

The 2017 Delaware Bay Horseshoe Crab Spawning Survey

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Abstract

Spawning counts of horseshoe crabs were scheduled for 25 beaches in New Jersey and Delaware during moon phases in May and June. The schedule included 300 events of which 274 counts were completed with 26 dates cancelled due to no access (5), no beach (2), weather (14), no surveyors (3) and other (2). An additional 60 counts were scheduled on five restored/replenished beaches in New Jersey with 15 dates cancelled due to road flooding (8) and beach flooding (7).

A single day peak estimate of 581,872 horseshoe crabs (308,938 New Jersey, 272,934 Delaware) was reached on June 11th, two days after the full moon. The 2017 peak combined estimate was the second highest estimate, slightly lower than the 2009 estimate of 586,298. New Jersey's peak estimate of 308,938 was the highest encountered, setting a record, whereas Delaware's peak estimate of 274,934 was in the mid range of the time series (1999-2017). The peak estimate of 44,241 for the five additional beaches was achieved on June 11th as well.

The 2017 seasonal activity for the Delaware Bay was 2,039,709 (997,715 New Jersey, 1,041,994 Delaware). The seasonal estimate was the third greatest, behind the 2016 estimate of 2,461,704 and slightly behind the 2009 estimate of 2,049,200. The seasonal number of horseshoe crabs for the new/restored beaches was estimated to be 98,422.

The average male to female sex ratio of 5.15 (4.68 for New Jersey and 5.66 for Delaware) was higher than the years 1999-2016 with the 2011 sex ratio of 5.36 being the exception. The average sex ratio in Delaware was higher than usual and was influenced by the high sex ratios encountered during the June 25th count. For the five additional New Jersey beaches, the sex ratio of 5.43 was higher than the average sex ratio of 4.68 for the other 12 New Jersey beaches.

The sex ratio combined with the seasonal estimate for 2017 equated to estimates of 331,660 female spawners and 1,708,049 males. The number of female spawners was among the highest and was similar to the 2015 spawning season, however the estimate was 100,000 less than the 2016 female estimate.

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 acquired from the survey.

Methods

Horseshoe crabs were enumerated in the months of May and June 2017 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 13 Delaware beaches from south to north were Cape Henlopen, Broadkill, Primehook, Fowler, Slaughter, Big Stone, Bennetts Pier, South Bowers North Bowers, Ted Harvey Wildlife Management Area (WMA), Kitts Hummock, Pickering and Woodland. New Jersey's 12 beaches included Higbees, North Cape May, Townbank, Villas, Norburys Landing, South Cape Shore Lab, Highs, Pierces Point, Kimbles, Reeds, Fortescue and Gandys.

The counts were taken simultaneously along the 25 beaches during the high tides encompassing the new and full moons on the dates of May 8th, 10th, 12th, 23rd, 25th, 27th and June 7th, 9th, 11th, 21st, 23rd, 25th. Times of high tides ranged from 7:08pm to 11:00pm 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. If incomplete counts of less than 100 quadrats occurred, they were calculated and utilized the same way as complete counts.

Five additional beaches in New Jersey were surveyed after beach restoration/replenishment during the last few years. The beaches listed south to north: North Pierces Point, Cooks, Moores, Thompsons, and Dyers Cove. The survey/beach lengths were 450 meters for North Pierces Point, 350 meters for Cooks Beach, 1000 meters for Moores Beach, 900 meters for Thompsons, and 300 meters for Dyers Cove. The survey/beach lengths were used to calculate the approximate number of horseshoe crabs spawning on these beaches.

Results

Along the 25 beaches, three hundred surveys were scheduled, 156 in Delaware and 144 in New Jersey. Of these, 274 surveys (91%) were conducted with 26 cancellations due to no access (5), no beach (2), weather (14), no surveyors (3) and other (2). The majority of the cancellations (17 of the 26) occurred on two dates, May 12th, the full moon and May 25th, the new moon. (Table 1A and 1B)

Seventeen counts were incomplete, three in Delaware and fourteen in New Jersey. Surveys were incomplete if fewer than 100 quadrats were counted, with Gandys Beach being the exception where a complete count is 66 quadrats. The incomplete counts in Delaware were May 27th and June 21st at Big Stone (96 and 54 quadrats respectively) and June 21st at Kitts Hummock (45 quadrats). In New Jersey, incomplete counts were recorded May 25th at Reeds (79 quadrats), May 25th, June 21st, and June 25th at Townbank (70, 59, 88 quadrats respectively), May

8th, May 10th, May 12th and June 7th at Fortescue (98, 99, 99, 98 quadrats respectively) and May 10th, May 23rd, June 7th, June 11th, June 23rd and June 25th at Gandys (33, 48, 33, 45, 35, 64 quadrats respectively).

Sixty counts were scheduled for the five restored/replenished beaches in New Jersey. A total of 45 surveys (75%) were performed and 15 dates were canceled due to road flooding (8) and beach flooding (7). Counts at all five beaches were canceled May 25th. Nine incomplete counts occurred, May 12th at North Pierces Point (88 quadrats), June 21st and 23rd at Thompsons (86 and 96 quadrats) and May 8th, 10th, 12th, 23rd, 27th and June 9th at Dyers Cove (96, 96, 92, 89, 88 and 36 quadrats respectively). (Table 1C)

This year's (2017) peak estimate of spawners along Delaware and New Jersey's shores of 581,872 was the second greatest in the time series (1999-2017). The 2017 estimate was slightly lower than the 2009 estimate of 586,298 and replaces the 2016 count of 534,511 as the second. The peak spawning estimate was evenly distributed between New Jersey (53%) and Delaware (47%). Spawning estimates were greatest during three dates, May 27th, June 9th and June 11th, contributing 62% to Delaware's seasonal estimate and 78% to New Jersey's seasonal estimate. (Table 1A and 1B and Figure 1)

In New Jersey, the greatest densities were reached June 9th at South Cape Shore Lab of 32.27 horseshoe crabs per square meter and at Pierces Point of 28.52 crabs per meter. In Delaware, the greatest densities were achieved June 9th and 11th at Pickering of 25.93 crabs per meter and 35.40 crabs per meter respectively. Horseshoe crabs were observed on five of the 12 survey dates on the most northern beach in Delaware, Woodland beach. (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 (47% in DE and 63% in NJ) recorded densities lower than five horseshoe crabs per meter. Similar to the years 2015 and 2016, dates with high densities in 2017 were numerous with 14% in Delaware and 15% in New Jersey. Six zero counts were recorded in New Jersey, May 8th at North Cape May, Townbank, Gandys and Higbees, and again at Higbees May 12th and 23rd. The percentage of zero dates for Delaware (26 dates, 16.7%) was higher than previous years. Many of the zero counts occurred in the beginning of the season and six were recorded at Woodland beach. Missed dates (11% in New Jersey and 6% in Delaware) were caused mainly by weather cancellations and flooding conditions. (Table 1A and 1B and Table 3 and Figure 3)

The seasonal activity of 997,715 for the New Jersey side of the Bay was the second highest estimate in the time series (1999-2017). It was lower than the 2016

record estimate of 1,271,102 and slightly higher than the 2015 estimate of 982,487. Delaware's seasonal estimate of 1,041,994 was similar to the 2016 estimate of 1,190,602 and in the mid range of the series (1999-2017). (Table 4 and Figure 4). In 2017, Slaughter, Big Stone (due to its beach expanse) and Pickering had the highest estimates of spawning crabs. In New Jersey, Norburys Landing, South Cape Shore Lab and Fortescue had the highest spawning estimates. (Table 2).

