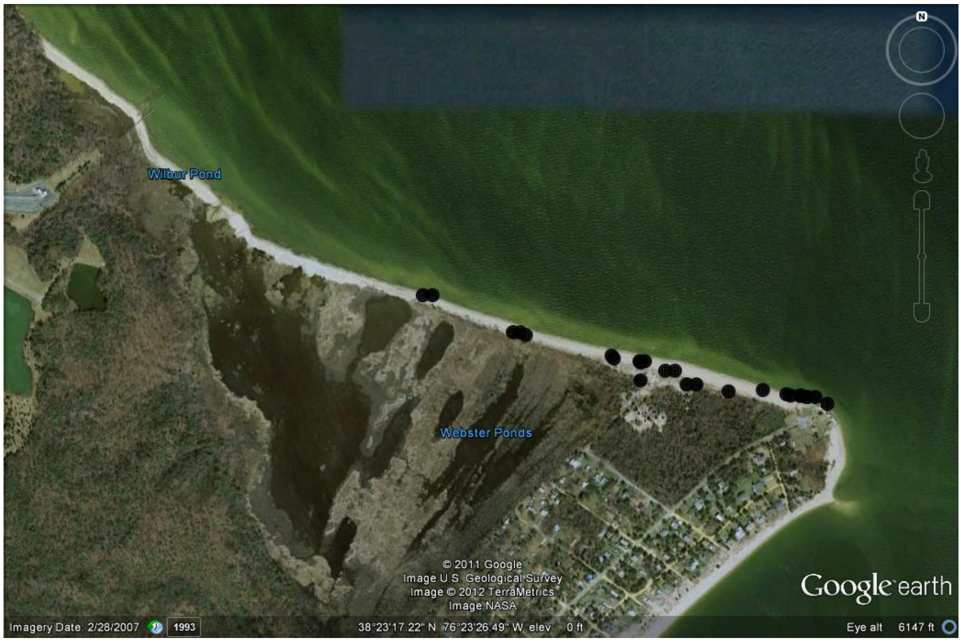

Figure 5. Location of spawning groups on the second survey, June 16. 26 spawning groups were observed.

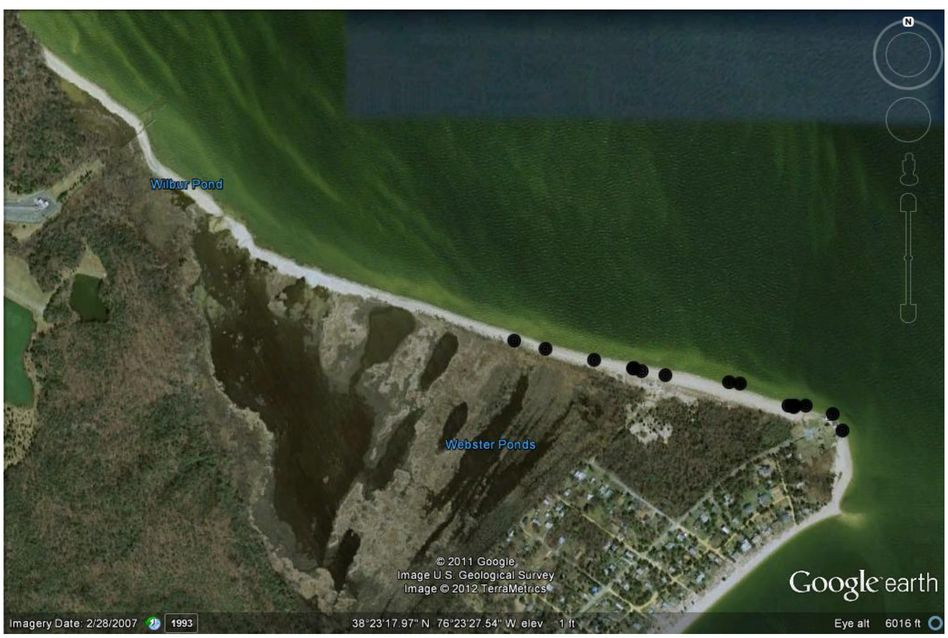

Figure 6. Location of spawning groups on the third survey, July 1. 16 spawning groups were observed.

The majority of spawning females were found with a single male (Fig. 7). This group comprised 62% of the observed spawning groups. Fewer females (24%) were found with two males. Groups involving more than two males were much less common.

