

The 2011 Delaware Bay Horseshoe Crab Spawning Survey

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Abstract

On twelve spring/summer nights in May and June with the tide high, the Delaware Bay Shore hosts volunteer groups to experience the phenomena of spawning horseshoe crabs. Coinciding with the new and full moons, 25 accessible beaches, 12 beaches in New Jersey and 13 beaches in Delaware, are designated to set the scene for the annual horseshoe crab survey.

Survey dates numbering 300 produced 267 dates or 89% of actual surveying. The remainder were canceled due to flooding (19), inclement weather (3), or volunteer unavailability (11).

The single day peak estimate of 477,715 for the entire Delaware Bay was attained on June 3rd, two days following the new moon. New Jersey's estimate of 190,449 and Delaware's estimate of 287,266 for June 3rd are similar to last year's estimates of 193,463 and 279,296 spawners respectively. Although New Jersey's peak estimate occurred on June 3rd, Delaware's peak was achieved on the new moon date of June 1st with 318,859 individuals spawning. This estimate coupled with New Jersey's estimate of 143,123 created a close estimate to the peak estimate of 461,982 on June 1st, the new moon date.

The male to female sex ratio of 5.36 made for a record 2011 ratio, surpassing the past 2009 highest ratio of 5.04. Computing the sex ratio per state, New Jersey's was 4.00 males per female and Delaware's 6.27 males per female. The beach with the lowest sex ratio (2.125 males per female) in Delaware was Woodland Beach, also the beach with the least amount of horseshoe crabs observed and counted (17 males and 8 females). Pickering Beach had the highest sex ratio of 9.01 along with the greatest amount of horseshoe crabs (12,354 males and 1,371 females). In New Jersey, the North Cape May beach had the lowest sex ratio of 2.48 and the lowest number of horseshoe crabs counted (698 males and 282 females).

The grand total of seasonal activity for both states was 1,997,203 (314,026 females and 1,683,177 males). The seasonal estimate compared to the 2009 total of 2,049,200 horseshoe crabs (339,271 females and 1,709,929 males) and very close to the 2007 estimate of 1,947,372 (330,064 females and 1,617,308 males). Although the estimate is higher than all the other years (except the 2007 and 2010 years), the number of females has not changed dramatically due to the higher sex ratio.

Introduction

Since its inception in 1999, our survey has made tremendous strides and is now considered the premier method of estimating the spawning population of horseshoe crabs. To continue with this undertaking each year we rely on many eager and energetic groups and volunteers who generously give of their time and their efforts to learn, count, enter and analyze the data reaped from the results of the survey.

Methods

Horseshoe crabs were enumerated in the months of May and June 2011 along the shores of the Delaware Bay. Twenty-five beaches were represented in this year's count (13 along the state of Delaware's coast and 12 along the coast of New Jersey). The Delaware beaches from north to south were Woodland, Pickering, Kitts Hummock, Ted Harvey Wildlife Management Area (WMA), North Bowers, South Bowers, Bennetts Pier, Big Stone, Slaughter, Fowler, Primehook, Broadkill, and Cape Henlopen. New Jersey beaches included Gandys, Fortescue, Reeds, Kimbles, Pierces Point, Highs, South Cape Shore Lab, Norburys Landing, Villas, Townbank, North Cape May and Higbees. Sea Breeze beach was not surveyed this year due to flooding and access problems.

Simultaneous counts were taken on both New Jersey and Delaware beaches coinciding with the peak high tides and following the new and full moons. The dates of counting were: May 1, 3, 5, 15, 17, 19 and May 30, June 1, 3, 13, 15 and 17. High tide times ranged from 7:32 p.m. to 11:10 p.m., allowing adjustments for tidal flow entering the bay. All counts initiate with the onset of the high tide on one kilometer of preset beach. Where one contiguous kilometer of beach is not available, adjustments are made to place quadrats closer to each other completing the counting with 100 quadrats.

Results

Coverage by the volunteers accounted for 89%, or 267, of the entire 300 scheduled counts. In New Jersey, 14 dates were cancelled due to no access and flooding (7), weather (3) and no surveyors (4). Inaccessibility to the beach occurred at South Cape Shore Lab May 5th and June 15th, Kimbles beach May 15th, May 17th and June 13th and Gandys beach May 15th and May 17th. The weather related cancellations occurred at Higbees May 15th and 19th and at Gandys May 19th. Surveyors were not available May 30th at Higbees and Townbank and June 15th and 17th at Pierces Point. (Table 1A)

Nineteen cancellations occurred in Delaware during the 2011 spawning season. Of these, seven were canceled citing volunteer unavailability and 12 for no access. Access was compromised by flooding for the full moon date of May 17th date on six of the surveyed beaches, Primehook, Fowler, Slaughter, Bennetts Pier, South