The general spawning activity for the five additional New Jersey beaches mirrored the overall activity with a peak spawning date of June 11th and three dates (May 27th, June 9th and June 11th) contributing to the majority of the seasonal estimate (82%). The greatest densities were achieved May 27th (20.95 horseshoe crabs per meter) and June 11th (18.47 crabs per meter) at Thompsons beach. However, the percentage of densities greater than 10 crabs per meter for the additional beaches was almost half the percentage of high densities for the 12 beaches (8% compared to 15%) and the percentage of dates missed was more than double the percentage for the 12 New Jersey beaches' percentages (25% compared to 11%). (Table 1 C and Figure 1C)

The 2017 average sex ratio was 5.15 for the entire Delaware Bay and was one of the highest on record. Combined with the seasonal estimate, it equated to 331,660 females spawning along the survey beaches. The estimate was less than the 2016 record estimate but was within the range of the greater female estimates for the time series (1999-2017). (Table 5 and Figure 5) The average sex ratio for the five additional New Jersey beaches was 5.43 and was higher than the average sex ratio of the other surveyed beaches in New Jersey (4.68).

The average sex ratio for each beach was calculated by dividing the total number of males by the total number of females counted during the survey counts (Table 6 and Figure 6). The total number of horseshoe crabs counted was plotted against the sex ratio for 273 dates (Figure 7). The sex ratio of 22 from a single group observed May 23rd at Cape Henlopen was not plotted for graphing purposes. The resultant distribution is similar to the 2016 Figure (6), the majority of the sex ratios are in the range of 2 to 4.

Similar to categorizing densities, sex ratios (males per female) were also categorized according to percentage of occurrence for the 12 New Jersey beaches, the 13 Delaware beaches and the five new/restored New Jersey beaches. The categories were less than 1 (more females were observed than males), 1 male to less than 3 males per female, 3 to less than 5 males per female, 5 to less than 7 males per female and greater than 7 males per female. The highest sex ratios (male/female) recorded for the season occurred in Delaware. An extremely high ratio was observed at Cape Henlopen May 23rd of 22 males surrounding one female. The other high sex ratios were recorded June 25th at Ted Harvey WMA (9.42), Kitts Hummock (9.44), Cape Henlopen (9.89), Big Stone (10.77), Pickering (11.46) and South Bowers (11.57). In New Jersey, high sex ratios occurred May 23rd (8.37) and June 11th (9.10) at Fortescue and June 25th at Gandys (10.11). The highest sex ratio

for the restored/replenished beaches was recorded June 11th at Dyers Cove (8.39). (Table 7 and Figure 7A).

Average sex ratios were also calculated for each survey night for the 13 Delaware beaches, the 12 New Jersey beaches and the additional five New Jersey beaches. The ratios were graphed by survey date (Figure 7B) and also graphed by State separating the May and June counts (Figure 7C and 7D). The sex ratios for the three groups of beaches were comparable during the full moon dates, June 7th, 9th and 11th, most likely due to the greater numbers encountered during these dates (Figure 7B). Sex ratios graphed by State illustrate the range of sex ratios for each State (Figure 7C and 7D). The graph highlights the higher sex ratios observed in Delaware during the late June counts and illustrates the less variable sex ratios observed in early June similar to Figure 7B.

Observations of tagged horseshoe crabs during the survey counts numbered 321, mainly from New Jersey (282) where tagging took place during the season. The majority of the tagged animals were alive (15 recorded dead) and encountered outside the quadrats (78%). Many of the tagged animals were observed at Kimbles (88) and Reeds (47). (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)

Summary

The 2017 peak estimate was the second highest and the seasonal activity was among the highest encountered over the time series (1999-2017). Horseshoe crab spawning activity was good despite the weather experienced during this year's season and the high tides that caused road and beach flooding. The high peak estimate achieved in June may have been the result of the horseshoe crabs finally being able to reach the shore to spawn after rough and high waters earlier in the season.

Discussion

New Jersey's estimates are trending upwards while Delaware's numbers are remaining in the mid range of the time series (1999-2017). During much of the time series, New Jersey estimates were lower than Delaware's, however recent numbers along New Jersey beaches are comparable and in some cases surpassing Delaware's numbers.

Surveying of the horseshoe crab spawning population is more important than ever with our changing coastline and increased use of the beach areas. The many years of spawning data allows analysis of horseshoe crab numbers before and after beach rebuilding by sand deposition. Other ways to protect our beaches are being explored and with our lengthy survey coverage, conclusions can be made to assure the horseshoe crab spawning population is not adversely affected.

Acknowledgements

THANK YOU TO ALL!

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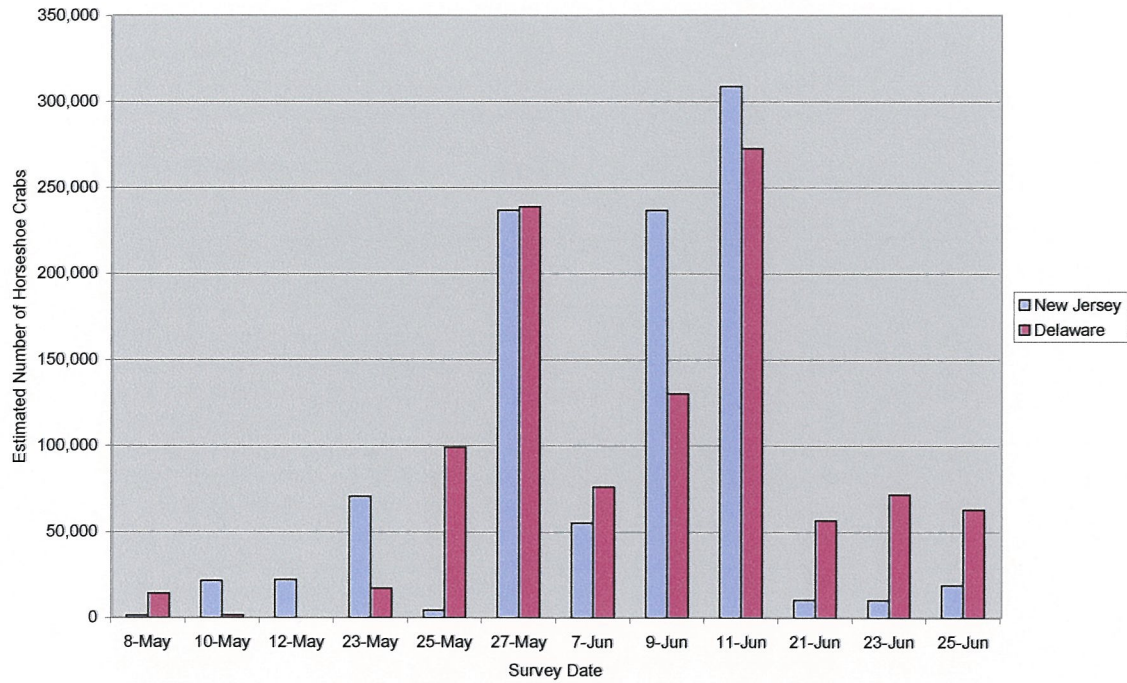