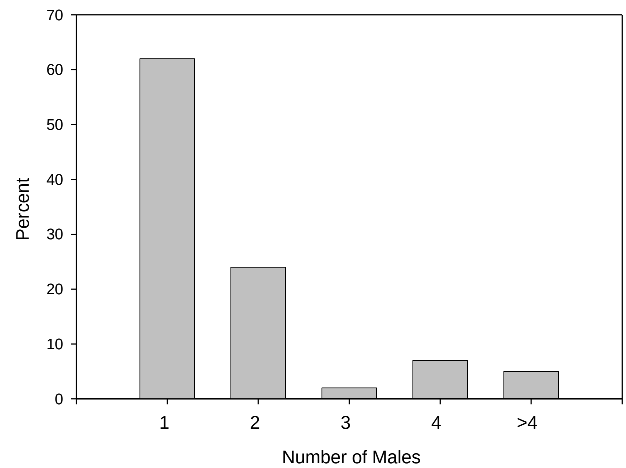

Figure 7. The percentage of spawning females that were accompanied by different numbers of males.

<u>Beach Profile</u>

Profile differences were seen between the northern beach, a stretch of beach in the middle region, and the southern beach. The northern beach generally had wide, flat beaches, with little slope until the 1-2 meters of beach adjacent to the water. The middle beach was characterized by short beaches, with a continuous steep slope down to the water. The southern beach appeared similar to the northern beach. The area was wider, and the slope was generally less steep. Slopes at each benchmark are compared in Figure 8. Photographs of the beach from the northern, middle and southern areas are shown in Figure 9. Figure 10 shows beach profiles for each benchmark. The vertical scale is exaggerated to allow a better comparison of profile changes.

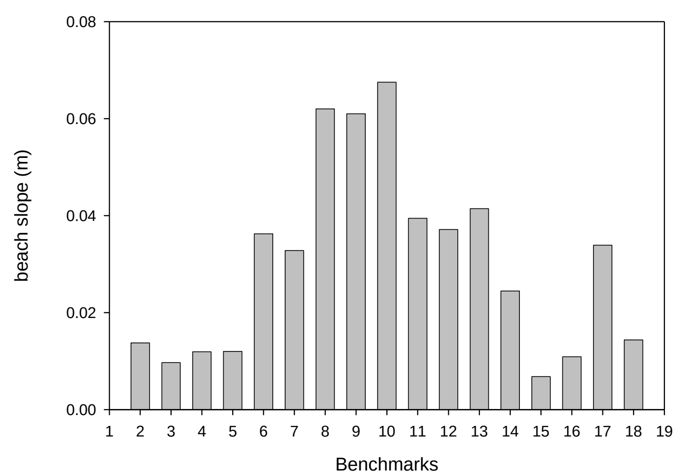

Figure 8. Beach slopes at each benchmark. Slopes were calculated by dividing the total elevation drop by the horizontal distance of the profile.

Figure 9. Photographs of Cove Point beach, taken March 2011. 7A: Northern beach. The breakwaters are visible. A wide beach, with low wave energy. 7B: Middle beach, near benchmark 9. Short, steep beach with increased wave energy. 7C: Southern beach. Wide beach, less slope than middle beach, and higher wave energy than northern beach.

