The 2015 Delaware Bay Horseshoe Crab Spawning Survey

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Abstract

Spawning counts of horseshoe crabs were scheduled for 23 beaches in New Jersey and Delaware during moon phases in May and June. The schedule included 276 events of which 256 counts were completed with 20 dates cancelled due to no access/flooding (3), no beach (2), no surveyors (4), weather (10) and other (1). An additional 48 counts were scheduled on four restored/replenished beaches in New Jersey with three dates canceled due to no access/flooded (2) and weather (1).

The single day peak estimate of 380,936 horseshoe crabs was attained on May 16th, two days before the new moon. This estimate was greater than last year's peak estimate (322,672) and directly in the mid range of previous years' estimates lower than eight years and greater than eight years (Data set from 1999-2015). The peak single day estimate for the new beaches added to the survey in 2015 was 41,026 on May 16th.

The grand total of seasonal activity for the Delaware Bay was 1,815,426 of which 982,487 individuals were estimated for the New Jersey side and 832,939 for the Delaware side. Spawning activity for the Delaware shoreline was one of the lowest estimates encountered in the time series and greater than only four seasonal estimates, the 1999 estimate (830,405), the 2005 estimate (749,473), the 2012 estimate (622,619) and the 2014 estimate (814,120). New Jersey's estimate was the greatest estimate of all the time series with the exception of the 2009 estimate (811,724). The 2015 seasonal estimate for New Jersey doubled or in some cases tripled many of the other seasonal estimates. The seasonal number of horseshoe crabs for the new/restored beaches was estimated to be 154,568.

The average male to female sex ratio of 4.47 (5.05 for New Jersey and 3.83 for Delaware) was higher than last year (4.38) with more males counted in relation to females. The sex ratio of 2015 was higher than 11 of the previous years and was less than five years; 2006 (4.53), 2007 (4.90), 2008 (4.90), 2009 (5.04) and 2011 (5.36). The 2015 sex ratio combined with the high seasonal estimate translated into an estimate of 331,887 female spawners. A high sex ratio of 6.83 was calculated for the four additional New Jersey beaches.

Introduction

Since its inception in 1999, our survey has made tremendous strides and is 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 2015 along the shores of the Delaware Bay. Twenty-three beaches were represented in this year's count (11 along the state of Delaware's coast and 12 along the coast of New Jersey). In the past, Delaware's beaches totaled 13, however this year Broadkill Beach was not surveyed due to a Replenishment Project and Fowlers Beach was not surveyed because the entry road was damaged due to flooding. The 11 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, Primehook 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. The most northern beach in New Jersey, Sea Breeze, is no longer surveyed due to flooding and access problems.

The counts were taken simultaneously along the 23 beaches during the high tides encompassing the new and full moons on the dates of May 1st, 3rd, 5th, 16th, 18th, 20th, 31st and June 2nd, 4th, 14th, 16th, 18th. Times of high tides ranged from 7:57pm to 11:20pm with the high tide approaching the northern beaches later into the night. Counts begin with the onset of the changing tide from peak high to beginning ebb on one kilometer of preset beach. Where one contiguous kilometer of beach was not available, adjustments were made to randomly place 100 quadrats within the amount of contiguous beach available.

Last year, other groups with assistance from the Delaware Bay Survey initiated surveys of four additional beaches in New Jersey, north Pierces Point, Cooks, Moores and Thompsons. This year, surveying of the four beaches adhered strictly to the Delaware Bay Spawning Survey protocol covering all 12 dates. Resultant beaches and lengths were north Pierces Point with a survey length of 450 meters, Cooks Beach with a survey length of 350 meters, Moores Beach with a survey length of 1000 meters and Thompsons with a survey length of 900 meters.

Results

A total of 276 surveys were scheduled, the counts in Delaware totaled 132 and in New Jersey, 144. Counts from the additional four beaches numbered 48. A total of 324 counts were scheduled and 301 dates completed or 93% of actual surveying. The remaining counts were canceled due to no access/flooding (5), no beach (2), weather (11), volunteer unavailability (4) or reason not specified (1). Seven counts were incomplete: three in Delaware (20 quadrats at Bennetts and 28 quadrats at Ted Harvey WMA on June 14th and 75 quadrats at Primehook on June 2nd) and four in New Jersey (17 quadrats at Kimbles and 88 quadrats at Villas on

June 14th, and 97 quadrats at Kimbles and 44 quadrats at Thompsons on June 18th). The incomplete counts were calculated and utilized in the same way as the 100 quadrat counts.

In New Jersey including the four additional beaches, 13 dates were cancelled due to no access and flooding (2), weather (6), no surveyors (4) and other (1). The six weather cancellations were scattered throughout the season, May 16th (1), June 2nd (1), June 14th (3) and June 18th(1). Surveying at Gandys Beach was not a problem this year with no incomplete surveys performed and no cancellations due to flooding. (Table 1A)

Ten cancellations occurred in Delaware during the 2015 spawning season due to no access/flooding (3), no beach (2) and weather (5). The weather cancellations occurred on June 14th (4) and June 18th (1). (Table 1B)

This year's (2015) peak estimate of spawners along Delaware and New Jersey's shores of 380,936 was directly in the mid range of the time series (eight estimates lower and eight estimates greater)(Data set from 1999-2015) (Table 2). The majority of spawning activity in New Jersey (77%) and Delaware (80%) occurred during five counts in May; May 5th, May 16th, May 18th, May 20th and May 31st. The highest densities of the season occurred during the five May dates as well. On May 16th, the greatest densities of the 2015 year were 20.79 and 26.33 crabs per meter achieved at Pierces Point, New Jersey and Pickering Beach, Delaware, respectively. Horseshoe crabs were not observed on the most northern beach in Delaware, Woodland beach in 2015. (Table 1A and 1B and Figure 1)

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 analyzed in percentages since the number of dates and/or beaches may change yearly. As in previous years, the majority of the dates surveyed (56% in DE and 55% in NJ) revealed densities lower than five horseshoe crabs per meter. Dates with high densities were numerous in 2015, with 13% in Delaware and 19% in New Jersey. Dates with zero crabs were similar to other years (14% in Delaware and 10% in New Jersey). Few dates (7% in New Jersey and 7% in Delaware) were missed, thus yielding the lowest percentage in the years 1999-2015 for missed dates. (Table 3 and Figure 3 and 3A). In Delaware, eleven of the 18 zero dates were observed at Woodland beach, the most northern beach. In New Jersey, ten of the 14 zero dates occurred during the initial day of the 2015 survey. (Table 1A and 1B)

The seasonal activity for the New Jersey side of the Bay (982,487) was the greatest estimate encountered from the years 1999 to 2015. It doubled or in some cases tripled many of the other years' estimates with the exception of the 2009 estimate (811,724). Delaware's seasonal estimate (832,939) was one of the lowest;

slightly greater than 1999 (830,405) and 2014 (814,120) and greater than 2005 (749, 743) and 2012 (622,619). (Table 4 and Figure 4)

The shortfall in Delaware's seasonal estimate was not likely due to the temporary removal of Fowlers and Broadkill beaches. The 2014 seasonal estimates for Broadkill was 45,105 and for Fowlers, 15, 270. These estimates contributed 7% to the 2014 overall seasonal estimate for Delaware of 814,120. During the survey years of 1999-2015, the top spawning beaches in Delaware were Slaughter, South Bowers and Big Stone (due to its beach expanse) and the beaches in New Jersey have been Norburys Landing, South Cape Shore Lab and Fortescue (Table 2 and Figure 2).