Bowers and Ted Harvey WMA. Additional counts scheduled for May 15th, June 13th and June 15th were canceled at Fowler Beach, May 19th at Bennetts Pier, June 15th and 17th at Woodland Beach due to flooding. Seven cancellations due to volunteer unavailability occurred at Cape Henlopen May 5th, Fowlers May 1st and May 30th, Slaughter June 17th, Bennetts Pier May 3rd and June 1st and Ted Harvey WMA June 17th. (Table 1B)

This year's (2011) peak estimate of spawners along Delaware and New Jersey's shores was comparable to 2010 (Table 2). The peak activity was recorded June 3rd 477,715 individuals estimated, the highest count of the 12 nights in New Jersey and the second highest count in Delaware. Delaware's peak was achieved on June 1st with 318,859 horseshoe crabs estimated. This estimate coupled with New Jersey's estimate of 143,123 spawners on this date created a comparable peak estimate of 461,982 horseshoe crabs on June 1st.

In New Jersey, 67% of the seasonal spawning occurred surrounding the new moon date of June 1st. If the counts, May 30th, June 1st and June 3rd are combined with the May 19th estimate, 79% of the seasonal spawning estimate was recorded during this time (Table 1A and Figure 1). Spawning activity in New Jersey for the overall season was the highest at South Cape Shore Lab with 150,656 individuals and the second highest at Norburys Landing with 102,425 spawners. High densities were achieved at Pierces Point of 17.14 horseshoe crabs per square meter on May 19th and 16.52 crabs per square meter on June 3rd at South Cape Shore Lab. (Table 1A)

In Delaware, spawning activity was greatest during the three dates surrounding the new moon date of June 1st with 57% of the total seasonal activity (Table 1B and Figure 1). If the spawning estimate for May 19th is included with the May 30th, June 1st and June 3rd new moon estimates, 74% of the total spawning estimate for Delaware occurred during this time. The highest seasonal activity occurred on Big Stone beach, estimated to be 359,350 spawners followed by 203,070 on Slaughter. Five other beaches in Delaware had spawning estimates over 100,000 animals; Pickering (137,250), South Bowers (135,309), Kitts Hummock (117,360), Ted Harvey WMA (115,090) and Primehook (101,300). The most northern beach on the Delaware side of the Bay, Woodland Beach, had very few horseshoe crabs yielding an estimate of 125 horseshoe crabs. Coinciding with good spawning activity, densities numbering over 20 crabs per square meter were observed at Pickering Beach on May 17th with a density of 28.43, June 1st of 26.16 and June 3rd 23.99, Kitts Hummock on June 1st of 20.23 and June 3rd of 21.5, Ted Harvey of 24.56 and Slaughter of 20.29 crabs per square meter on June 1st. (Table 1B)

The seasonal estimate of 1,997,203 was similar to the 2009 estimate (2,049,200) and the 2007 estimate (1,947,372) (Table 4 and Figure 4). The 2011 male to female ratio was 5.36 – higher than the previous years' ratios. The 2009 sex ratio of 5.04 is the only year ratio that is close to the 2011 ratio. (Sex ratios are

computed by averaging the total number of males and females counted throughout the entire season.) Estimating the number of males and females by utilizing the 5.36 ratio and the 2011 seasonal estimate resulted in 1,683,177 males and 314,026 females spawning (Table 5 and Figure 5).

We observe and utilize four levels of spawning activity to categorize the densities for each count. No spawning activity equals 0 crabs, low activity equals less than 5 crabs per meter, moderate activity equals 5 to 10 crabs per meter, and high activity equals greater than 10 crabs per meter. The data is then analyzed in percentages since number of dates and/or beaches may change yearly. As in previous years, the majority of the dates surveyed (49% in DE and 58% in NJ) showed horseshoe crabs densities lower than five crabs per meter. Highest densities were observed in Delaware on 32 dates or 21%. This percentage is the greatest of high densities observed since 1999. In New Jersey, high densities were noted on 7% of the survey dates. (Table 3 and Figure 3)

Dates with zero crabs (13 in Delaware and 15 in New Jersey) were in the mid range of previous years, some years having fewer and others greater (Table 3 and Figure 3). Delaware's most northern beach, Woodland Beach rendered zero counts during nine of the 10 dates surveyed (Table 1B). At the start of the season, zero crabs were observed on New Jersey's most southern beach, Higbees, and most northern accessible beach, Gandys (Table 1A).

Discussion

This year's peak count was 477,715 spawning individuals during the June 3rd count, two days after the new moon date. The 2011 peak estimate for New Jersey of 190,449 and Delaware's of 287,266 were comparable to last year's estimates (Table 2). A close peak count occurred on June 1st of 461,982 with New Jersey's estimate of 143,123 and Delaware's estimate of 318,859 (Table 1A and 1B).