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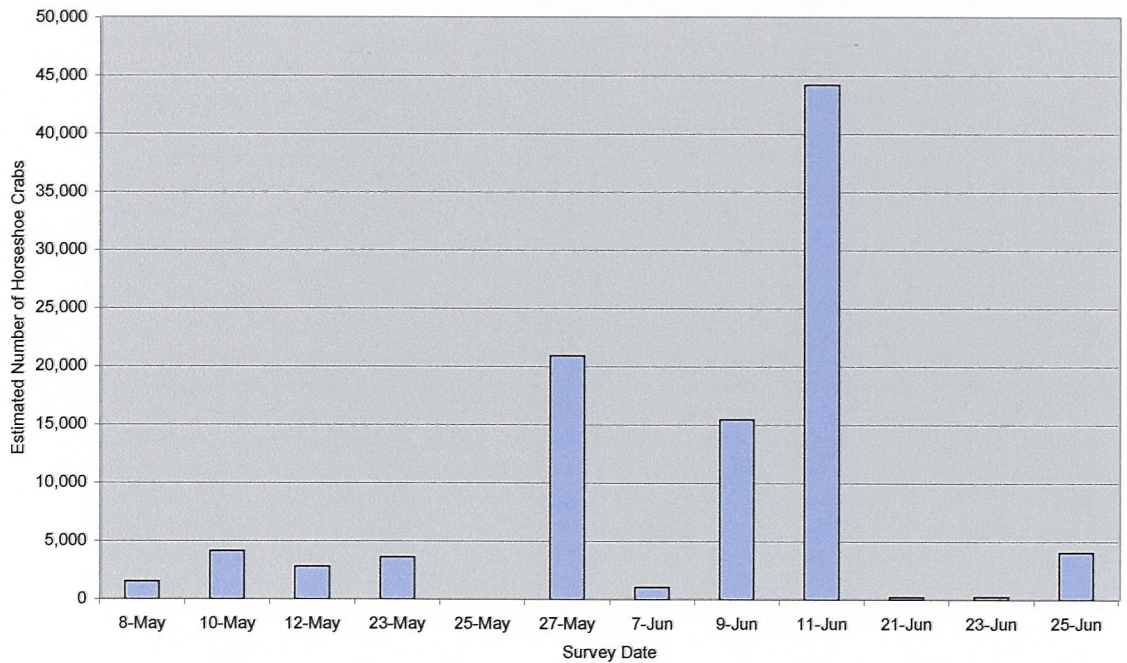