The results from the four additional beaches concur with the results of the 23 New Jersey beaches with the exception of the sex ratio. The estimated numbers for the four beaches were calculated using the 2015 measured beach length. The peak spawning date was May 16th and the seasonal estimate totaled 154, 568 horseshoe crabs for these beaches. The majority of the spawning (75%) occurred during May 16th, May 18th, May 20th and May 31st. The greatest density was at North Pierces Point on May 16th of 18.31 crabs per meter. The percentage of dates with zero crabs was 4%, the percentage with low activity was 52%, the percentage with moderate activity was 15%, the percentage with high activity was 23% and the percentage of dates missed was 6%. Since the four additional beaches are in the mid range of the Delaware Bay, it would be expected that dates with zero crabs to be fewer and dates with moderate to high activity to be greater than the other New Jersey beaches. (Table 1 C and Figure 1C)

The average male to female sex ratio for both shores of 4.47 combined with the seasonal estimate translated to 331,887 females spawning. The number of female spawners was higher than 13 of the preceding years and similar to the 2006 estimate (340,932) and the 2009 estimate (339,271). The 2013 estimate was greatest of all the years 1999-2015 with 375,304 females spawning. (Table 5 and Figure 5)

The sex ratios during the 1999-2005 were in the range of 3.38 to 3.89 males per female. With the exception of the 2013 ratio (3.74), the following years, 2006-2014 were in a wider range of 4.25 to 5.36. The 2015 average sex ratio of 4.47 falls into this range. The average sex ratio for Delaware was 3.83 and for New Jersey, 5.05. (Table 6)

The average sex ratio for the four additional New Jersey beaches was 6.83, considerably higher than the average sex ratio of 4.47 for the 23 beaches. This sex ratio was influenced by the high sex ratios on six occasions at Thompsons Beach, May 16th (12.30), May 18th (9.62), May 31st (12.83), June 16th (9.17) and at Moores, May 5th (10.12) and June 18th (10.00).

The sex ratio is highly variable among years, among beaches and within beaches, and the 2015 ratios certainly exhibit the wide range. Average, high and low sex ratios per beach illustrate the wide range in sex ratios (Table 6 and Figure 6). Sex ratios (males per female) were also categorized according to number and percentage of occurrence for the 12 New Jersey beaches, the 11 Delaware beaches and the four new/restored New Jersey beaches. The categories were less than 1 (more females were observed than males), 1 to less than 3 (1-3 males per female), 3 to less than 5 (3-5 males per female), 5 to less than 7 (5-7 males per female) and greater than 7 (7 males or greater per female) (Table 7 and Figure 7 and 7C).

Observations of tagged horseshoe crabs during the survey counts numbered 235. The sharp increase was the result of extensive tagging efforts in 2015. The majority of the tagged animals were alive (four recorded dead) and encountered outside the quadrats (74%). Most of the tagged animals were observed on New Jersey beaches where the majority of the crabs were initially tagged: Fortescue, Kimbles, Reeds, Cooks and Moores. (On the back of the Tally Sheets, tag information is recorded: the tag number, the type of tag, if the tagged horseshoe crab was observed in the quadrat or outside and if the crab was dead or alive.) (Table 8)

Discussion

Compared with other years in the Data Set (1999-2014), the 2015 survey results were atypical with exceptional spawning activity in New Jersey and low activity in Delaware. More spawners were estimated along the New Jersey shores in 2015. This occurrence has only happened twice, the first being in the 2012 year with 668,950 spawners in New Jersey and 622,619 in Delaware. Also, the seasonal estimate for New Jersey (982,487) was the greatest seasonal estimate encountered in New Jersey, far exceeding every year's estimate with the exception of the 2009 estimate (811,724). Cancellations were few which aided in building up the numbers. Although weather didn't cancel many counts, it did adversely affect the June 2nd and 4th counts on the Delaware side resulting in low numbers.

Of considerable interest is the range of sex ratios. The sex ratio is extremely variable and is influenced by many factors. The survey protocol must be followed to assure that accurate data is collected. First, counting must start immediately following the high tide. Unpublished data illustrate that the number of males surrounding a female, rises and falls, but is greatest at the height of the tide. It is extremely important that counting is performed at the same time relative to high tide. Secondly, females can be partially to entirely buried in the sediment and can be difficult to observe. It is highly recommended that physical verification (feeling the sediment with one's hand) is employed. One plausible explanation for the higher than usual average sex ratio on the replenished beaches is that it was easier for the females to bury in the newly placed, loosely packed sand and become completely buried, thus not be visible to the surveyor.

It seems the more data gathered, more questions are raised. It is important to remember that the survey is exposing trends in the spawning population, not absolutes. Besides establishing trends, the survey contributes to our knowledge of the spawning behavior and habitat of the horseshoe crabs.

Acknowledgements
Thank you to all the people involved in the Survey and a welcome to the newcomers.

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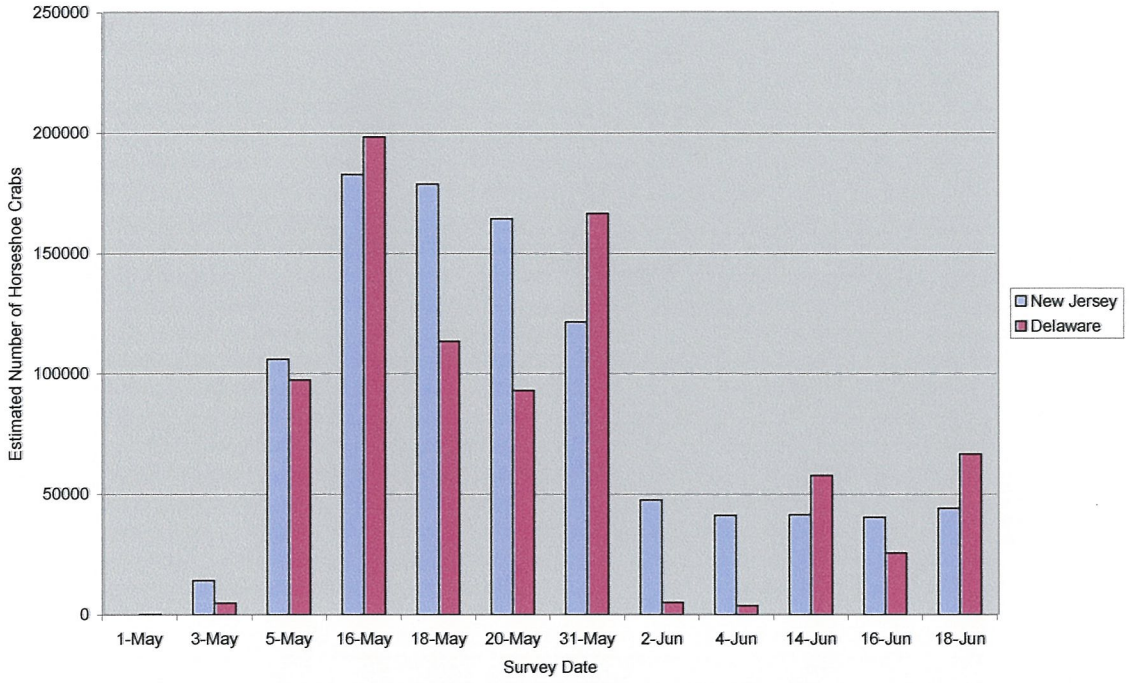