This year's seasonal spawning estimate of 1,997,203 was comparable to the 2009 and 2007 estimates (Table 4). Delaware's estimate was the highest of all years since 1999 with the exception of the 2007 estimate of 1,450,837. Unfortunately, the estimate coupled with the record high sex ratio of 2011, translates into a modest increase in the number of females. Horseshoe crab activity tends to become male dominated as the spawning individuals increase. The lowest sex ratios were observed along the beaches with the lowest count of spawners, Woodland in Delaware and Higbees and North Cape May beaches in New Jersey.

Our most immediate concern for the survey is flooding along the Delaware Bay shore which is adversely affecting data collection and creating safety concerns. For the 2011 survey, the most northern beach in New Jersey, Sea Breeze was removed from the list of accessible beaches. In the early years of the survey, two sections of Sea Breeze comprised the count. Eventually, the southern section was inundated with water and the road along the Bay was too treacherous to reach the

area. The northern section was a 100 meter section that contained some “rip rap” but was able to be counted. This year, 2011, with the reclamation of the area by the State of New Jersey Department of Environmental Protection, it could no longer be justified for the dedicated volunteer to continue at Sea Breeze.

Gandys, Kimbles and South Cape Shore Lab areas are also experiencing flooding of the road and beach. Gandys beach was traditionally surveyed along its east-west expanse in front of the homes and another section at the most westerly point, land owned by the Nature Conservancy. Some years ago, the westerly section was underwater and only the portion in front of the houses was surveyed. Eventually the high tide water came right under the houses and the beach length surveyed was lessened to 100 meters at the entrance point, the small parking lot. This year Gandys beach has continued to be a problem and the suggestion has been made to survey the 100 meter section without the use of the quadrat.

Surveying at Kimbles beach proved to be difficult this year as well. Cancellations occurred on three of the scheduled counts due to road flooding. The beach itself is being inundated with water and the southern end during an extreme high tide has water flowing over the dune grass and into the marsh area. This beach is owned by United States Fish and Wildlife Service (USFWS) and perhaps next year, the staff will assist in the survey as they are more familiar with the area and the risks involved in counting and accessing the beach.

The beach at South Cape Shore Lab is the most productive spawning beach (highest seasonal estimate since 1999) along the Delaware Bay Shore in New Jersey. In the early years of the count, the expanse of beach length at South Cape Shore Lab was 800 meters, stretching from the north end bulkhead at the Rutgers Marine Laboratories to Green Creek at the south end. However, a new creek formed mid way along the transect made it impossible to reach the southern point of the beach count area. The beach expanse was then lessened to 400 meters to count a total of 100 quadrats. In addition to the cancellation of two counts, May 5th and June 15th, five of the counts (May 15th, 17th, 19th, June 3rd and 17th) resulted in less than 100 quadrats counted. High water and storm erosion occurred at the north end of the beach making counting almost undoable during high tide. In addition, the private road floods during the highest of tides. The dedicated couple who have surveyed this beach continuously since 1999 decided that the 2011 year would be their last due to a multitude of other commitments. For the future, the beach and access road may prove to be too difficult for a novice volunteer.

The two beaches in Delaware with the most cancellations were Fowlers and Bennetts Pier. Last season due to flooding issues, the beach length at Fowlers beach was halved from 1000 meters to 500 meters to accommodate a full count of 100 quadrats. During the 2011 survey, four counts (May 15th, 17th and June 13th, and 15th) were canceled due to flooding along the entrance road. The counts at Bennetts Pier were canceled on two dates (May 17th and 19th) and incomplete on one date (May 15th) due to road flooding and beach flooding. Also, Bennetts Pier is known as

a “party spot” and safety was a particular concern this year. Additionally, Primehook, Slaughter, South Bowers and Ted Harvey WMA beaches were canceled due to flooding during the full moon date of May 17th.

Adding to the cancellations, 21 of the counts (including five at South Cape Shore Lab and two at Bennetts Pier) were deemed incomplete due to flooding associated with high tide along the beach area. One count (May 15th) at Big Stone was incomplete due to weather (lightening). For the incomplete surveys, quadrats counted numbered 30, 30, 32, 34, 37, 43, 45, 46, 50, 50, 50, 51, 52, 64, 65, 73, 80, 87, 89, 92, 94, and 97. The dates of these were May 3rd (3), May 15th (4), May 17th (3), May 19th (1), June 1st (1), June 3rd (1), June 13th (3), June 15th (3) and June 17th (3).

Acknowledgements

As governing groups struggle with horseshoe crab management, the survey data base is increasingly more crucial and essential. Fortunately, we have been blessed with volunteers, without which these meaningful counts and facts would not be possible.