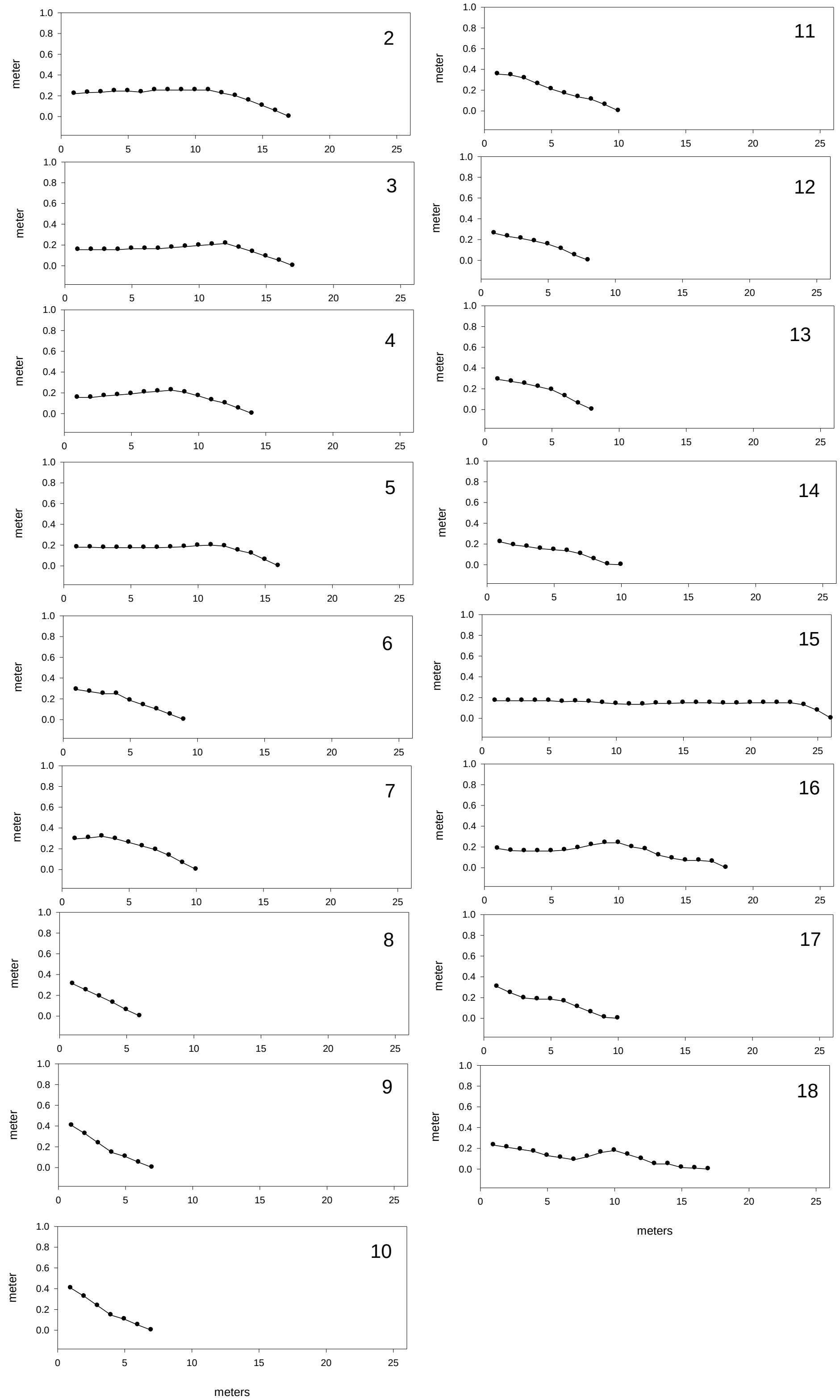

Figure 10. Profiles for Cove Point beach at benchmarks 2 – 18.

Physical Beach Parameters

Hydrogen Sulfide –H_2S readings from beach pore water were low everywhere, with no differences between the northern and southern beach (Fig. 11). This is different from 2009, where the northern beach had significantly higher H_2S concentrations compared with the southern beach.

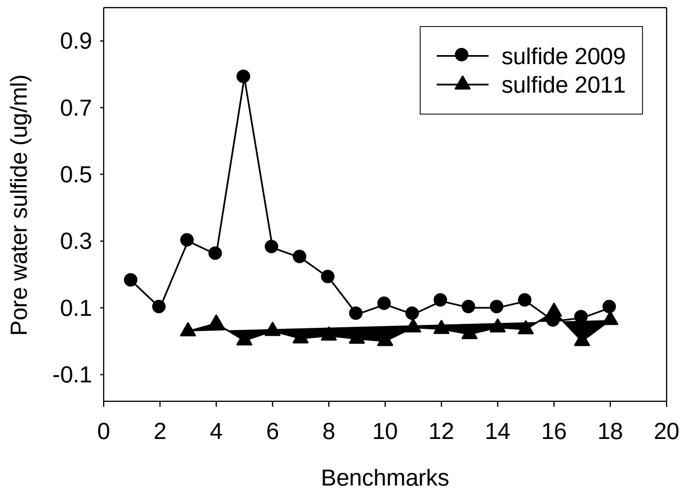

Figure 11. Sulfide readings from beach pore water collected at each benchmark.