Figure 1C. New Jersey Spawning Estimates During 2015 Survey
New and Restored Beaches

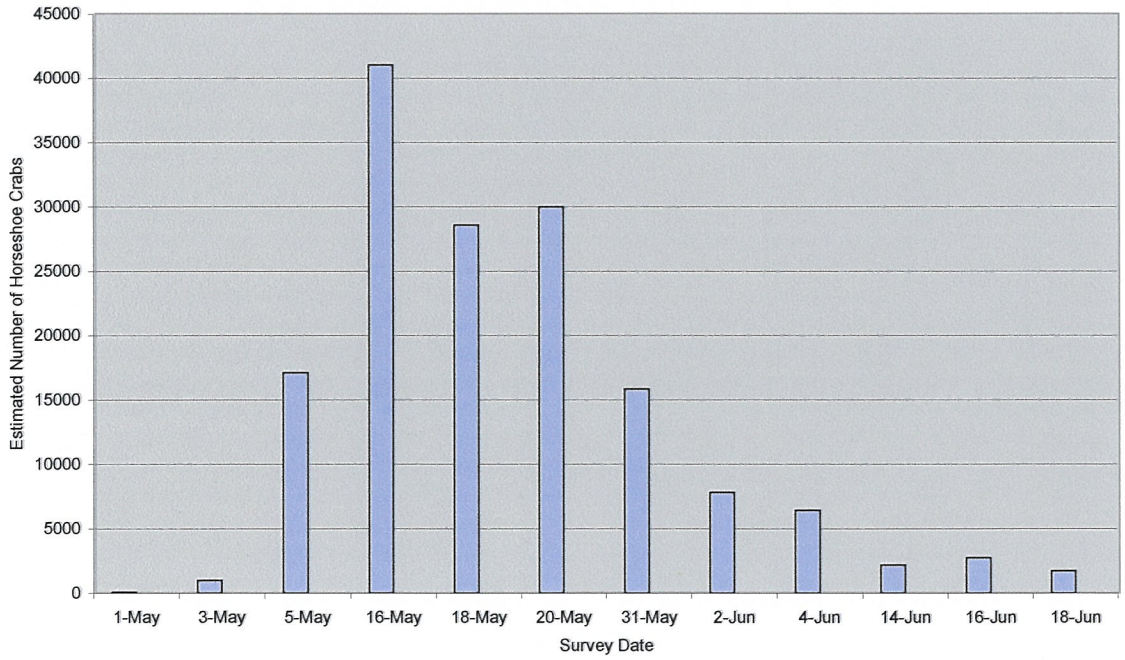

Figure 2. Peak Estimates of Spawning Horseshoe Crabs Years 1999-2015

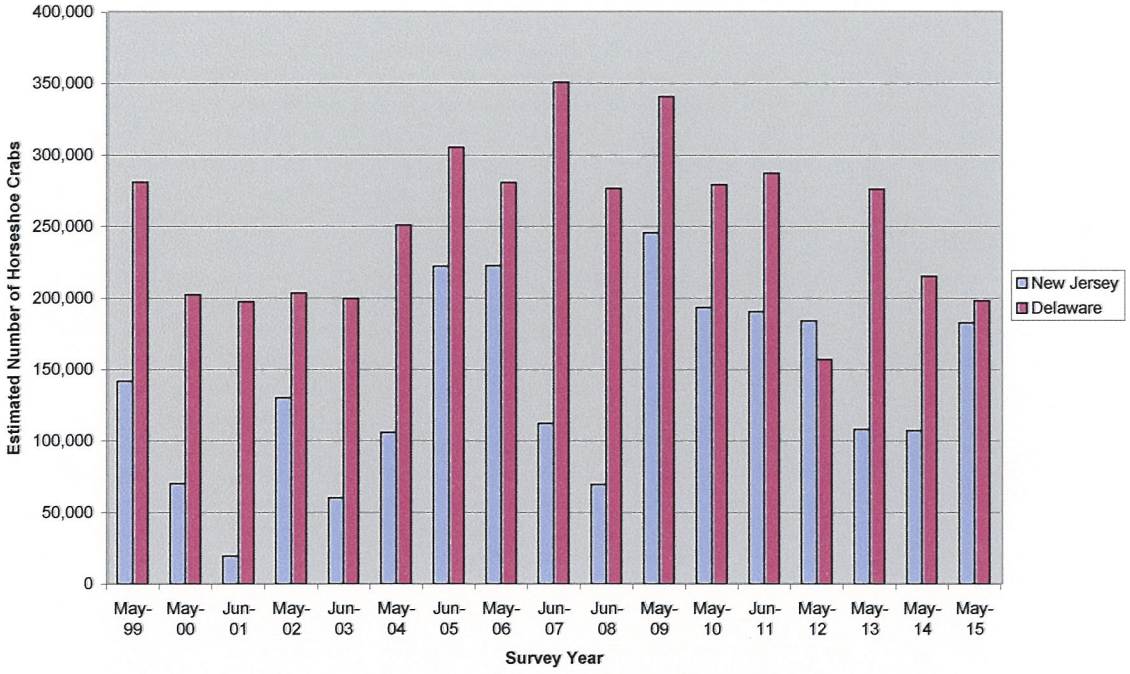

Figure 3. Percentages of Horseshoe Crab Densities by Year 1999-2015

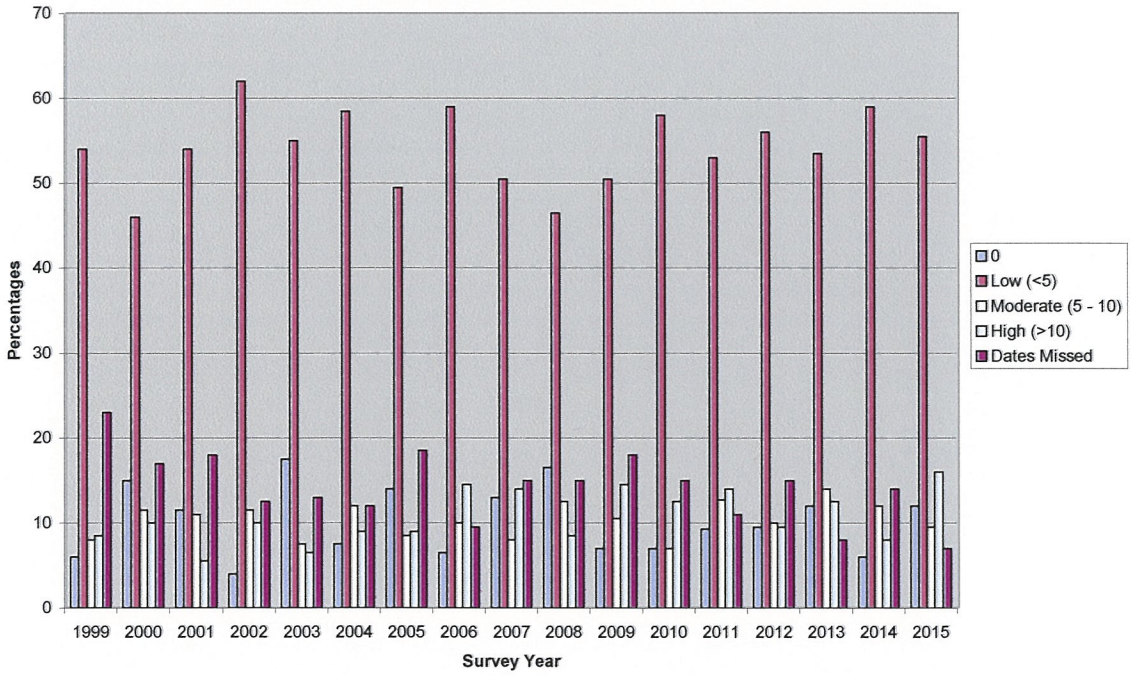

Figure 3A. Percentages of Horseshoe Crab Densities By Category 1999-2015

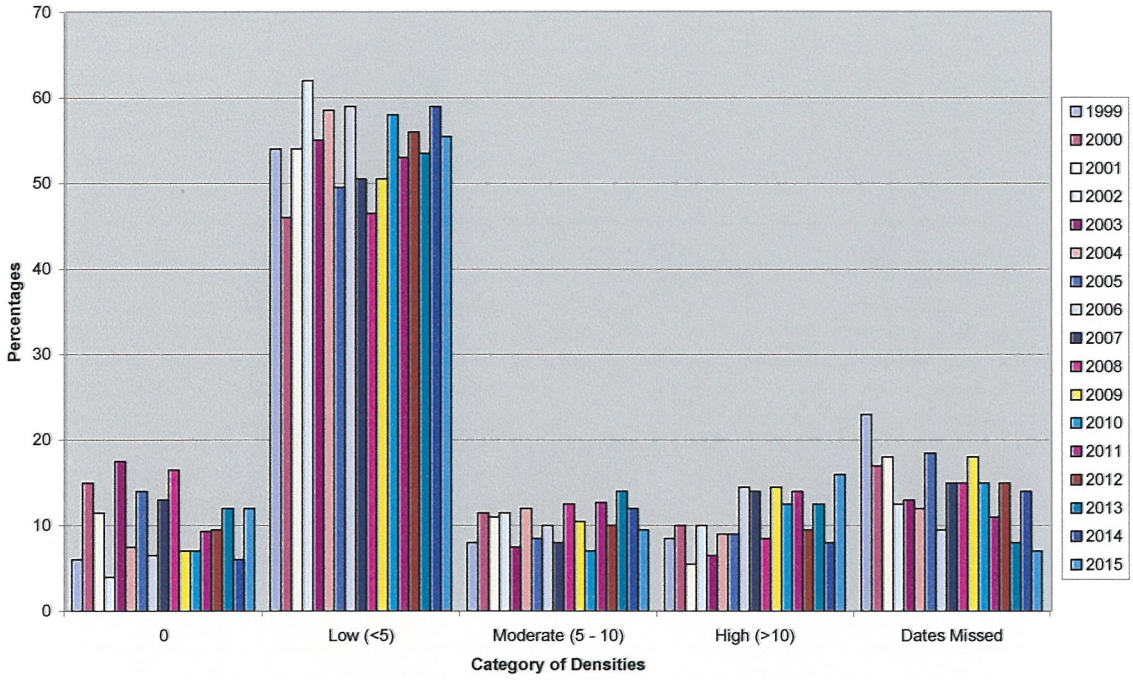

Figure 4. Seasonal Estimates of Horseshoe Crabs 1999-2015

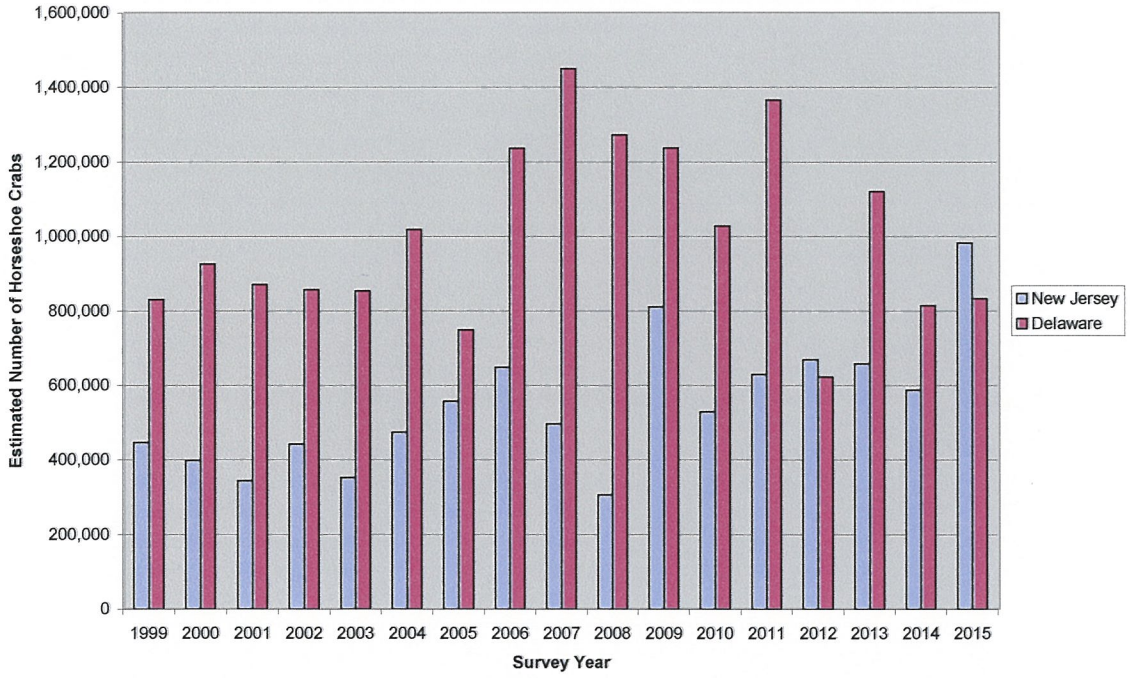

Figure 5. Seasonal Estimates of Male and Female Horseshoe Crabs 1999-2015

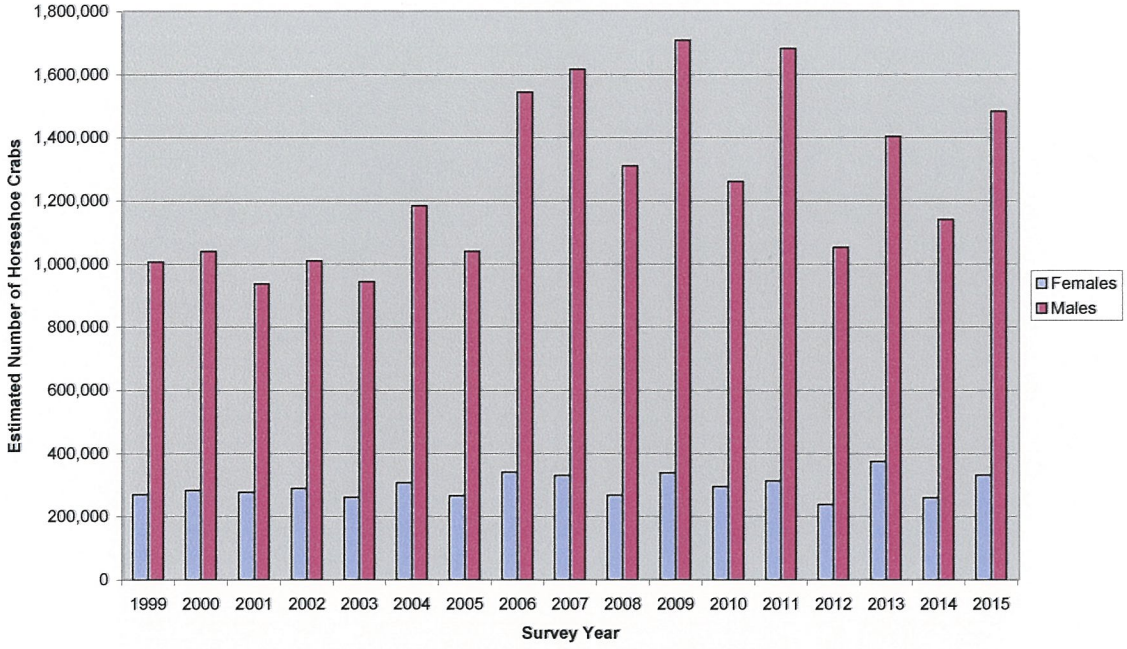

Figure 6. Average Sex Ratios by Beach 2015

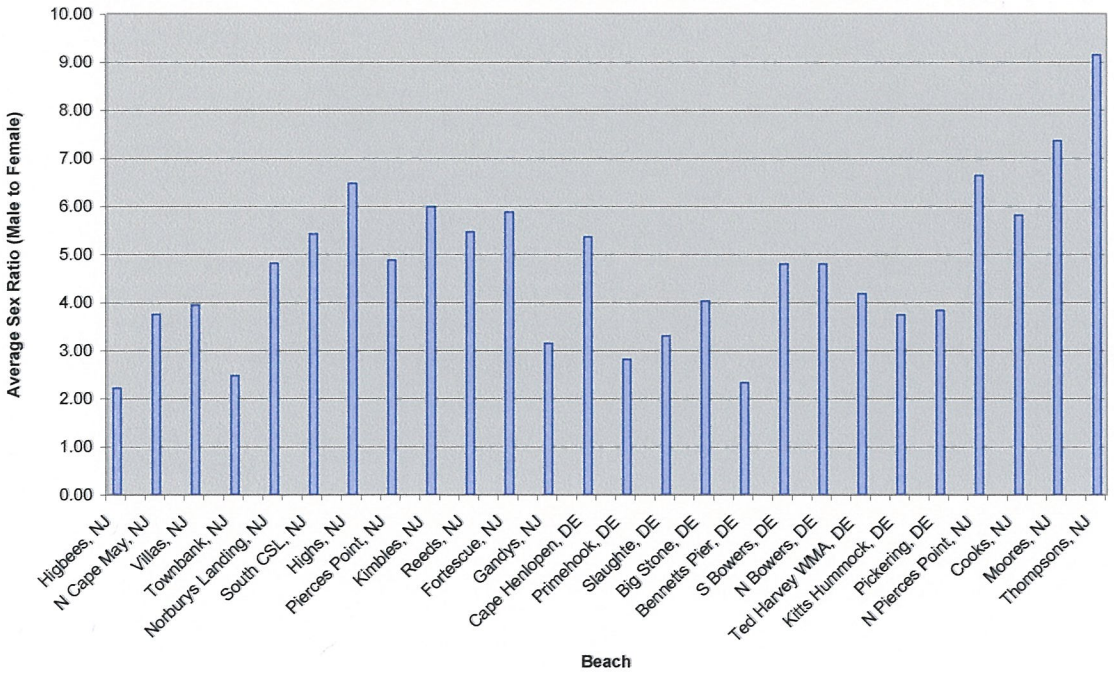

Figure 7. New Jersey and Delaware Sex Ratios vs.Number of Horseshoe Crabs 2015

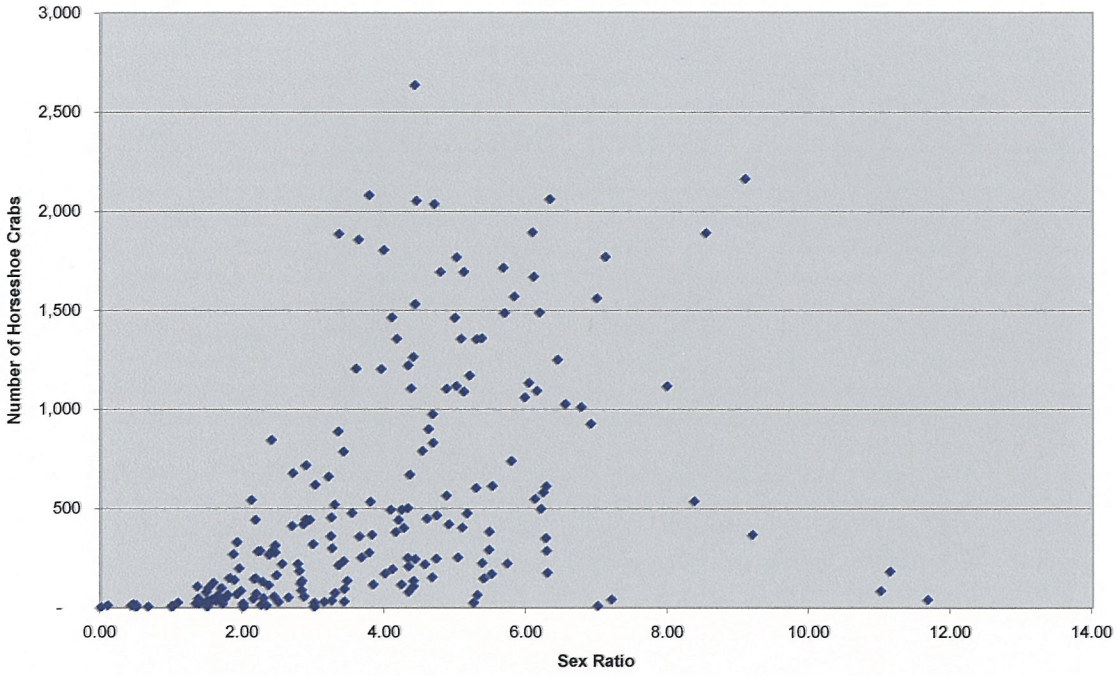

Figure 7C. New/Restored New Jersey Sex Ratios vs. Number of Horseshoe Crabs 2015

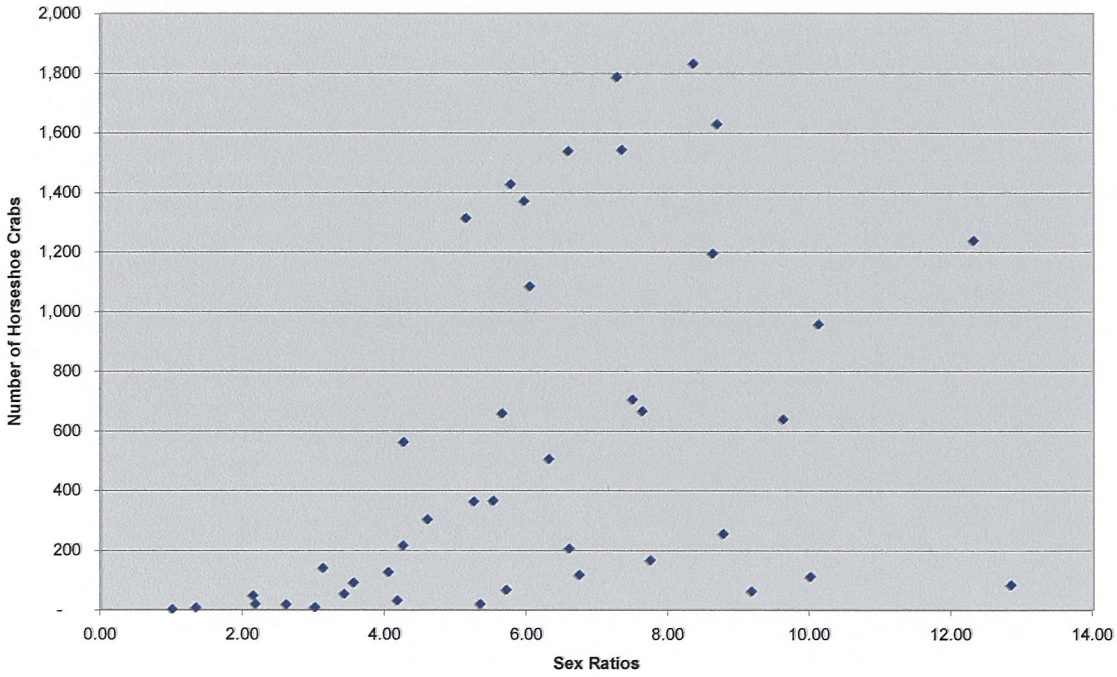

