November 2, 2018

End-of-Year Report for 2018

*Limulus polyphemus*
Horseshoe Crab Monitoring & Tagging Activity in Raritan Bay & Sandy Hook Bay, Monmouth County, New Jersey, May & June 2018. Conducted by Volunteers with the Bayshore Regional Watershed Council and Save Coastal Wildlife

Copy of report to:
Brookdale Community College, Environmental Science Department
M.A.S.T (Marine Academy of Science and Technology)
Monmouth University
National Park Service/Gateway National Recreation Area
NJDEP/Fish & Wildlife Division
New York-New Jersey Baykeeper
US Fish & Wildlife

Report prepared by:
Joseph Reynolds
Co-chair
Bayshore Regional Watershed Council PO Box 541 Navesink, NJ 07752
(732) 872-2834
bayshorewatershed@comcast.net
www.restoreraritanbay.org
www.savecoastalwildlife.org

The full HSC monitoring database is available for downloading from Save Coastal Wildlife website at: https://www.savecoastalwildlife.org/horseshoe-crab-monitoring
Summary

This is an end-of-year report for a study in 2018 to monitor Horseshoe Crab mating activities at five estuarine sites along Sandy Hook Bay & Raritan Bay in Monmouth County, New Jersey. The project began in 2009 and is ongoing. This report marks the tenth year of the study.

A Raritan Bay – Sandy Hook Bay, Monmouth County, New Jersey Horseshoe Crab spawning survey was implemented by volunteers with the Bayshore Regional Watershed Council, Save Coastal Wildlife, and with cooperation from high school students with the Marine Academy of Science and Technology (M.A.S.T.), located at Sandy Hook, NRA. Volunteers with Monmouth County Parks & Bergen County Parks have also been on hand for many years. More than 50 volunteers in total are involved every year to implement this survey. By collaborating with efforts from the general public, the benefits of citizen-based conservation activities become clear: education and public involvement are key components to the most effective wildlife conservation programs.

OLD BUSINESS for 2018
Volunteers with the Bayshore Regional Watershed Council and other organizations conducted monitoring and tagging activities at five (5) sites during periods of high tide on dates that coordinated with full and new moon phases in May and June.

FINDINGS for 2018
The total Horseshoe Crab population in the study area was the highest it has ever been since monitoring activities began in 2009. The total horseshoe crab population was 6,480, which is more than double the previously high mark of 2,913 crabs in 2013. It will be interesting to find in subsequent years if the 2018 population number will sustain, increase, decrease or crash.

Total female horseshoe crabs in 2018 made up approximately 20 percent of this population. Male crabs continue to out-number or out-balance the female population. The low female ratio is having a ripple effect on numbers for burrowing pairs and clusters. There were 279 counted buried pairs, and 338 clusters counted during the study in 2018.

The hot spot for HSC mating activity continues to be Cliffwood Beach in Aberdeen Township. A potential emerging hot spot is Leonardo Beach in Middletown Township.

Background
Horseshoe crabs are ‘living fossils’, the last survivors of a group of organisms that first appeared in the fossil record over 400 million years ago. Besides their extraordinary antiquity, horseshoe crabs are also of paramount importance to
human health. Their blood contains a clotting agent, LAL (Limulus Amoebocyte Lysate), which provides a fast, reliable test for the presence of infectious bacteria in drugs, as well as prosthetic devices such as heart valves and hip replacements.

Horseshoe crabs play a vital role ecologically along the shores of the New York – New Jersey Harbor Estuary, including Sandy Hook Bay & Raritan Bay. Migratory shorebirds, including ruddy turnstones (Arenaria interpres), dunlins (Calidris alpine), and sanderlings (Calidris alba) relay on a large amount of horseshoe crab eggs to provide nourishment during their migrations from the tropics to northern Canada to breed. One bird in particular, the red knot (Calidris canutus) feeds almost primarily on horseshoe crab eggs during its stopover. Although red knots have a limited migratory population in Lower New York Bay, including Raritan Bay and Sandy Hook Bay, regular sightings by volunteers with the Bayshore Watershed Council have observed the bird during spring migration at the tip of Sandy Hook peninsula and at Conaskonk Point in Union Beach. Sightings usually occur in May with a small population of less than a dozen birds. The red knot population in November 2013 was listed as a threatened species under the federal Endangered Species Act by the U.S. Fish and Wildlife Service.