Sand Grain Size – Most (>80%) sand grains were in a medium or coarse range (>0.5 mm). Pooled samples for 2009 and 2011 sand cores were generally similar (Fig. 12). Although fine sand (< 0.125 mm) made up a small proportion of the total, it differed between benchmarks and between years. In 2009, the northern beach had a significantly higher proportion of fine sand compared with the southern beach. In 2011, the first three benchmarks had a higher proportion of fine sand than in 2009, but the percentage dropped after that and the remainder of the beach showed a lower percentage of fine sand than in 2009 (Fig. 13).

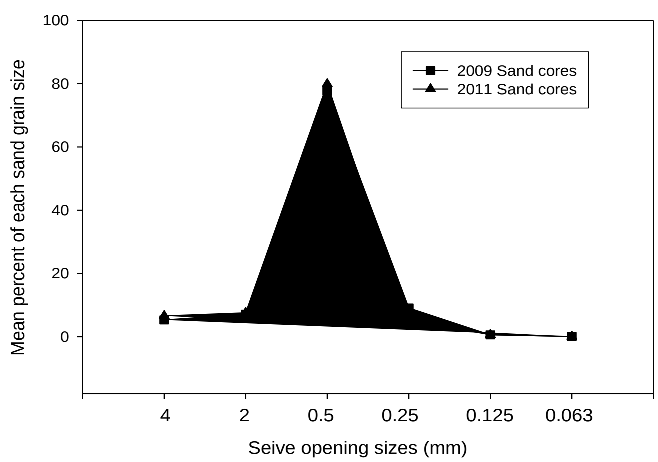

Figure 12. The distribution of sand grain sizes from cores taken at each benchmark.

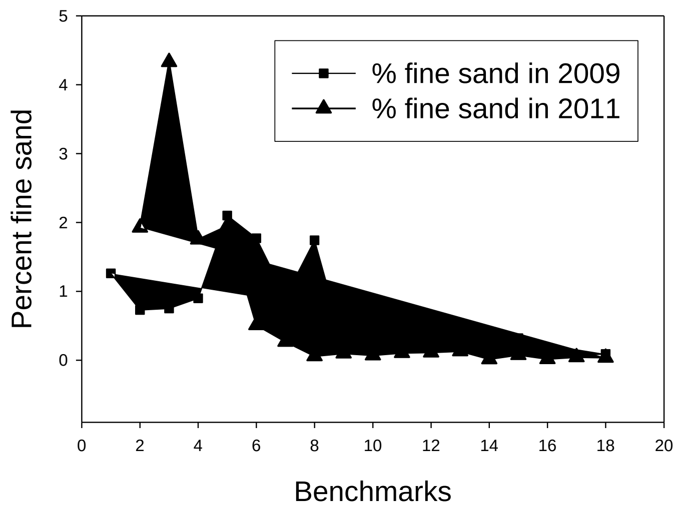

Figure 13. The percentage of fine sand (< 0.125 mm) in core samples from each benchmark, collected in 2009 and 2011.

Figure 14 shows the average number of spawning groups observed over a seven year period. In 2004, 99 spawning groups were observed in a single survey. The 2005 survey is not shown as only two groups were observed that year. The averages for 2006, 2007, 2008 and 2011 represent three surveys per year.

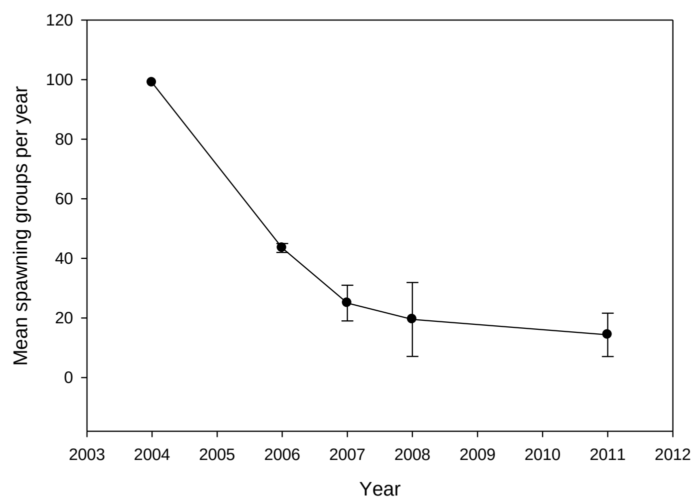

Figure 14. Mean number of spawning groups observed from 2004 to 2011. A single survey was done in 2004. Error bars are ± standard error.