Table 1. 2015 Survey Results- Densities and Estimates
A. New Jersey Beaches (*Indicates beaches surveyed every year)

Moon Phase	Full-2	Full	Full+2	New-2	New	New+2	Full-2	Full	Full+2	New-2	New	New+2	
Date	**1-May**	**3-May**	**5-May**	**16-May**	**18-May**	**20-May**	**31-May**	**2-Jun**	**4-Jun**	**14-Jun**	**16-Jun**	**18-Jun**	**Totals**
Higbees * (0.98 km)													
Density of HSC, Crabs/m	0.00	0.00	0.00	0.01	0.04	0.08	0.10	0.04	cancel	0.83	1.34	cancel	
Estimated Number of HSC	0	0	0	10	39	78	98	39	surveyors	813	1,313	surveyors	2,391
North Cape May * (3 km)													
Density of HSC, Crabs/m	0.00	0.00	cancel	0.03	0.21	0.34	0.28	cancel	0.41	2.50	2.52	4.64	
Estimated Number of HSC	0	0	surveyors	90	630	1,020	840	weather	1,230	7,500	7,560	13,920	32,790
Villas (2 km)													
Density of HSC, Crabs/m	0.01	0.04	4.97	2.08	1.63	2.76	4.41	2.19	1.11	5.59	6.69	5.48	
Estimated Number of HSC	20	80	9,940	4,160	3,260	5,520	8,820	4,380	2,220	11,180	13,380	10,960	73,920
Townbank (2.3 km)													