Figure 2. Peak Estimates of Spawning Horseshoe Crabs Years 1999-2017

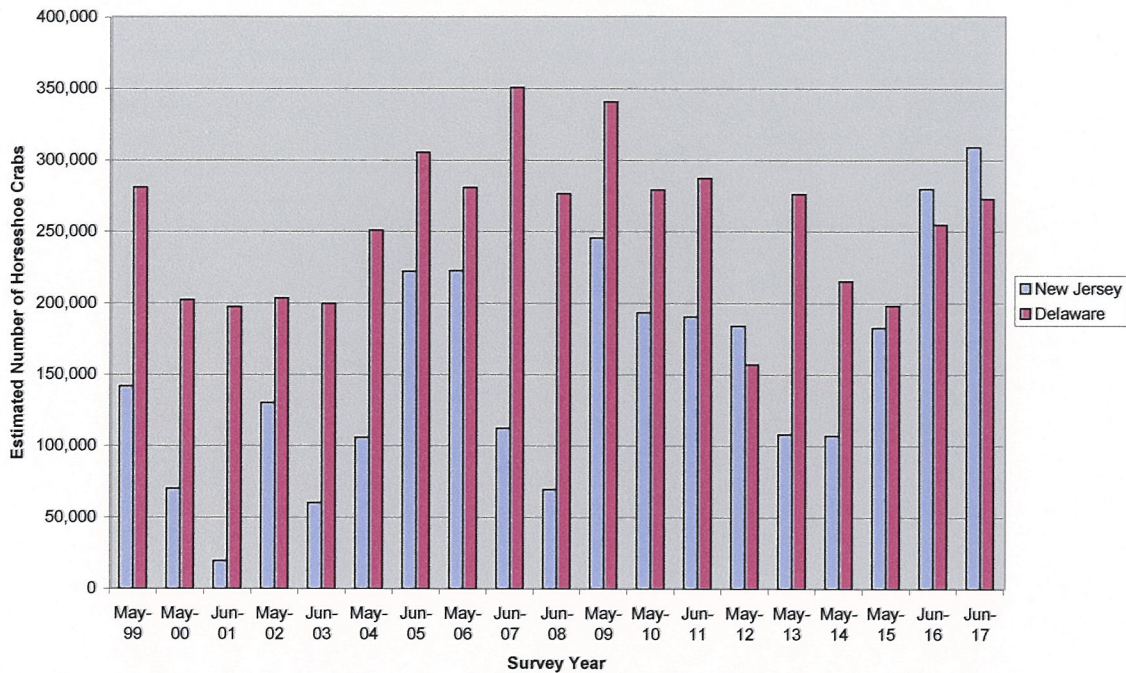


Figure 3. Percentages of Horseshoe Crab Densities by Year 1999-2017

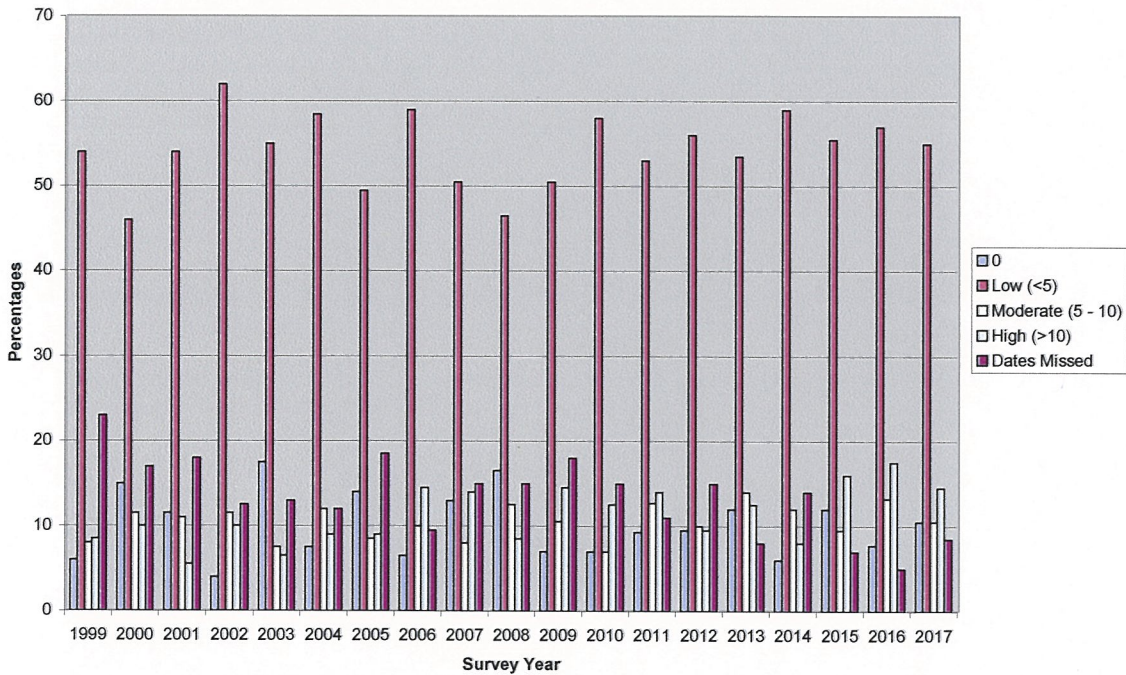


Figure 4. Seasonal Estimates of Horseshoe Crabs 1999-2017

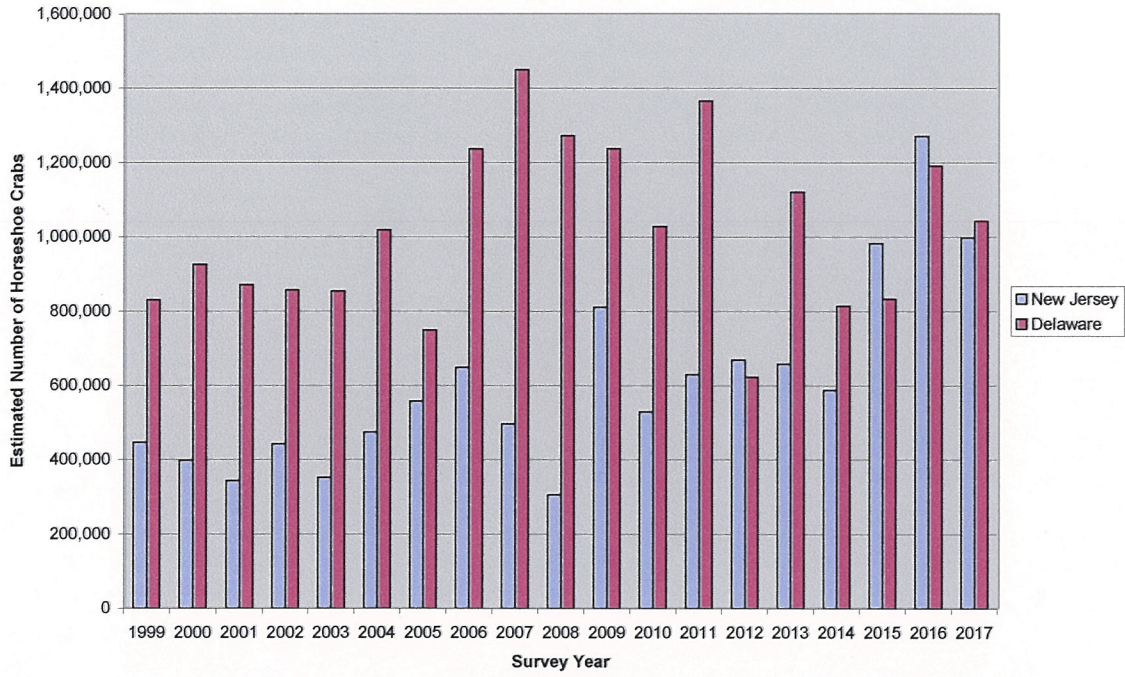


Figure 5. Seasonal Estimates of Male and Female Horseshoe Crabs 1999-2017