In 2009, volunteer members of the Bayshore Regional Watershed Council approved a measure to conduct a study to monitor and tag horseshoe crab (Limulus polyphemus) spawning populations at five (5) sites along Sandy Hook Bay & Raritan Bay in Monmouth County, New Jersey. The goal of the study was to obtain a better determination of the spawning population of this aquatic species, and to ascertain if the population is stable, increasing, or decreasing. In addition, by tagging horseshoe crabs, this study will help to better understand the migration patterns, abundance, and survival rates of recaptured tagged horseshoe crabs over the course of the study in the project area.

The five (5) monitoring sites along Raritan Bay & Sandy Hook Bay in Monmouth County, New Jersey include: 1) Plum Island at Sandy Hook Gateway National Recreation Area, 2) near the mouth of Many Mind Creek in the Borough of Atlantic Highlands, 3) Leonardo Beach in Middletown Township, 4) Keyport Harbor, near the mouth of Chingarora Creek and at the western side of Conaskonk Point in the Borough of Keyport, and 5) Cliffwood Beach in Aberdeen Township.

**Field Methods**
Data was collected during full moon and new moon high tide event cycles in May and June. Monitoring activities by volunteers were divided into two activities: (1) counting spawning populations of Horseshoe Crabs and (2) tagging single adult Horseshoe Crabs in order to determine travel patterns. Both activities took place at the same time by watershed volunteers in May & June.

Field methods and activities for counting crab populations by watershed volunteers were similar to protocol described by the USGS in their volunteer information entitled, “SURVEYING HORSESHOE CRABS” (please see USGS web site: [http://www.lsc.usgs.gov/aeb/2065/protocol.asp](http://www.lsc.usgs.gov/aeb/2065/protocol.asp))
Only single crabs will be tagged. Never tag crabs that are in pairs or clusters. Crabs will only be selected for tagging activities within the monitoring area or transect zone on the beach after the crab has been counted or surveyed by an observer.

Attach only one tag per animal. If the animal is damaged near the attachment area, do not tag the animal.

1. Tags will be attached to the left posterior (rear) point of the prosoma (first section of body). There is a high concentration of fibrous material within the body in this area, which minimizes bleeding. Before drilling the attachment hole, clean off any epibionts (barnacles, etc.) near the attachment site.

2. USFWS (US Fish & Wildlife) recommends first cleaning the area where the hole will be drilled by rubbing the spot with alcohol.

3. Next the drill should be dipped into a Betadine antiseptic solution to disinfect the drill before making the hole in the shell (prosoma).

4. The tag is attached by drilling a 5/32” hole (7/64” for small tags) through the left side of the prosoma near the dorsal edge and then pushing the plastic pin (with tag) into the hole as far as it will go (it should NOT go all the way through the prosoma and come out the other side).

5. This procedure should be repeated for every individual that is being tagged.

6. All tags will be used in consecutive sequential procedure. One number after another.
7. Any crabs found with tags already attached to the shell are to be reported to the Beach Captain and recorded on the re-sighting form.

If you plan to tag crabs, please bring a cordless drill with tape on a 5/32-inch drill bit up 1/8" from the tip to tag the crabs. Also, we will need measuring tape and rulers that measure in millimeters. Bring plenty of clipboards, pens/pencils, flashlights or headlamps.

Field methods for tagging crab population were the same protocol as described by USFWS. Only single adult Horseshoe Crabs were tagged. Crabs that were in the process of mating were left alone so as not to interrupt the course of action. In brief, the protocol called for volunteers to attach a circular individual numbered disc to the left posterior (rear) of the prosoma (first section of body) by drilling a 5/32" hole through the side and then pushing the plastic pin (with tag) into the hole as far as it can go. Data sheets recorded the tag number, sex, prosomal width (PW) in millimeters (widest point of the crab), the date tagged, beach name, waterbed name, and state.