Density of HSC, Crabs/m	0.00	0.03	0.08	0.25	1.45	1.06	0.18	cancel	0.29	4.76	4.10	1.97	
Estimated Number of HSC	0	69	184	575	3,335	2,438	414	surveyors	667	10,948	9,430	4,531	32,591
Norburys Landing (2.43 km)													
Density of HSC, Crabs/m	0.00	0.24	10.10	20.59	12.20	13.54	12.02	3.66	3.57	2.53	1.16	cancel	
Estimated Number of HSC	0	583	24,543	50,034	29,646	32,902	29,209	8,894	8,675	6,148	2,819	weather	193,452
South CSL * (2.2 km)													
Density of HSC, Crabs/m	0.00	0.73	5.79	18.91	14.84	4.74	14.60	3.82	6.03	1.22	0.46	1.47	
Estimated Number of HSC	0	1,606	12,738	41,602	32,648	10,428	32,120	8,404	13,266	2,684	1,012	3,234	159,742
Highs * (0.8 km)													
Density of HSC, Crabs/m	0.00	2.91	18.87	13.52	21.59	4.93	10.93	0.88	1.46	1.15	0.25	0.25	
Estimated Number of HSC	0	2,328	15,096	10,816	17,272	3,944	8,744	704	1,168	920	200	200	61,392
Pierces Point (0.7 km)													
Density of HSC, Crabs/m	0.00	6.12	16.93	20.79	16.93	17.13	11.70	10.26	5.63	0.80	4.41	5.00	
Estimated Number of HSC	0	4,284	11,851	14,553	11,851	11,991	8,190	7,182	3,941	560	3,087	3,500	80,990