Table 1. 2011 Survey Results – Densities and Estimates
A. New Jersey Beaches
(*Indicates beaches surveyed every year)

Moon Phase Date	New-2 1-May	New 3-May	New+2 5-May	Full-2 15-May	Full 17-May	Full+2 19-May	New-2 30-May	New 1-Jun	New+2 3-Jun	Full-2 13-Jun	Full 15-Jun	Full+2 17-Jun	Totals
Higbees * (0.98 km)													
Density of HSC, Crabs/m	0	0	0	0	cancel	cancel	cancel	0.9	5.45	0.5	6.57	0.48	
Estimated Number of HSC	0	0	0	0	0	0	0	882	5,341	490	6,439	470	13,622
North Cape May * (3 km)													
Density of HSC, Crabs/m	0.01	0	0.01	0.02	0.02	0.38	0.18	2.56	6.06	0	1.53	0.1	
Estimated Number of HSC	30	0	30	60	60	1,140	540	7,680	18,180	0	4,590	300	32,610
Villas (2 km)													
Density of HSC, Crabs/m	0	0.21	0.01	0.11	0	0.1	2.24	6.63	11.99	0.06	3.86	2.92	
Estimated Number of HSC	0	420	20	220	0	200	4,480	13,260	23,980	120	7,720	5,840	56,260
Townbank (2.3 km)													
Density of HSC, Crabs/m	0.05	0	0.02	0	0.47	0.55	cancel	6.52	9.05	0.09	2.31	0.08	
Estimated Number of HSC	115	0	46	0	1,081	1,265	0	14,996	20,815	207	5,313	184	44,022
Norburys Landing (2.43 km)													
Density of HSC, Crabs/m	0.01	2.11	0	1.59	1.64	5.39	5.28	8.12	14.6	0.44	1.3	1.67	
Estimated Number of HSC	24	5,127	0	3,864	3,985	13,098	12,830	19,732	35,478	1,069	3,159	4,058	102,425
South CSL * (2.2 km)													
Density of HSC, Crabs/m	0.05	2.11	cancel	8.24	2.28	14.09	10.92	12.44	16.52	0.01	cancel	1.82	
Estimated Number of HSC	110	4,642	0	18,128	5,016	30,998	24,024	27,368	36,344	22	0	4,004	150,656
Highs * (0.8 km)													
Density of HSC, Crabs/m	0.58	5.34	0.21	2.34	1.27	7.31	4.56	5.04	3.71	0.22	0.26	0.33	
Estimated Number of HSC	464	4,272	168	1,872	1,016	5,848	3,648	4,032	2,968	176	208	264	24,936
Pierces Point (0.7 km)													
Density of HSC, Crabs/m	2.29	9.67	0.63	2.49	0.4	17.14	10.04	7.56	3.98	0.09	cancel	cancel	
Estimated Number of HSC	1,603	6,769	441	1,743	280	11,998	7,028	5,292	2,786	63	0	0	38,003
Kimbles (1 km)													
Density of HSC, Crabs/m	0.12	1.68	0.06	cancel	cancel	0.64	4.26	6.48	4.35	cancel	0	0.03	
Estimated Number of HSC	120	1,680	60	0	0	640	4,260	6,480	4,350	0	0	30	17,620
Reeds * (1.53 km)													
Density of HSC, Crabs/m	0.56	1.46	0.01	2.35	2.54	2.38	7	11.98	10.87	0.43	0.2	0.86	
Estimated Number of HSC	857	2,234	15	3,596	3,886	3,641	10,710	18,329	16,631	658	306	1,316	62,179
Fortescue (2.6 km)													
Density of HSC, Crabs/m	0.01	0.27	0.03	0.29	1.54	3.15	6.32	8.9	5.62	0.2	0.14	0.06	
Estimated Number of HSC	26	702	78	754	4,004	8,190	16,432	23,140	14,612	520	364	156	68,978
Gandys * (1.2 km)													
Density of HSC, Crabs/m	0	0	0	cancel	cancel	cancel	5.43	1.61	7.47	0.22	0.17	0.75	
Estimated Number of HSC	0	0	0	0	0	0	6,516	1,932	8,964	264	204	900	18,780
Totals	3,349	25,846	858	30,236	19,328	77,018	90,468	143,123	190,449	3,589	28,303	17,522	630,091

Table 1. 2011 Survey Results – Densities and Estimates
 B. Delaware Beaches
 (*Indicates beaches surveyed every year)