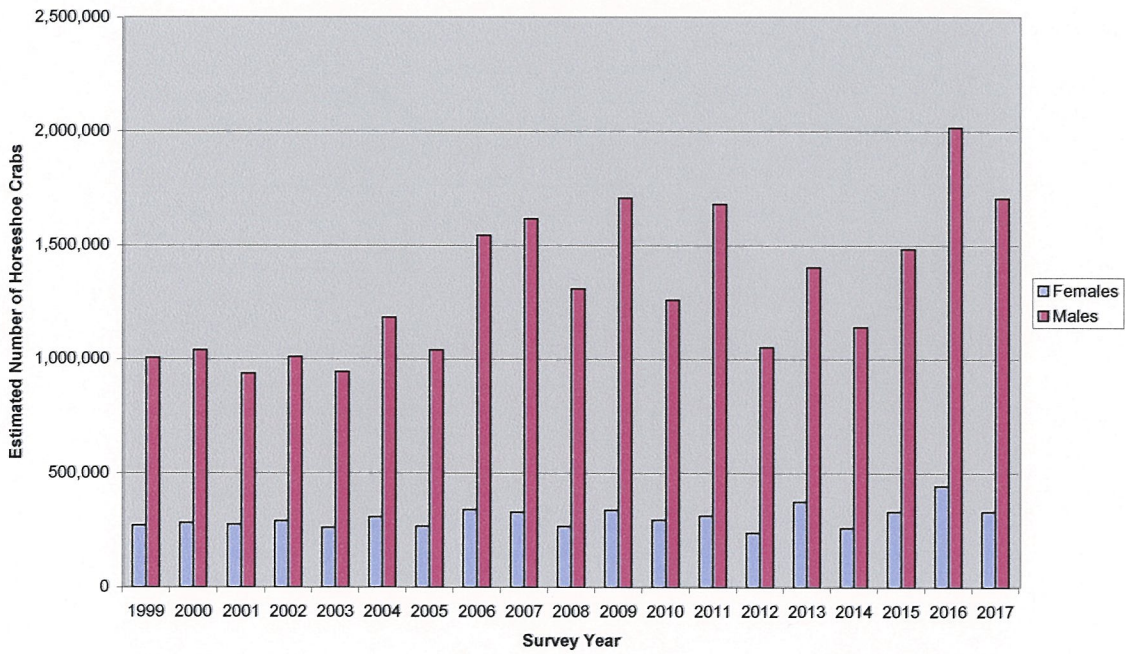


Figure 6. Average Sex Ratios by Beach 2017

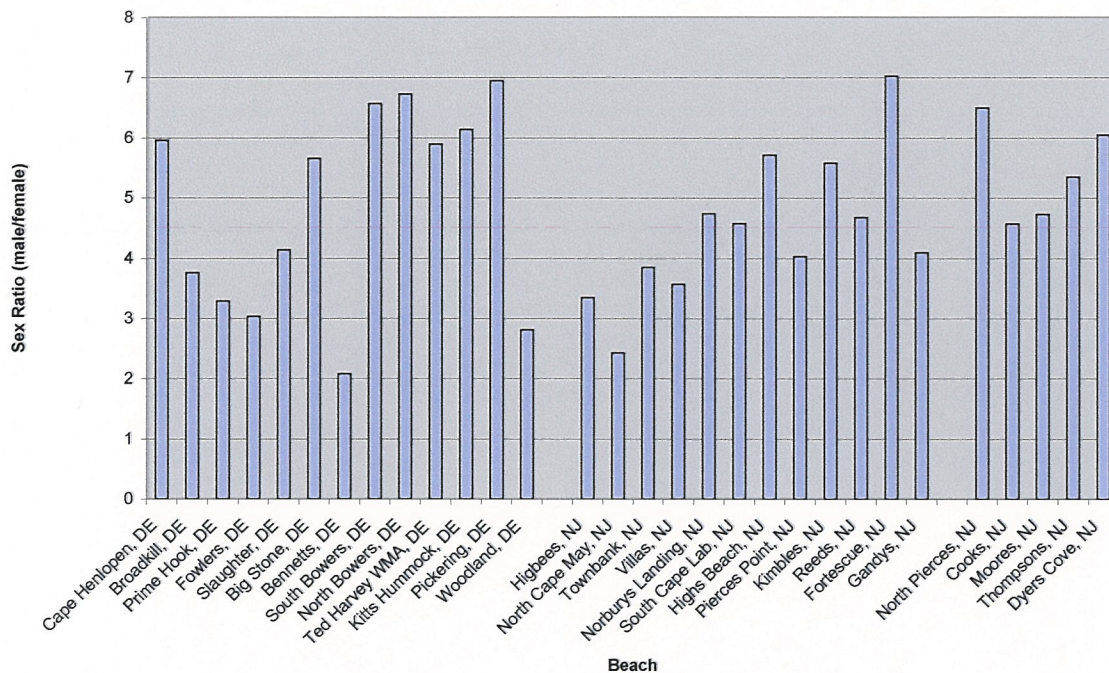


Figure 7. Numbers of Horseshoe Crabs versus Sex Ratios 2017

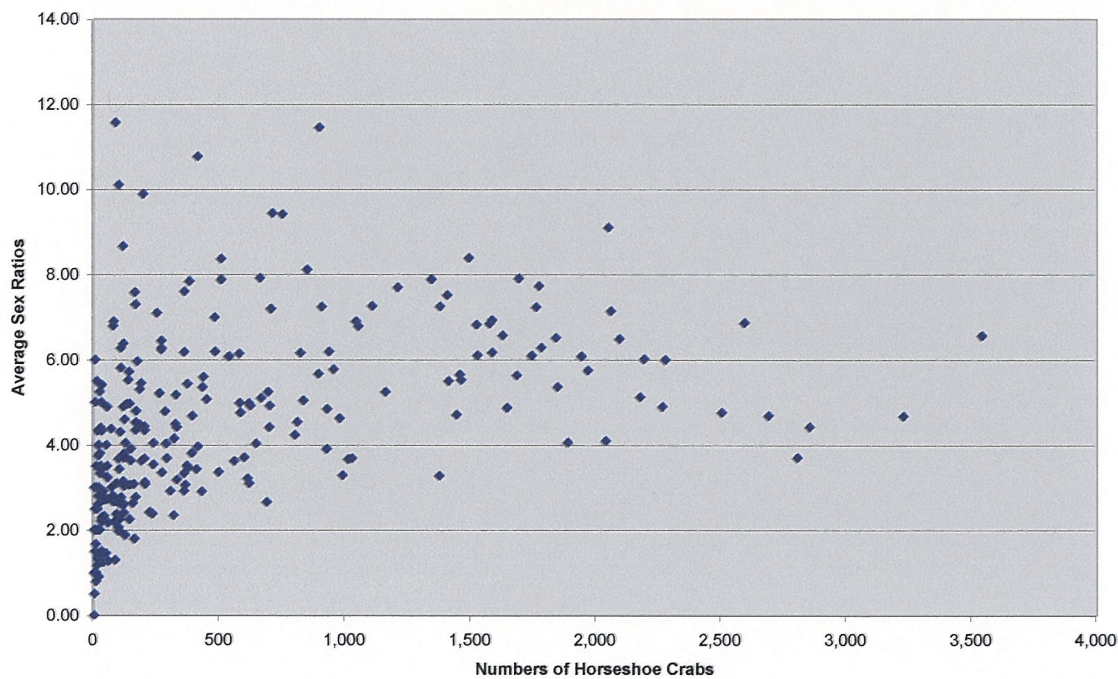


Figure 7A. Sex Ratio Categories 2017

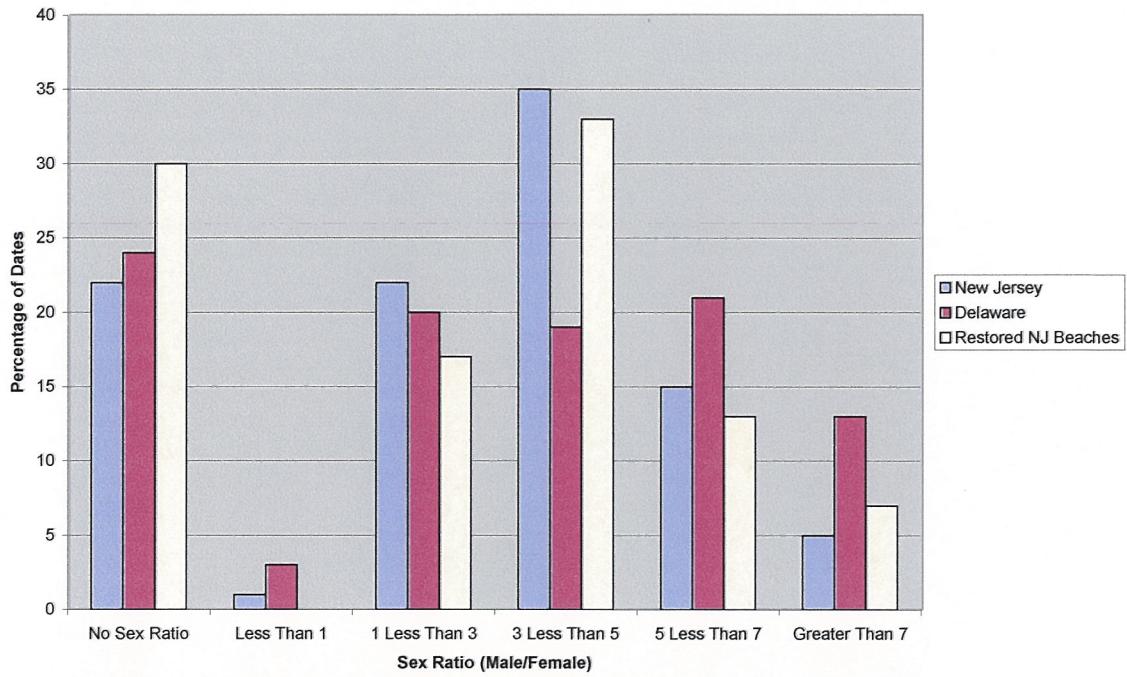


Figure 7B. Average Sex Ratios by Survey Date 2017