Kimbles (1 km)													
Density of HSC, Crabs/m	0.00	1.35	11.14	17.66	17.68	15.69	9.75	1.75	1.82	0.59	0.04	0.39	
Estimated Number of HSC	0	1,350	11,140	17,660	17,680	15,690	9,750	1,750	1,820	590	40	390	77,860
Reeds * (1.53 km)													
Density of HSC, Crabs/m	0.00	2.44	4.02	8.98	12.49	16.68	9.25	5.32	1.94	0.08	0.64	0.84	
Estimated Number of HSC	0	3,733	6,151	13,739	19,110	25,520	14,153	8,140	2,968	122	979	1,285	95,900
Fortescue (2.6 km)													
Density of HSC, Crabs/m	0.01	0.03	4.47	11.32	13.56	15.58	3.49	2.22	1.08	cancel	0.28	0.41	
Estimated Number of HSC	26	78	11,622	29,432	35,256	40,508	9,074	5,772	2,808	weather	728	1,066	136,370
Gandys * (1.2 km)													
Density of HSC, Crabs/m	0.00	0.03	2.32	cancel	6.71	11.91	0.00	1.98	2.09	cancel	cancel	4.20	
Estimated Number of HSC	0	36	2,784	weather	8,052	14,292	0	2,376	2,508	weather	other	5,040	35,088
Totals	46	14,147	106,049	182,671	178,779	164,332	121,411	47,641	41,271	41,466	40,548	44,126	982,487