In 2014, two new tagging protocols were instituted as directed by US Fish and Wildlife and the National Park Service:

1. All single crabs to be tagged will first have the area where the hole will be drilled to be cleaned by rubbing the spot with alcohol.
2. Then the drill should be dipped into a Betadine antiseptic solution to disinfect the drill before making the hole in the shell (prosoma).
3. This procedure should be repeated for every individual to be tagged.
4. Any crabs found with tags already attached to the shell will be reported to the Beach Captain and recorded on a re-sighting form.

The watershed council received a total of 400 tags in 2018 supplied by USFWS. About 299 tags were employed this year. The tally is as follows:

150 crabs were tagged at Cliffwood Beach in Aberdeen Township.
125 crabs were tagged at the mouth of Many Mind Creek in Atlantic Highlands.
24 crabs were tagged at Plum Island at Sandy Hook NRA.

All horseshoe crabs tagged were single males except for two single females tagged at Cliffwood Beach on May 29, 2018.
Protocol to Conduct Spawning Survey

Each site beach will be sampled along a transect of 1,000 feet.

1. As volunteers walk to the starting location, find a stick (1 to 2 ft. long) that you can use to determine high tide. When you get to the starting location, stand the stick in the sand at the tide line. The tide line is the highest point on the beach that the water reaches. Move the stick up the beach as the water reaches higher on the beach. Begin the survey when the tide begins to recede and the water no longer reaches the stick. Record your starting time on the Beach Site Sheet where it says START OF SURVEY.

2. The “horseshoe crab line” you will follow is not a straight line and may be above or below the water line or the surf zone - typically the area where the waves break and wash over the horseshoe crabs, especially males seeking females. If there is an obstruction or discontinuation in the beach section (bulkhead, large boulder, etc.), pace up to the obstruction, walk to the other side of it, and then continue your pace count on the other side. Do not include the width of the obstruction in your transect.

3. Count the animals of each sex separately. If a horseshoe crab is not buried, the two most common ways to determine its sex are its size and position. Males are for the most part smaller and clasped or crowded on top of females. The first pair of appendages for males is also bulbous (like a marble), so they have the strength to clasp a female tightly. The bulbous shape is diagnostic for males.

4. To survey horseshoe crabs, you will start at one end of a marked section of beach. At the “start time,” you should begin counting all horseshoe crabs (dead or alive, single males and females, swimming pairs, buried pairs, and clusters) along a 1,000 feet of beach.

5. The Observer (first person) will walk along the "horseshoe crab line" and count out loud the number of horseshoe crabs and the Recorder (second person) records these observations on the Data Sheet. The Observer should always focus on counting horseshoe crabs that are spawning on the beach according to the following rules:

   a. Crabs above the Surf Zone (on beach): Count all that are present.
   b. Crabs in the Surf Zone: Count all that are present and include the submerged crabs that are obviously part of the spawning event.

6. Continue this way until you have sampled a 1,000 foot transect. You can stop while counting, but do not walk backwards and re-count.
RESULTS FOR 2018:

Below are the results for the tenth (10th) year of monitoring HSC at five sites along the edge of Sandy Hook Bay and Raritan Bay in Monmouth County, NJ. Data was collected on a total of four nights, which corresponded with full and new moon evenings.

**FIRST NIGHT**

Tuesday, May 15, 2018

Raritan Bay & Sandy Hook Bay

Starting time: 8:30pm

Moon Phase: NEW Moon

Water & Weather Conditions

Water temperature: Low to mid 60s F
Water condition: Turbid (after storm)
Wave condition: Calm
Air temperature: upper 60s F
Sky conditions: Cloudy with light rain
Winds: NNW 5-10mph

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Total Crabs</th>
<th>Total females</th>
<th>Total males</th>
<th>Single males</th>
<th>Single females</th>
<th>Swimming Pairs</th>
<th>Burrowed Pairs</th>
<th>Clusters</th>
<th>Dead crabs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plum Island</td>
<td>24</td>
<td>6</td>
<td>18</td>
<td>10</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Mouth Of Many Mind Creek</td>
<td>183</td>
<td>57</td>
<td>126</td>
<td>48</td>
<td>0</td>
<td>30</td>
<td>17</td>
<td>10</td>
<td>1 (u)</td>
</tr>
<tr>
<td>Leonardo Beach</td>
<td>9</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Keyport Harbor</td>
<td>87</td>
<td>33</td>
<td>54</td>
<td>22</td>
<td>2</td>
<td>63</td>
<td>0</td>
<td>0</td>
<td>1 (m)</td>
</tr>
<tr>
<td>Cliffwood Beach</td>
<td>100</td>
<td>29</td>
<td>71</td>
<td>39</td>
<td>1</td>
<td>15</td>
<td>10</td>
<td>3</td>
<td>1(f)</td>
</tr>
</tbody>
</table>