Date	Moon Phase												Totals
	New-2 1-May	New 3-May	New+2 5-May	Full-2 15-May	Full 17-May	Full+2 19-May	New-2 30-May	New 1-Jun	New+2 3-Jun	Full-2 13-Jun	Full 15-Jun	Full+2 17-Jun	
Cape Henlopen (1.5 km)													
Density of HSC, Crabs/m	0.02	0.05	cancel	0.95	4.06	6.34	4.78	7.75	3.62	0.46	2.72	1.92	
Estimated Number of HSC	30	75	0	1,425	6,090	9,510	7,170	11,625	5,430	690	4,080	2,880	49,005
Broadkill (1.5 km)													
Density of HSC, Crabs/m	0	0.03	0.12	0	0	0.54	2.71	8.74	14.42	0.09	2.75	1.07	
Estimated Number of HSC	0	45	180	0	0	810	4,065	13,110	21,630	135	4,125	1,605	45,705
Primehook * (2.0 km)													
Density of HSC, Crabs/m	0.22	1.73	1.42	4.55	cancel	5.73	4.35	12.42	12.68	0.81	5.59	1.15	
Estimated Number of HSC	440	3,460	2,840	9,100	0	11,460	8,700	24,840	25,360	1,620	11,180	2,300	101,300
Fowler * (3 km)													
Density of HSC, Crabs/m	cancel	1.02	0.02	cancel	cancel	1.48	cancel	0.18	0.15	cancel	cancel	0.05	
Estimated Number of HSC	0	3,060	60	0	0	4,440	0	540	450	0	0	150	8,700
Slaughter * (3 km)													
Density of HSC, Crabs/m	0.35	7.13	2.61	2.78	cancel	8.85	2.63	20.29	14.98	2.57	5.5	cancel	
Estimated Number of HSC	1,050	21,390	7,830	8,340	0	26,550	7,890	60,870	44,940	7,710	16,500	0	203,070
Big Stone * (5.0 km)													
Density of HSC, Crabs/m	1.15	0.79	2.44	1.75	0.06	16.84	11.23	16.7	14.21	0.55	1.89	4.26	
Estimated Number of HSC	5,750	3,950	12,200	8,750	300	84,200	56,150	83,500	71,050	2,750	9,450	21,300	359,350
Bennetts Pier (2.6 km)													
Density of HSC, Crabs/m	0.3	cancel	0.27	0.34	cancel	cancel	0.75	cancel	9	0.41	0.57	1.93	
Estimated Number of HSC	780	0	702	884	0	0	1,950	0	23,400	1,066	1,482	5,018	35,282
South Bowers (2.3 km)													
Density of HSC, Crabs/m	0.57	2.98	1.82	4.1	cancel	11.01	10.7	16.01	10.38	0.38	0.18	0.7	
Estimated Number of HSC	1,311	6,854	4,186	9,430	0	25,323	24,610	36,823	23,874	874	414	1,610	135,309
North Bowers * (1.3 km)													
Density of HSC, Crabs/m	0.93	1.47	2.72	3.91	0.03	8.04	6.98	12.77	8.64	0.04	0	0.29	
Estimated Number of HSC	1,209	1,911	3,536	5,083	39	10,452	9,074	16,601	11,232	52	0	377	59,566
Ted Harvey WMA (1.0 km)													
Density of HSC, Crabs/m	5.99	16.71	7.09	11.85	cancel	18.3	15.91	24.56	14.41	0.03	0.24	cancel	
Estimated Number of HSC	5,990	16,710	7,090	11,850	0	18,300	15,910	24,560	14,410	30	240	0	115,090
Kitts Hummock * (1.0 km)													
Density of HSC, Crabs/m	6	12.42	4.79	12.73	0.12	19.34	16.74	20.23	21.5	0.42	0.38	2.69	
Estimated Number of HSC	6,000	12,420	4,790	12,730	120	19,340	16,740	20,230	21,500	420	380	2,690	117,360
Pickering (1 km)													
Density of HSC, Crabs/m	5.14	18.56	3.12	11.6	0.03	28.43	18.37	26.16	23.99	0.26	0.25	1.34	
Estimated Number of HSC	5,140	18,560	3,120	11,600	30	28,430	18,370	26,160	23,990	260	250	1,340	137,250
Woodland * (0.5 km)													
Density of HSC, Crabs/m	0	0	0	0	0	0	0.25	0	0	0	cancel	cancel	
Estimated Number of HSC	0	0	0	0	0	0	125	0	0	0	0	0	125
Totals	27,700	88,435	46,534	79,192	6,579	238,815	170,754	318,859	287,266	15,607	48,101	39,270	1,367,112

Table 2. Comparison of Data on Horseshoe Crabs Spawning on Delaware Bay Shores
Years 1999- 2011