Table 1. 2015 Survey Results - Densities and Estimates
B. Delaware Beaches (*Indicates Beaches Surveyed Every Year)

Moon Phase	Full-2	Full	Full+2	New-2	New	New+2	Full-2	Full	Full+2	New-2	New	New+2	
Date	**1-May**	**3-May**	**5-May**	**16-May**	**18-May**	**20-May**	**31-May**	**2-Jun**	**4-Jun**	**14-Jun**	**16-Jun**	**18-Jun**	**Totals**
Cape Henlopen (1.5 km)													
Density of HSC, Crabs/m	0.01	0.06	0.10	0.29	2.46	2.98	0.93	0.54	2.17	3.67	2.23	5.34	
Estimated Number of HSC	15	90	150	435	3,690	4,470	1,395	810	3,255	5,505	3,345	8,010	31,170
Primehook * (2.0 km)													
Density of HSC, Crabs/m	0.02	0.31	2.83	11.05	8.44	3.29	7.15	1.03	cancel	4.54	2.20	2.69	
Estimated Number of HSC	40	620	5,660	22,100	16,880	6,580	14,300	2,060	flooded	9,080	4,400	5,380	87,100
Slaughter * (3 km)													
Density of HSC, Crabs/m	0.03	0.44	13.54	3.81	2.85	2.34	6.60	0.61	cancel	6.78	1.34	5.42	
Estimated Number of HSC	90	1,320	40,620	11,430	8,550	7,020	19,800	1,830	no beach	20,340	4,020	16,260	131,280
Big Stone * (5.0 km)													
Density of HSC, Crabs/m	0.01	0.04	0.19	10.88	11.03	1.49	8.86	cancel	0.00	1.69	0.70	3.60	
Estimated Number of HSC	50	200	950	54,400	55,150	7,450	44,300	no access	0	8,450	3,500	18,000	192,450
Bennetts Pier (2.6 km)													
Density of HSC, Crabs/m	0.00	0.00	0.05	0.27	0.35	0.13	2.82	0.05	0.00	4.85	2.66	2.13	
Estimated Number of HSC	0	0	130	702	910	338	7,332	130	0	12,610	6,916	5,538	34,606
South Bowers (2.3 km)													
Density of HSC, Crabs/m	0.00	0.63	6.11	14.87	6.18	3.14	10.60	cancel	0.16	cancel	0.45	cancel	
Estimated Number of HSC	0	1,449	14,053	34,201	14,214	7,222	24,380	no access	368	weather	1,035	weather	96,922
North Bowers * (1.3 km)													
Density of HSC, Crabs/m	0.00	0.34	2.84	7.39	4.00	4.19	7.90	0.09	0.13	0.08	0.21	1.70	
Estimated Number of HSC	0	442	3,692	9,607	5,200	5,447	10,270	117	169	104	273	2,210	37,531
Ted Harvey WMA (1.0 km)													
Density of HSC, Crabs/m	0.02	0.51	11.16	20.51	4.41	20.33	14.63	0.11	cancel	cancel	0.67	1.96	
Estimated Number of HSC	20	510	11,160	20,510	4,410	20,330	14,630	110	no beach	weather	670	1,960	74,310
Kitts Hummock * (1.0 km)													
Density of HSC, Crabs/m	0.01	0.19	12.63	18.55	1.24	15.30	12.04	0.06	0.12	1.86	0.44	5.19	
Estimated Number of HSC	10	190	12,630	18,550	1,240	15,300	12,040	60	120	1,860	440	5,190	67,630
Pickering (1 km)													
Density of HSC, Crabs/m	0.00	0.02	8.29	26.33	3.19	18.84	18.03	0.05	0.01	cancel	0.98	4.20	
Estimated Number of HSC	0	20	8,290	26,330	3,190	18,840	18,030	50	10	weather	980	4,200	79,940
Woodland * (0.5 km)													
Density of HSC, Crabs/m	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	cancel	0.00	0.00	
Estimated Number of HSC	0	0	0	0	0	0	0	0	0	weather	0	0	0
Totals	225	4,841	97,335	198,265	113,434	92,997	166,477	5,167	3,922	57,949	25,579	66,748	832,939

Table 1. 2015 Survey Results- Densities and Estimates
C. New and Restored New Jersey Beaches

Moon Phase	**Full-2**	**Full**	**Full+2**	**New-2**	**New**	**New+2**	**Full-2**	**Full**	**Full+2**	**New-2**	**New**	**New+2**	
Date	**1-May**	**3-May**	**5-May**	**16-May**	**18-May**	**20-May**	**31-May**	**2-Jun**	**4-Jun**	**14-Jun**	**16-Jun**	**18-Jun**	**Totals**
North Pierces Point (0.45 km)													
Density of HSC, Crabs/m	0	0.31	6.58	18.31	cancel	15.42	10.83	cancel	1.4	2.15	0.19	0.53	
Estimated Number of HSC	0	140	2,961	8,240	0	6,939	4,874	0	630	968	86	239	25,074
Cooks (0.35 km)													
Density of HSC, Crabs/m	0	0.91	6.64	15.38	14.27	13.7	13.13	3.65	3.02	0.18	0.19	0.67	
Estimated Number of HSC	0	319	2,324	5,383	4,995	4,795	4,596	1,278	1,057	63	67	235	25,109
Moores (1 km)													
Density of HSC, Crabs/m	0.05	0.47	9.56	16.27	17.86	11.93	5.62	5.04	3.62	1.16	2.05	1.1	
Estimated Number of HSC	50	470	9,560	16,270	17,860	11,930	5,620	5,040	3,620	1,160	2,050	1,100	74,730
Thompsons (0.9 km)													
Density of HSC, Crabs/m	0.02	0.07	2.54	12.37	6.37	7.04	0.83	1.66	1.26	cancel	0.61	0.18	
Estimated Number of HSC	18	63	2,286	11,133	5,733	6,336	747	1,494	1,134	0	549	162	29,655
Totals	68	991	17,131	41,026	28,588	30,000	15,836	7,812	6,441	2,191	2,751	1,735	154,568