Discussion

Prior to restoration, Cove Point beach could be divided into two areas: northern beach and southern beach. The northern beach was characterized by erosion and exposed underlying vegetation. This was correlated with high sulfide levels in pore water and a higher proportion of fine sand. Hydrogen sulfide is toxic, while beaches composed of fine sand pack tighter and makes anaerobic conditions more likely within the sand. Neither condition is conducive for egg survival. The southern beach was very different: little or no erosion and a wide beach with low sulfide levels and coarser grained sand. Horseshoe crabs spawned on the southern beach, which appeared to be more suitable habitat.

Following the restoration, it is more accurate to divide the beach into three areas: northern, middle and southern. Based on beach profiles, benchmarks 2-5 define the northern beach, benchmarks 6-13 define the middle beach, and benchmarks 14-19 define the southern beach.

The northern beach is now wide, with little slope until close to the water's edge. Wave action is low, due to the breakwaters. Sulfide levels are low. Sand composition is similar to 2009, although the northernmost portion has a higher proportion of fine sand compared with that earlier measurement. Conditions appear more favorable to horseshoe crab spawning, but no animals were observed on the beach in this area.

The middle beach appears to be eroding. The beach is short, with steeper slopes to the water. These steeper sloped beaches receive higher wave energy, because this area is beyond the breakwaters and steep beaches absorb wave energy more abruptly. Sulfide levels are low, and the sand contains a lower proportion of fine grains. This is likely due to the higher wave energy, which tends to wash the smaller massed, fine grains off the beach. Although the short beach and steep slope do not appear ideal, a few horseshoe crabs were observed in this beach area, as far north as section eight.

The southern beach seems little changed from 2009. Beaches appear stable. They are not eroding, and the rise in elevation seen on southern beach profiles suggest that sand may be accreting. Sulfide levels are low. Fine sand grains are less common, again likely due to increased wave energy compared with the northern beach. As in earlier years, the majority of horseshoe crabs spawned within this area.

Overall, the restoration appears to have increased suitable horseshoe crab spawning habitat. The northern beach in particular has physical characteristics similar to the southern beach when compared with 2009. However, horseshoe crabs do not appear to have extended their spawning area beyond earlier limits. It is possible that there are other, unmeasured parameters that make the northern beach unsuitable for spawning. It is also possible that female crabs have not yet made the behavioral adjustment to move northward to new habitat. Further surveys in subsequent years can determine if this population eventually extends its spawning area northward into the restored beach area.

Figure 14 shows a decline in horseshoe crab spawning groups from 2004 to 2011. Is this decline real? These surveys were conducted by choosing a single night when the beach would most likely experience the highest tide of that cycle. This should correlate with a spawning peak. However, it is nearly certain that females also spawn on nights adjacent to high tide peak. It is thus possible that the chosen survey night did not capture the highest density of spawning females, and the decline reflects missing the spawning peak rather than a real decline in spawning activity. A full survey, including all possible spawning nights and daytime surveys, would help to determine if this was a problem. It would also produce a more complete picture of spawning activity.

If the decline is real, what is the cause? It may be that spawning numbers were declining as the beach was eroding and suitable habitat was shrinking. The restoration project appears to have increased useable spawning beach. However, in this survey crabs did not use these new areas and spawning numbers continued to decline. Surveys in subsequent years should be able to determine if spawning numbers increase after the beach restoration. If spawning does not increase, then it is possible that this decline in spawning groups represents a decline in crab population numbers. The Chesapeake Bay population is considered genetically distinct from the larger Atlantic coast and Delaware Bay populations. This suggests that there is little mixing between crabs spawning at Cove Point and other crab populations, although horseshoe crab migration and movement haven't been studied to our knowledge in this portion of the Chesapeake Bay. There currently is no information concerning the population status of these mid-Chesapeake crabs (Sheila Eyler, personal communication). More work is needed to evaluate this population. As a potentially distinct group, it might not be replaced by other migrating crabs if it declines. The Chesapeake would thus lose the important ecological functions performed by these ancient animals.