Horseshoe Crabs	3-Jun-11	29-May-10	24-May-09	3-Jun-08	1-Jun-07	27-May-06	8-Jun-05	21-May-04	14-Jun-03	28-May-02	5-Jun-01	18-May-00	30-May-99
	477,715	472,759	586,298	346,319	463,587	503,435	527,520	356,739	259,957	333,553	216,929	272,770	422,775
New Jersey Estimate	190,449	193,463	245,444	69,669	112,497	222,653	222,168	105,973	60,272	130,164	19,726	70,293	141,720
Delaware Estimate	287,266	279,296	340,854	276,650	351,090	280,782	305,352	250,766	199,685	203,389	197,203	202,477	281,055
Beaches in DE	13	13	13	13	13	13	13	13	13	13	13	11	9
Beaches in NJ	12	12	13	12	11	11	11	11	10	10	10	11	13
Main Beaches in DE	Big Stone	Big Stone	Big Stone	Big Stone	Big Stone	Big Stone	Big Stone	Big Stone	Big Stone	S. Bowers	Slaughter	Slaughter	Slaughter
	Slaughter	Slaughter	Slaughter	Slaughter	Slaughter	Slaughter	S. Bowers	Slaughter	Slaughter	Slaughter	Big Stone	Big Stone	Big Stone
	S. Bowers	S. Bowers	S. Bowers	Pickering	S. Bowers	S. Bowers	Bennets	Pickering	Pickering	Big Stone			
	Pickering	Pickering	Pickering			Pickering	Slaughter		Ted Harvey	Pickering			
							Pickering						
Main Beaches in NJ	South CSL	South CSL	South CSL	South CSL	South CSL	South CSL	South CSL	South CSL	South CSL	South CSL	South CSL	South CSL	Townbank
	Norburys	Norburys	Norburys	Norburys		Norburys	Norburys	Fortescue	Fortescue	Gandys			Norburys
	Fortescue	Gandys	Reeds			Fortescue	Villas	Norburys	Norburys	Sea Breeze			South CSL

Table 3. Percentages of Horseshoe Crab Densities 1999-2011

Survey Year	State	Percentage				Dates Missed
		Zero (0)	Low (<5)	Moderate (5-10)	High (>10)	
1999	New Jersey	4	65	10	6	15
	Delaware	8	43	6	11	31
2000	New Jersey	16	54	10	5	14
	Delaware	14	38	13	15	20
2001	New Jersey	10	63	5	5	17
	Delaware	13	46	11	6	19
2002	New Jersey	3	61	10	8	13
	Delaware	5	63	13	12	7
2003	New Jersey	17	60	7	3	13
	Delaware	18	50	8	10	13
2004	New Jersey	5	63	9	8	14
	Delaware	10	54	15	10	10
2005	New Jersey	14	48	6	10	21
	Delaware	14	51	11	8	16
2006	New Jersey	5	64	8	12	11
	Delaware	8	54	12	17	8
2007	New Jersey	16	58	1	10	15
	Delaware	10	43	15	18	15
2008	New Jersey	21	51	8	0	19
	Delaware	12	42	17	17	11
2009	New Jersey	4	50	8	14	24
	Delaware	10	51	13	15	12
2010	New Jersey	5	60	6	8	20
	Delaware	9	56	8	17	10
2011	New Jersey	10	58	15	7	10
	Delaware	8	49	10	21	12

Table 4. Seasonal Estimates of Horseshoe Crabs 1999-2011

Year	New Jersey	Delaware	Total
1999	447,128	830,405	1,277,533
2000	398,847	925,837	1,324,684
2001	343,351	871,375	1,214,726
2002	442,586	857,362	1,299,948
2003	352,800	853,721	1,206,521
2004	474,019	1,019,014	1,493,033
2005	557,956	749,473	1,307,429
2006	648,728	1,236,627	1,885,355
2007	496,535	1,450,837	1,947,372
2008	306,306	1,272,312	1,578,618
2009	811,724	1,237,476	2,049,200
2010	529,606	1,028,611	1,558,217
2011	630,091	1,367,112	1,997,203

Table 5. Seasonal Estimates of Male and Female Horseshoe Crabs 1999-2011

Year	Sex Ratio	Females	Males
1999	3.72	270,664	1,006,869
2000	3.67	283,658	1,041,026
2001	3.38	277,335	937,391
2002	3.48	290,167	1,009,781
2003	3.61	261,718	944,803
2004	3.85	307,842	1,185,191
2005	3.89	267,368	1,040,061
2006	4.53	340,932	1,544,423
2007	4.90	330,064	1,617,308
2008	4.90	267,562	1,311,056
2009	5.04	339,271	1,709,929
2010	4.25	296,803	1,261,414
2011	5.36	314,026	1,683,177