Table 2. Comparison of Data on Horseshoe Crabs Spawning on Delaware Bay Shores
Years 1999-2015

)ay	May 16	May 26	May 23	May 22	Jun 03	May 29	May 24	Jun 03	Jun 01	May 27	Jun 08	May 21	Jun 14	May 28	Jun 05	May 18	May 30
'ear	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999
HSC	380,936	322,672	384,548	341,062	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
NJ :stimate	182,671	107,278	108,194	184,046	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
)E :stimate	198,265	215,394	276,354	157,016	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 n DE	11	13	13	13	13	13	13	13	13	13	13	13	13	13	13	11	9
Beaches n NJ	12	12	12	12	12	12	13	12	11	11	11	11	10	10	10	11	13
Beaches n DE	Big Stone	Kitts Hummock	Slaughter	Pickering	Big Stone	Big Stone	Big Stone	Big Stone	Big Stone	Big Stone	Big Stone	Big Stone	Big Stone	S. Bowers	Slaughter	Slaughter	Slaughter
	Slaughte	Pickering	Pickering	Ted Harvey	Slaughter	Slaughter	Slaughter	Slaughter	Slaughter	Slaughter	S. Bowers	Slaughter	Slaughter	Slaughter	Big Stone	Big Stone	Big Stone
	South Bowers	Big Stone	Big Stone	S. Bowers	S. Bowers	S. Bowers	S. Bowers	Pickering	S. Bowers	S. Bowers	Bennets	Pickering	Pickering	Big Stone			
				Big Stone	Pickering	Pickering	Pickering			Pickering	Slaughter		Ted Harvey	Pickering			
											Pickering						
Beaches n NJ	Norburys	Norburys	Fortescue	Fortescue	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
	South CSL	Reeds	Norburys	South CSL	Norburys	Norburys	Norburys	Norburys		Norburys	Norburys	Fortescue	Fortescue	Gandys			Norburys
	Fortescue	Fortescue		Gandys	Fortescue	Gandys	Reeds			Fortescue	Villas	Norburys	Norburys	Sea Breeze			South CSL

Table 3. Percentages of Horseshoe Crab Densities 1999-2015

				Percentage		
Survey Year	State	0	Low (<5)	Moderate (5-10)	High (>10)	Dates Missed
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
2012	New Jersey	6	56	16	8	14
	Delaware	13	56	4	11	16
2013	New Jersey	11	56	15	8	10
	Delaware	13	51	13	17	6
2014	New Jersey	5	64	13	6	13
	Delaware	8	55	12	10	16
2015	New Jersey	10	55	9	19	7
	Delaware	14	56	10	13	7

Table 4. Seasonal Estimates of Horseshoe Crabs 1999-2015

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
2012	668,950	622,619	1,291,569
2013	658,675	1,120,264	1,778,939
2014	587,460	814,120	1,401,580
2015	982,487	832,939	1,815,426

Table 5. Seasonal Estimates of Male and Female Horseshoe Crabs 1999-2015

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
2012	4.41	238,737	1,052,832
2013	3.74	375,304	1,403,635
2014	4.38	260,517	1,141,063
2015	4.47	331,887	1,483,539

Table 6. Sex Ratios by Beach 2015

Beach	Average	Lowest	Date	Highest	Date
Higbees, NJ	2.21	0.43	May 31	3.00	May 18, June 02
N Cape May, NJ	3.75	1.55	May 31	4.73	June 18
Villas, NJ	3.94	2.36	June 04	6.20	May 05
Townbank, NJ	2.47	0.50	May 03	3.53	June 14
Norburys Landing, NJ	4.81	3.00	May 03	6.77	May 05
South CSL, NJ	5.42	2.29	June 16	6.24	May 05
Highs, NJ	6.47	1.50	June 16	9.09	May 18
Pierces Point, NJ	4.87	3.78	May 16	6.54	June 02
Kimbles, NJ	5.98	2.33	June 14	11.13	June 04
Reeds, NJ	5.46	1.78	June 16	11.67	June 18
Fortescue, NJ	5.87	2.00	May 03	7.20	June 18
Gandys, NJ	3.14	1.00	May 03	4.67	May 05
Cape Henlopen, DE	5.35	2.00	May 03	9.19	June 14
Primehook, DE	2.81	1.48	June 02	4.36	May 16
Slaughter, DE	3.29	1.65	June 02	5.07	May 05
Big Stone, DE	4.02	1.00	May 03	5.50	June 14
Bennetts Pier, DE	2.32	1.50	May 05,18, June 02	3.35	June 18
S Bowers, DE	4.79	0.45	June 04	6.27	May 05
N Bowers, DE	4.79	0.44	June 04	7.00	June 14
Ted Harvey WMA, DE	4.17	0.10	June 02	5.00	May 05
Kitts Hummock, DE	3.73	0.50	June 04	4.43	May 20
Pickering, DE	3.82	0.44	June 04	4.68	May 05
N Pierces Point, NJ	6.63	3.12	June 04	8.34	May 16
Cooks, NJ	5.81	2.17	June 16	7.62	May 05
Moores, NJ	7.35	2.13	May 03	10.12	May 05
Thompsons, NJ	9.14	1.00	May 01	12.83	May 31

Table 7. Number and Percentages of Sex Ratios 2015

Sex Ratio	New Jersey Number	New Jersey Percentage	Delaware Number	Delaware Percentage	New/Restored NJ Number	New/Restored NJ Percentage
No Sex Ratio	29	20%	32	24%	6	13%
Less Than 1	2	1%	8	6%	0	0%
1 to less than 3	33	23%	44	33%	5	10%
3 to less than 5	38	26%	34	26%	9	19%
5 to less than 7	33	23%	11	8%	13	27%
Greater than 7	9	6%	3	2%	15	31%
Totals	144	99.00%	132	99.00%	48	100.00%

Table 8. Tagged Horseshoe Crabs Observed During Surveys 2007-2015

Year	Total	Delaware	New Jersey	In Quadrat	Outside	Alive	Dead	Unreadable
2007	116	95	21	30	86	102	14	3
2008	73	65	8	16	57	70	3	0
"2009	153	62	91	26	127	145	8	10
2010	100	71	29	19	81	94	6	14
2011	191	87	104	31	160	175	16	11
2012	106	42	64	50	56	104	2	4
2013	147	88	59	45	102	130	17	3
2014	104	56	48	22	82	94	10	1
2015	235	42	193	61	174	231	4	1
Totals	**1225**	**608**	**617**	**300**	**925**	**1145**	**80**	**47**