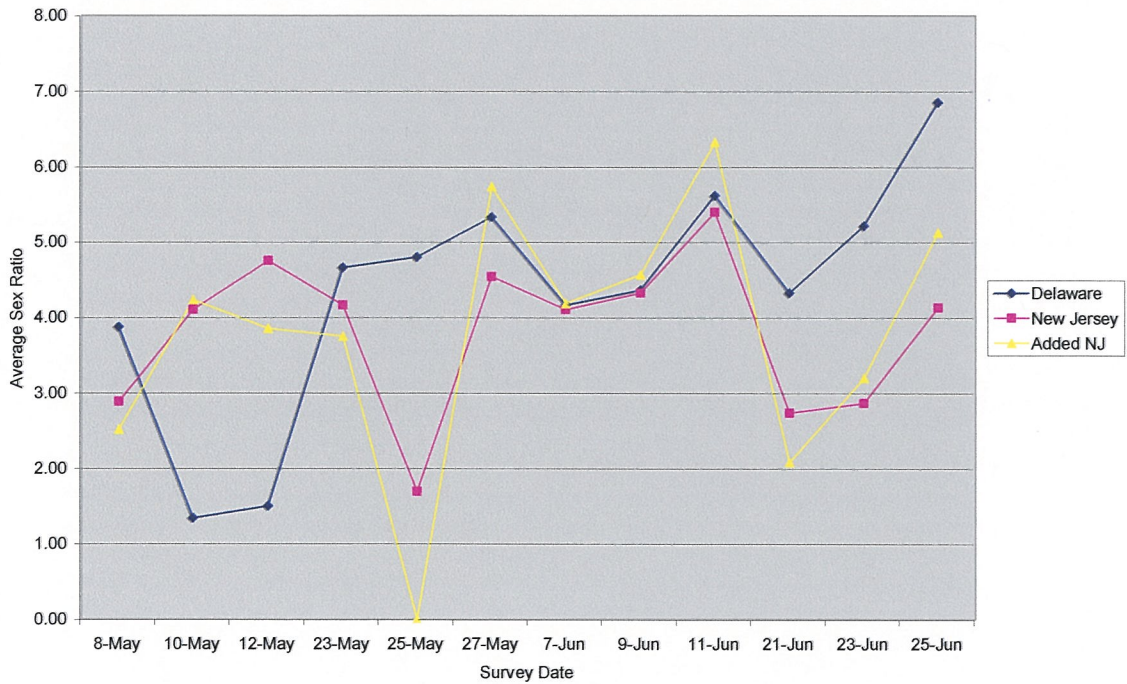


Figure 7C. Sex Ratios by State During May 2017

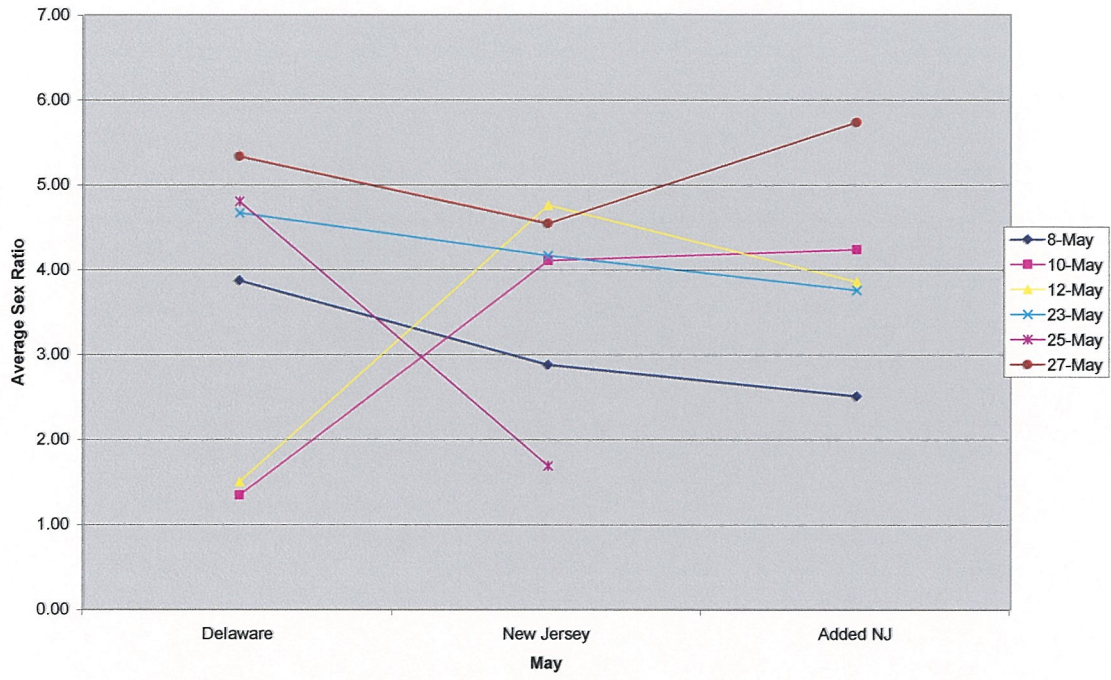


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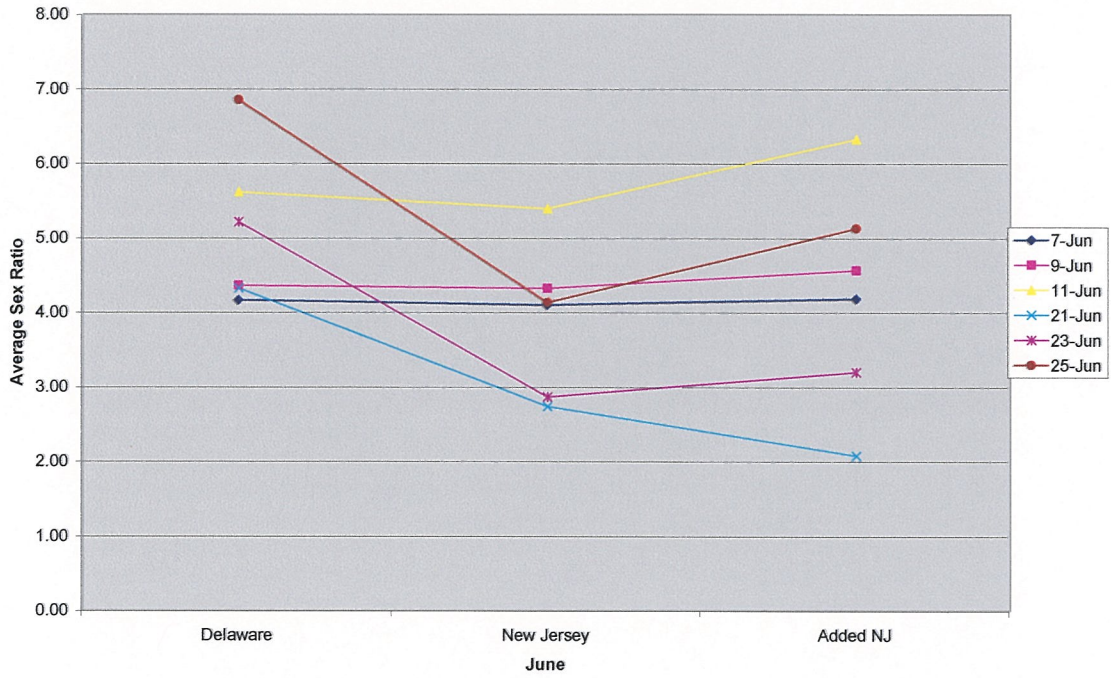


Table 1. 2017 Survey Results- Densities and Estimates
A. New Jersey Beaches (*Indicates beaches surveyed every year)