m = males, f = females, u = sex unidentified

**Leonardo Beach Survey ended at around 8:45pm due to frequent lightning**

Total for all five sites monitored on Tuesday, May 15, 2018

<table>
<thead>
<tr>
<th></th>
<th>Total Crabs</th>
<th>Total females</th>
<th>Total males</th>
<th>Single males</th>
<th>Single females</th>
<th>Swimming Pairs</th>
<th>Burrowed Pairs</th>
<th>Clusters</th>
<th>Dead crabs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>403</td>
<td>128</td>
<td>275</td>
<td>122</td>
<td>3</td>
<td>114</td>
<td>28</td>
<td>15</td>
<td>3</td>
</tr>
</tbody>
</table>
SECOND NIGHT
Tuesday, May 29, 2018
Raritan Bay & Sandy Hook Bay
Starting time: 8:45pm
Moon Phase: FULL Moon

Water & Weather Conditions
Water temperature: Low to mid 60s F
Water condition: Very Turbid
Wave condition: Calm
Air temperature: mid 70s F
Sky conditions: Clear
Winds: SSE 5-10mph

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Total Crabs</th>
<th>Total females</th>
<th>Total males</th>
<th>Single males</th>
<th>Single females</th>
<th>Swimming Pairs</th>
<th>Burrowed Pairs</th>
<th>Clusters</th>
<th>Dead crabs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plum Island</td>
<td>38</td>
<td>3</td>
<td>35</td>
<td>30</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Mouth Of Many Mind Creek</td>
<td>656</td>
<td>139</td>
<td>517</td>
<td>322</td>
<td>2</td>
<td>77</td>
<td>30</td>
<td>30</td>
<td>1 (m)</td>
</tr>
<tr>
<td>Leonardo Beach</td>
<td>1125</td>
<td>215</td>
<td>910</td>
<td>539</td>
<td>2</td>
<td>111</td>
<td>49</td>
<td>53</td>
<td>2 (m) 4 (f)</td>
</tr>
<tr>
<td>Keyport Harbor</td>
<td>242</td>
<td>71</td>
<td>171</td>
<td>64</td>
<td>0</td>
<td>14</td>
<td>34</td>
<td>23</td>
<td>0</td>
</tr>
<tr>
<td>Cliffwood Beach</td>
<td>1765</td>
<td>444</td>
<td>1322</td>
<td>558</td>
<td>1</td>
<td>191</td>
<td>104</td>
<td>145</td>
<td>1 (m)</td>
</tr>
</tbody>
</table>

* m = males, f = females, u = sex unidentified

Total for all five sites monitored on May 29, 2018

<table>
<thead>
<tr>
<th></th>
<th>Total Crabs</th>
<th>Total females</th>
<th>Total males</th>
<th>Single males</th>
<th>Single females</th>
<th>Swimming Pairs</th>
<th>Burrowed Pairs</th>
<th>Clusters</th>
<th>Dead crabs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>3826</td>
<td>872</td>
<td>2955</td>
<td>1513</td>
<td>5</td>
<td>394</td>
<td>217</td>
<td>253</td>
<td>8</td>
</tr>
</tbody>
</table>
THIRD NIGHT
Wednesday, June 13, 2018
Raritan Bay & Sandy Hook Bay
Starting time: 8:15pm
Moon Phase: NEW Moon

Water & Weather Conditions
Water temperature: mid to upper 60s F
Water condition: Very Turbid
Wave condition: Calm
Air temperature: mid 70s F
Sky conditions: partly cloudy
Winds: ESE 5-10mph