Figure 1. New Jersey and Delaware Spawning Estimates During 2011 Survey

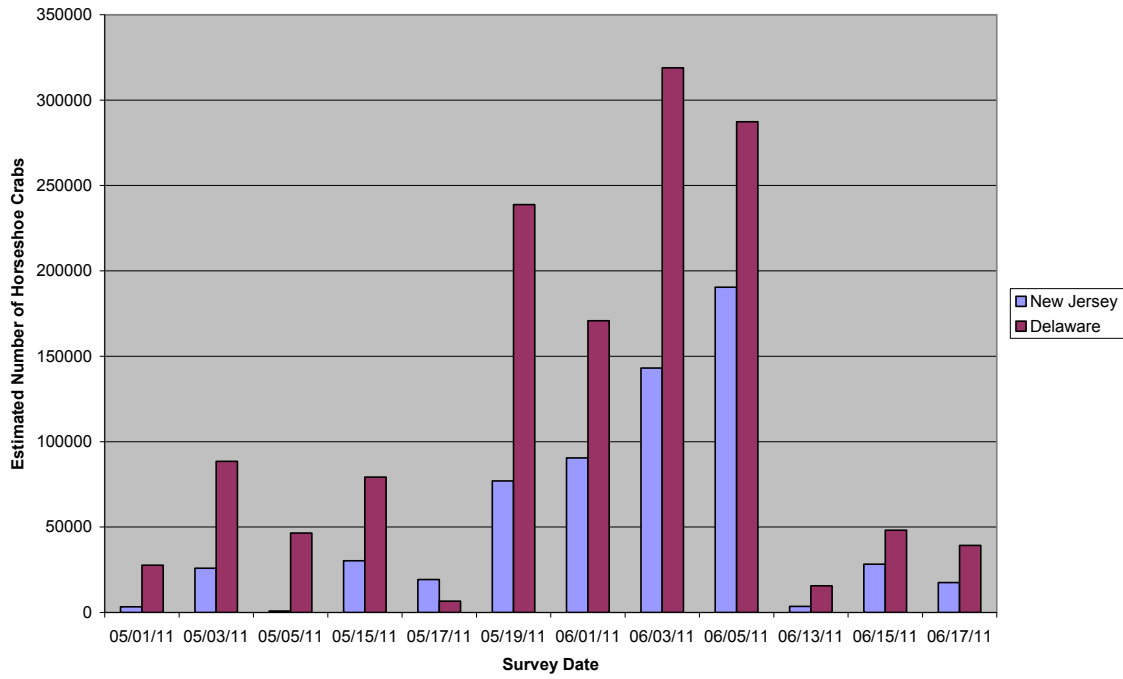


Figure 2. Peak Estimates of Spawning Horseshoe Crabs Years 1999-2011

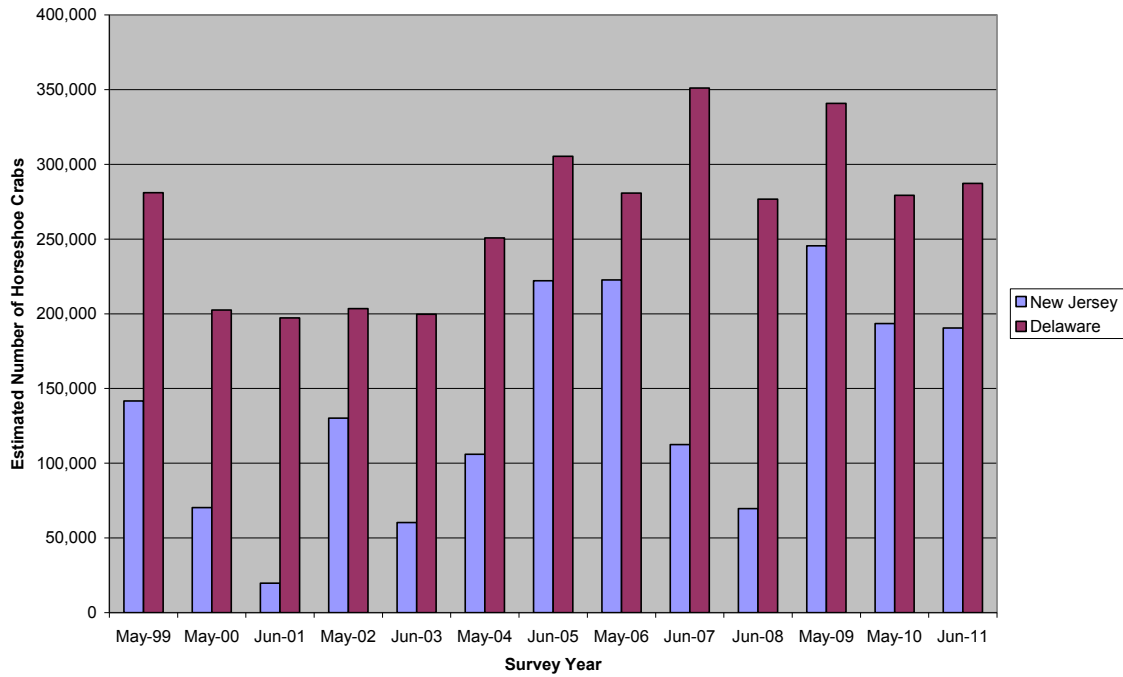