Moan Phase	Full-2 8-May	Full 10-May	Full+2 12-May	New-2 23-May	New 25-May	New+2 27-May	Full-2 7-Jun	Full 9-Jun	Full+2 11-Jun	New-2 21-Jun	New 23-Jun	New+2 25-Jun	Totals
Higbees * (0.98 km)													
Density of HSC, Crabs/m	0.00	0.01	0.00	0.00	0.01	0.14	0.06	0.88	2.86	0.18	0.17	1.22	
Estimated Number of HSC	0	10	0	0	10	137	59	862	2,803	176	167	1,196	5,419
North Cape May * (3 km)													
Density of HSC, Crabs/m	0.00	0.03	cancel	0.01	1.24	cancel	cancel	0.98	1.59	0.30	0.72	1.09	
Estimated Number of HSC	0	90	weather	30	3,720	no sheets	no surveyor	2,940	4,770	900	2,160	3,270	17,880
Townbank (2.3 km)													
Density of HSC, Crabs/m	0.00	0.04	cancel	0.26	0.03	1.81	0.97	4.97	8.09	0.41	0.32	2.16	
Estimated Number of HSC	0	92	weather	598	69	4,163	2,231	11,431	18,607	943	736	4,968	43,838
Villas (2 km)													
Density of HSC, Crabs/m	0.03	0.76	cancel	3.30	cancel	9.26	4.29	9.89	20.40	1.19	0.51	0.91	
Estimated Number of HSC	60	1,520	weather	6,600	weather	18,520	8,580	19,780	40,800	2,380	1,020	1,820	101,080
Norburys Landing (2.43 km)													
Density of HSC, Crabs/m	0.02	1.56	0.25	4.08	cancel	21.77	1.66	14.44	19.68	1.16	1.21	1.02	
Estimated Number of HSC	49	3,791	608	9,914	weather	52,901	4,034	35,089	47,822	2,819	2,940	2,479	162,446
South CSL * (2.2 km)													
Density of HSC, Crabs/m	0.04	0.33	0.90	3.05	cancel	22.67	6.98	26.88	32.27	0.13	0.19	cancel	
Estimated Number of HSC	88	726	1,980	6,710	weather	49,874	15,356	59,136	70,994	286	418	no sheets	205,568
Highs * (0.8 km)													
Density of HSC, Crabs/m	0.27	1.06	4.32	9.28	cancel	18.41	2.83	14.57	15.85	0.29	0.04	0.04	
Estimated Number of HSC	216	848	3,456	7,424	weather	14,728	2,264	11,656	12,680	232	32	32	53,568
Pierces Point (0.7 km)													
Density of HSC, Crabs/m	0.02	2.02	6.88	18.88	cancel	28.03	3.59	28.52	15.26	3.90	0.39	0.49	
Estimated Number of HSC	14	1,414	4,816	13,216	weather	19,621	2,513	19,964	10,682	2,730	273	343	75,586
Kimbles (1 km)													
Density of HSC, Crabs/m	0.12	3.80	2.01	5.82	cancel	9.78	2.68	14.11	16.27	0.06	0.19	0.53	
Estimated Number of HSC	120	3,800	2,010	5,820	weather	9,780	2,680	14,110	16,270	60	190	530	55,370
Reeds * (1.53 km)													
Density of HSC, Crabs/m	0.02	3.59	3.27	3.60	0.41	13.75	2.03	11.60	17.61	0.03	0.59	0.24	
Estimated Number of HSC	31	5,493	5,003	5,508	627	21,038	3,106	17,748	26,943	46	903	367	86,812
Fortescue (2.6 km)													
Density of HSC, Crabs/m	0.32	1.41	1.66	5.06	cancel	16.84	4.80	15.24	20.51	cancel	0.55	1.09	
Estimated Number of HSC	832	3,666	4,316	13,156	no access	43,784	12,480	39,624	53,326	weather	1,430	2,834	175,448
Gandys * (1.2 km)													
Density of HSC, Crabs/m	0.00	0.01	0.01	1.20	cancel	1.83	1.68	3.75	2.70	cancel	0.07	1.00	
Estimated Number of HSC	0	12	12	1,440	no access	2,196	2,016	4,500	3,240	weather	84	1,200	14,700
Totals	1,409	21,461	22,201	70,416	4,426	236,742	55,319	236,841	308,938	10,572	10,353	19,038	997,715

Table 1. 2017 Survey Results - Densities and Estimates
 B. Delaware Beaches (*Indicates Beaches Surveyed Every Year)

Date	Moon Phase		Full 10-May	Full+2 12-May	New-2 23-May	New 25-May	New+2 27-May	Full-2 7-Jun	Full 9-Jun	Full+2 11-Jun	New-2 21-Jun	New 23-Jun	New+2 25-Jun	Totals
	8-May	Full-2 8-May												
Cape Henlopen (1.5 km)														
Density of HSC, Crabs/m	0.00	0.00	0.00	0.00	0.23	1.48	5.78	0.30	3.73	9.35	2.68	2.61	1.96	
Estimated Number of HSC	0	0	0	0	345	2,220	8,670	450	5,595	14,025	4,020	3,915	2,940	42,180
Broadkill (1.5 km)														
Density of HSC, Crabs/m	0.01	0.08	0.08	0.00	0.08	1.42	8.33	0.02	0.37	5.59	0.83	1.16	2.01	
Estimated Number of HSC	15	120	120	0	120	2,130	12,495	30	555	8,385	1,245	1,740	3,015	29,850
Primehook * (2.0 km)														
Density of HSC, Crabs/m	0.00	0.38	cancel		0.02	2.90	6.11	0.13	2.33	10.11	1.18	1.26	1.04	
Estimated Number of HSC	0	760			40	5,800	12,220	260	4,660	20,220	2,360	2,520	2,080	50,920
Fowler * (3 km)														
Density of HSC, Crabs/m	0.19	0.09	0.00	0.00	0.00	cancel	6.44	0.19	0.85	3.17	1.31	1.16	1.62	
Estimated Number of HSC	570	270	0	0	0		19,320	570	2,550	9,510	3,930	3,480	4,860	45,060
Slaughter * (3 km)														
Density of HSC, Crabs/m	0.02	0.09	cancel		0.10	5.80	10.26	3.65	6.17	25.02	1.18	1.63	1.09	
Estimated Number of HSC	60	270			300	17,400	30,780	10,950	18,510	75,060	3,540	4,890	3,270	165,030
Big Stone * (5.0 km)														
Density of HSC, Crabs/m	0.03	0.02	0.00	0.00	0.00	3.92	9.31	0.14	2.37	4.82	1.46	4.49	4.12	
Estimated Number of HSC	150	100	0	0	0	19,600	46,550	700	11,850	24,100	7,300	22,450	20,600	153,400
Bennetts Pier (2.6 km)														
Density of HSC, Crabs/m	0.00	0.02	0.00	0.00	0.00	0.40	cancel	0.00	1.01	cancel	0.08	0.00	cancel	
Estimated Number of HSC	0	52	0	0	0	1,040		0	2,626		208	0		3,926
South Bowers (2.3 km)														
Density of HSC, Crabs/m	1.37	0.00	cancel		2.22	cancel	14.06	8.23	9.06	13.43	0.45	1.47	0.88	
Estimated Number of HSC	3,151	0			5,106		32,338	18,929	20,838	30,889	1,035	3,381	2,024	117,691
North Bowers * (1.3 km)														
Density of HSC, Crabs/m	0.06	0.00	0.01	0.01	4.35	5.06	11.07	8.48	9.54	15.75	0.00	0.50	0.37	
Estimated Number of HSC	78	0	13	13	5,655	6,578	14,391	11,024	12,402	20,475	0	650	481	71,747
Ted Harvey WMA (1.0 km)														
Density of HSC, Crabs/m	6.60	0.00	0.04	0.04	3.70	17.44	19.43	6.93	6.99	12.09	8.00	6.22	7.50	
Estimated Number of HSC	6,600	0	40	40	3,700	17,440	19,430	6,930	6,990	12,090	8,000	6,220	7,500	94,940
Kitts Hummock * (1.0 km)														
Density of HSC, Crabs/m	1.18	0.00	0.01	0.01	1.05	16.44	20.60	10.43	17.83	22.78	7.20	5.37	7.10	
Estimated Number of HSC	1,180	0	10	10	1,050	16,440	20,600	10,430	17,830	22,780	7,200	5,370	7,100	109,990
Pickering (1 km)														
Density of HSC, Crabs/m	2.51	0.00	0.00	0.00	0.89	10.52	21.94	15.85	25.93	35.40	17.72	16.92	8.97	
Estimated Number of HSC	2,510	0	0	0	890	10,520	21,940	15,850	25,930	35,400	17,720	16,920	8,970	156,650
Woodland * (0.5 km)														
Density of HSC, Crabs/m	0.00	0.00	0.00	0.00	0.00	cancel	0.57	0.00	0.07	0.00	0.20	0.07	0.31	
Estimated Number of HSC	0	0	0	0	0		285	0	35	0	100	35	155	610
Totals	14,314	1,572	63	63	17,206	99,168	239,019	76,123	130,371	272,934	56,658	71,571	62,995	1,041,994