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Total Crabs</th>
<th>Total females</th>
<th>Total males</th>
<th>Single males</th>
<th>Single females</th>
<th>Swimming Pairs</th>
<th>Burrowed Pairs</th>
<th>Clusters</th>
<th>Dead crabs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plum Island</td>
<td>22</td>
<td>4</td>
<td>18</td>
<td>12</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>2 (m)</td>
</tr>
<tr>
<td>Mouth Of Many Mind Creek</td>
<td>210</td>
<td>23</td>
<td>187</td>
<td>159</td>
<td>0</td>
<td>34</td>
<td>6</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Leonardo Beach</td>
<td>375</td>
<td>40</td>
<td>335</td>
<td>265</td>
<td>1</td>
<td>27</td>
<td>1</td>
<td>1</td>
<td>7 (f) 1 (m)</td>
</tr>
<tr>
<td>Keyport Harbor</td>
<td>126</td>
<td>21</td>
<td>105</td>
<td>75</td>
<td>1</td>
<td>14</td>
<td>3</td>
<td>2</td>
<td>1 (m)</td>
</tr>
<tr>
<td>Cliffwood Beach</td>
<td>1456</td>
<td>230</td>
<td>1226</td>
<td>738</td>
<td>0</td>
<td>146</td>
<td>20</td>
<td>63</td>
<td>1 (f)</td>
</tr>
</tbody>
</table>

* m = males, f = females, u = sex unidentified

Total for all five sites monitored on June 13, 2018

<table>
<thead>
<tr>
<th></th>
<th>Total Crabs</th>
<th>Total females</th>
<th>Total males</th>
<th>Single males</th>
<th>Single females</th>
<th>Swimming Pairs</th>
<th>Burrowed Pairs</th>
<th>Clusters</th>
<th>Dead crabs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>2189</td>
<td>310</td>
<td>1871</td>
<td>1249</td>
<td>2</td>
<td>225</td>
<td>30</td>
<td>69</td>
<td>12</td>
</tr>
</tbody>
</table>
FOURTH NIGHT  
Thursday, June 28, 2018  
Raritan Bay & Sandy Hook Bay  
Starting time: 9:00pm  
Moon Phase: FULL Moon  

Water & Weather Conditions  
Water temperature: upper 60s to low 70s F  
Water condition: Very Turbid (showers all day)  
Wave condition: Calm  
Air temperature: low 70s F  
Sky conditions: partly cloudy  
Winds: NW 5-10mph

<table>
<thead>
<tr>
<th>Site Name</th>
<th>Total Crabs</th>
<th>Total females</th>
<th>Total males</th>
<th>Single males</th>
<th>Single females</th>
<th>Swimming Pairs</th>
<th>Burrowed Pairs</th>
<th>Clusters</th>
<th>Dead crabs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plum Island</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mouth Of Many Mind Creek</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Leonardo Beach</td>
<td>39</td>
<td>5</td>
<td>34</td>
<td>27</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Keyport Harbor</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 (m)</td>
</tr>
<tr>
<td>Cliffwood Beach</td>
<td>17</td>
<td>3</td>
<td>14</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* m = males, f = females, u = sex unidentified

Total for all five sites monitored on June 28, 2018

<table>
<thead>
<tr>
<th>Total Crabs</th>
<th>Total females</th>
<th>Total males</th>
<th>Single males</th>
<th>Single females</th>
<th>Swimming Pairs</th>
<th>Burrowed Pairs</th>
<th>Clusters</th>
<th>Dead crabs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>62</td>
<td>9</td>
<td>52</td>
<td>39</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

Total Horseshoe Crab activity for May & June 2018

<table>
<thead>
<tr>
<th>Total Crabs</th>
<th>Total females</th>
<th>Total males</th>
<th>Single males</th>
<th>Single females</th>
<th>Swimming Pairs</th>
<th>Burrowed Pairs</th>
<th>Clusters</th>
<th>Dead crabs</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td>6480</td>
<td>1319</td>
<td>5153</td>
<td>2923</td>
<td>12</td>
<td>735</td>
<td>279</td>
<td>338</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>24</td>
</tr>
</tbody>
</table>
TOTAL HSC ACTIVITY FOR THE FIVE MONITORING SITES IN THE RARITAN BAY – SANDY HOOK BAY ESTUARINE COMPLEX FOR YEARS: 2009 to 2018 (ten years).