Figure 3. Percentages of Horseshoe Crab Densities 2000-2011

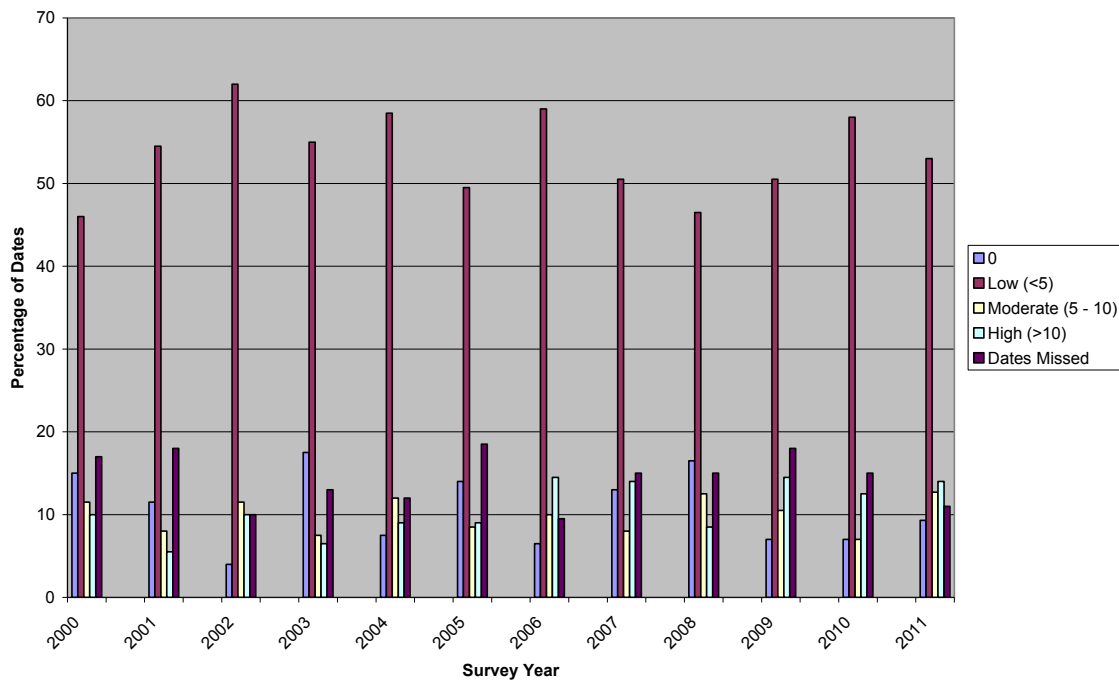


Figure 4. Seasonal Estimates of Horseshoe Crabs

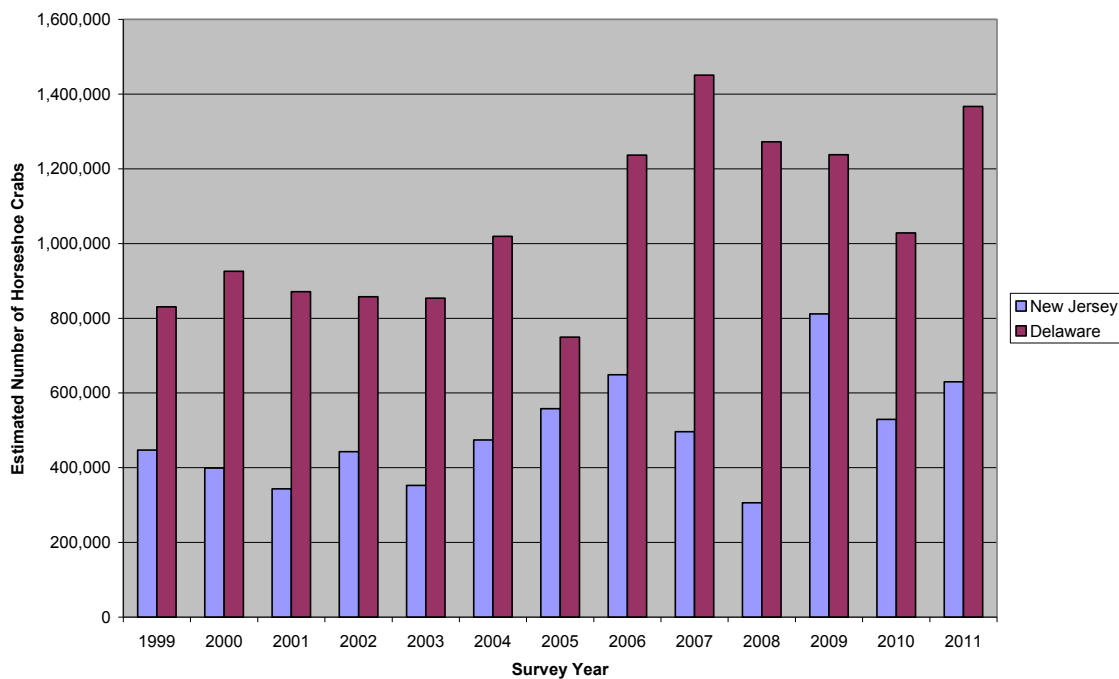


Figure 5. Seasonal Estimates of Male and Female Horseshoe Crabs