Table 1. 2017 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	Totals
Date	8-May	10-May	12-May	23-May	25-May	27-May	7-Jun	9-Jun	11-Jun	21-Jun	23-Jun	25-Jun	Totals
North Pierces Point (0.45 km)													
Density of HSC, Crabs/m	0.01	0.54	1.40	1.23	cancel	cancel	0.78	7.04	13.78	0.29	cancel	cancel	
Estimated Number of HSC	5	243	630	554	no beach	no beach	351	3,168	6,201	131	no beach	no beach	11,282
Cooks (0.35 km)													
Density of HSC, Crabs/m	0.00	1.74	1.87	3.19	cancel	cancel	0.52	4.12	6.65	0.06	cancel	0.05	
Estimated Number of HSC	0	609	655	1,117	no access	no beach	182	1,442	2,328	21	no beach	18	6,370
Moore's (1 km)													
Density of HSC, Crabs/m	0.02	0.98	0.16	0.20	cancel	cancel	0.18	5.97	14.61	cancel	cancel	cancel	
Estimated Number of HSC	20	980	160	200	no access	no access	180	5,970	14,610	no access	no access	no access	22,120
Thompsons (0.9 km)													
Density of HSC, Crabs/m	1.66	2.04	1.43	1.66	cancel	20.95	0.01	2.36	18.47	0.09	0.09	3.61	
Estimated Number of HSC	1,494	1,836	1,287	1,494	no access	18,855	9	2,124	16,623	81	81	3,249	47,133
Dyers Cove (0.30km)													
Density of HSC, Crabs/m	0.03	1.49	0.29	0.87	cancel	6.99	1.23	9.17	14.93	cancel	0.70	2.69	
Estimated Number of HSC	9	447	87	261	no access	2,097	369	2,751	4,479	no beach	210	807	11,517
Totals	1,528	4,115	2,819	3,625	0	20,952	1,091	15,455	44,241	233	291	4,074	98,422

**Table 2. Comparison of Data on Horseshoe Crabs Spawning on Delaware Bay Shores
Years 1999-2017 (2 pages)**

Peak Estimate	Jun 11	Jun 06	May 16	May 26	May 23	May 22	Jun 03	May 29	May 24	Jun 03
Year	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008
Number of Horseshoe Crabs	581,872	534,511	380,936	322,672	384,548	341,062	477,715	472,759	586,298	346,319
New Jersey Estimate	308,938	279,678	182,671	107,278	108,194	184,046	190,449	193,463	245,444	69,669
Delaware Estimate	272,934	254,833	198,265	215,394	276,354	157,016	287,266	279,296	340,854	276,650
Number of Beaches Surveyed in DE	13	13	11	13	13	13	13	13	13	13
Number of Beaches Surveyed in NJ	12	12	12	12	12	12	12	12	13	12
Main Beaches in DE	Slaughter	Big Stone	Big Stone	Kitts Hummock	Slaughter	Pickering	Big Stone	Big Stone	Big Stone	Big Stone
	Big Stone	South Bowers	Slaughte	Pickering	Pickering	Ted Harvey	Slaughter	Slaughter	Slaughter	Slaughter
	Pickering	Pickering	South Bowers	Big Stone	Big Stone	S. Bowers	S. Bowers	S. Bowers	S. Bowers	Pickering
						Big Stone	Pickering	Pickering	Pickering	
Main Beaches in NJ	Norburys	Norburys	Norburys	Norburys	Fortescue	Fortescue	South CSL	South CSL	South CSL	South CSL
	South CSL	South CSL	South CSL	Reeds	Norburys	South CSL	Norburys	Norburys	Norburys	Norburys
	Fortescue		Fortescue	Fortescue		Gandys	Fortescue	Gandys	Reeds	

**Table 2. Comparison of Data on Horseshoe Crabs Spawning on Delaware Bay Shores
Years 1999-2017 (2 pages)**

Day	Jun 01	May 27	Jun 08	May 21	Jun 14	May 28	Jun 05	May 18	May 30
Year	2007	2006	2005	2004	2003	2002	2001	2000	1999
Number of Horseshoe Crabs	463,587	503,435	527,520	356,739	259,957	333,553	216,929	272,770	422,775
New Jersey Estimate	112,497	222,653	222,168	105,973	60,272	130,164	19,726	70,293	141,720
Delaware Estimate	351,090	280,782	305,352	250,766	199,685	203,389	197,203	202,477	281,055
Number of Beaches Surveyed in DE	13	13	13	13	13	13	13	11	9
Number of Beaches Surveyed in NJ	11	11	11	11	10	10	10	11	13
Main Beaches in DE	Big Stone	Big Stone	Big Stone	Big Stone	Big Stone	S. Bowers	Slaughter	Slaughter	Slaughter
	Slaughter	Slaughter	S. Bowers	Slaughter	Slaughter	Slaughter	Big Stone	Big Stone	Big Stone
	S. Bowers	S. Bowers	Bennets	Pickering	Pickering	Big Stone			
		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	Townbank
		Norburys	Norburys	Fortescue	Fortescue	Gandys			Norburys
		Fortescue	Villas	Norburys	Norburys	Sea Breeze			South CSL

Table 3. Percentages of Horseshoe Crab Densities 1999-2017

Survey Year	State	Percentage				Dates Missed
		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
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
2016	New Jersey	2	58	15	18	7
	Delaware	13.5	56	11.5	17	3
2017	New Jersey	4	63	6	15	11
	Delaware	17	47	15	14	6

Table 4. Seasonal Estimates of Horseshoe Crabs 1999-2017

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
2016	1,271,102	1,190,602	2,461,704
2017	997,715	1,041,994	2,039,709

Table 5. Sex Ratios and Estimates of Male and Female Horseshoe Crabs 1999-2017

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
2016	4.54	444,351	2,017,353
2017	5.15	331,660	1,708,049

Table 6. Sex Ratios by Beach 2017

Beach	2016	2017
	Average Sex Ratio	Average Sex Ratio
	Male to Female	Male to Female
Cape Henlopen, DE	5.06	5.96
Broadkill, DE	3.85	3.76
Prime Hook, DE	2.76	3.29
Fowlers, DE	3.20	3.03
Slaughter, DE	3.63	4.14
Big Stone, DE	4.53	5.66
Bennetts, DE	2.24	2.08
South Bowers, DE	5.44	6.57
North Bowers, DE	5.62	6.73
Ted Harvey WMA, DE	5.10	5.90
Kitts Hummock, DE	4.72	6.14
Pickering, DE	4.82	6.95
Woodland, DE	2.88	2.81
		4.85
Higbees, NJ	2.76	3.35
North Cape May, NJ	3.34	2.43
Townbank, NJ	3.09	3.85
Villas, NJ	3.12	3.57
Norburys Landing, NJ	3.64	4.74
South Cape Lab, NJ	4.79	4.58
Highs Beach, NJ	5.08	5.72
Pierces Point, NJ	6.14	4.03
Kimbles, NJ	4.30	5.58
Reeds, NJ	4.71	4.68
Fortescue, NJ	4.61	7.03
Gandys, NJ	3.50	4.10
North Pierces, NJ	5.61	6.50
Cooks, NJ	3.67	4.57
Moores, NJ	4.62	4.73
Thompsons, NJ	5.35	5.35
Dyers Cove, NJ	4.48	6.05

Table 8. Tagged Horseshoe Crabs Observed During Surveys 2007-2017

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
2016	348	63	285	81	267	329	19	2
2017	321	39	282	70	251	306	15	1
Totals	1894	710	1184	451	1443	1780	114	50