<table>
<thead>
<tr>
<th>YEAR</th>
<th>Total crabs</th>
<th>Total females</th>
<th>Total males</th>
<th>Single males</th>
<th>Single females</th>
<th>*Swimming pairs</th>
<th>*Burrowing pairs</th>
<th>Clusters</th>
<th>Dead</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>1,174</td>
<td>495</td>
<td>679</td>
<td>251</td>
<td>96</td>
<td></td>
<td></td>
<td>27</td>
<td>6</td>
</tr>
<tr>
<td>2010</td>
<td>1,025</td>
<td>178</td>
<td>847</td>
<td>475</td>
<td>16</td>
<td></td>
<td></td>
<td>55</td>
<td>20</td>
</tr>
<tr>
<td>2011</td>
<td>2,321</td>
<td>399</td>
<td>1,922</td>
<td>1,225</td>
<td>86</td>
<td></td>
<td></td>
<td>139</td>
<td>28</td>
</tr>
<tr>
<td>2012</td>
<td>2,430</td>
<td>701</td>
<td>1,729</td>
<td>753</td>
<td>25</td>
<td></td>
<td></td>
<td>119</td>
<td>118</td>
</tr>
<tr>
<td>2013</td>
<td>2,913</td>
<td>743</td>
<td>2,170</td>
<td>1,259</td>
<td>40</td>
<td>265</td>
<td>276</td>
<td>240</td>
<td>95</td>
</tr>
<tr>
<td>2014</td>
<td>1,828</td>
<td>287</td>
<td>1,541</td>
<td>1,168</td>
<td>10</td>
<td>145</td>
<td>92</td>
<td>33</td>
<td>44</td>
</tr>
<tr>
<td>2015</td>
<td>828</td>
<td>157</td>
<td>663</td>
<td>347</td>
<td>32</td>
<td>51</td>
<td>43</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>2016</td>
<td>1,246</td>
<td>217</td>
<td>1,016</td>
<td>769</td>
<td>15</td>
<td>130</td>
<td>50</td>
<td>16</td>
<td>39</td>
</tr>
<tr>
<td>2017</td>
<td>2,077</td>
<td>400</td>
<td>1,677</td>
<td>1,066</td>
<td>8</td>
<td>154</td>
<td>150</td>
<td>70</td>
<td>42</td>
</tr>
<tr>
<td>2018</td>
<td>6480</td>
<td>1319</td>
<td>5153</td>
<td>2923</td>
<td>12</td>
<td>735</td>
<td>279</td>
<td>338</td>
<td>24</td>
</tr>
</tbody>
</table>

• In 2013, the parameter known as “pairs” was divided into two separate categories: “swimming pairs” and “burrowed pairs.” This was done in order to clarify better HSC mating activities at each monitoring site. Other parameters are consistent with the term of the study. The following is the total numbers of pairs (both swimming pairs and burrowing pairs) recorded from 2009 to 2012:
  2009: 334
  2010: 261
  2011: 254
  2012: 507
RECOMMENDATIONS
There needs to be greater protection for known mating sites in Raritan Bay and Sandy Hook Bay, including Cliffwood Beach in Aberdeen Township and Leonardo Beach in Middletown Township. Horseshoe crabs congregate along estuarine beaches seasonally to spawn, which make them especially vulnerable to exploitation, either intentionally or not, by local fishermen or beachgoers. A need exists for a public education campaign to inform people not to disturb spawning horseshoe crabs and to alert local residents about the importance of horseshoe crabs in local estuarine ecology.

APPRECIATION
Appreciation and gratitude is given to the project partners. This study is a cooperative effort involving the U.S. Fish and Wildlife Service, National Park Service, Gateway National Recreation Area, the New Jersey Division of Fish and Wildlife, Bayshore Regional Watershed Council, Save Coastal Wildlife, Brookdale Community College, Environmental Science Department, and Marine Academy of Science and Technology (M.A.S.T.) at Sandy Hook.

In addition, appreciation is given to over 50 volunteers from the watershed council, local citizens, and volunteers with the Monmouth County Park System and the Bergen County Park System, who routinely give up a bit of their time in May and June to assist in this project, so that other people might gain a better understanding of horseshoe crab activity in Raritan Bay & Sandy Hook Bay, Monmouth County, New Jersey. Without the help of everyone involved, this project would not have been accomplished. Thank you!