

The 2022 Delaware Bay Horseshoe Crab Spawning Survey

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Abstract

Counts of spawning horseshoe crabs were scheduled for 22 New Jersey and Delaware beaches during the full and new moon lunar phases in May and June 2022. A total of 264 counts were planned; however, South Bowers beach in Delaware could not be surveyed, resulting in 252 scheduled counts. Of these, 248 counts were completed, with four cancellations due to no beach area (2) and no surveyors (2). An additional 12 counts were scheduled on a restored beach in New Jersey. Ten counts were conducted with two cancellations, one due to no access and one due to no surveyors.

A single day peak estimate of 567,142** horseshoe crabs (240,980 New Jersey**, 326,162** Delaware) was reached on May 30th, the date of the new moon. The 2022 single day peak estimate for the Delaware Bay is the fifth highest estimate in the 23-year time series (1999-2022). Separately, New Jersey's 2022 peak estimate of 240,980** ranked sixth, and Delaware's peak estimate of 326,162** ranked fifth for the highest peak estimate in the time series (1999-2022). The May 30th date was the peak estimate for Delaware; however, New Jersey's peak estimate of 283,693 was reached June 1st, two days after the new moon.

The 2022 seasonal activity for the Delaware Bay was 2,608,111** (1,205,144** New Jersey, 1,402,967** Delaware). The seasonal estimate was the third greatest estimate in the time series, slightly below the 2018 estimate of 2,865,087 and below the 2019 estimate of 3,397,246.

The average male to female sex ratio for the entire Bay was 5.22** during the 12 survey nights. The ratio is the same as the 2021 ratio and lower than the 2018 of 5.54 and the 2019 ratio of 5.38. The sex ratio combined with the 2022 seasonal estimate equated to estimates of 419,310** female spawners and 2,188,801** males. The estimate of female spawners was the fourth highest, and the estimate of males was the third highest estimate of the time series (1999-2022).

Introduction

The Delaware Bay survey of spawning horseshoe crabs began in 1990 and was standardized in 1999. The standard survey protocol has continued, resulting in a data set spanning 23 years. The data is the accumulation of 12 counts conducted simultaneously along many Delaware Bay beaches during the horseshoe crab's spawning season over 23 years. The counts are physically rigorous, and conducted by many dedicated volunteers. The counts are also rigorous in their design, making the data extensive and comprehensive.

The design of the Survey allows the data to compare and analyze trends over time. The data has been reported as the Index of Spawning Activity (ISA) or the number

*Note Fortescue Beach, New Jersey and Woodland, Delaware were not surveyed in 2021, affecting the survey estimates.

**Note Higbees, New Jersey and South Bowers, Delaware were not surveyed in 2022, affecting the survey estimates.

of horseshoe crabs per square meter. The ISA is calculated annually by the States of New Jersey and Delaware and the United States Geological Service (USGS), and the ISA report is submitted to the Atlantic States Marine Fisheries Commission (ASMFC). The data is also used to calculate estimates and reported via the Volunteer survey report.

In the past few years, the survey could not be conducted as "usual" regarding the number of beaches covered. For the 2020 Survey, a limited number of beaches were surveyed for a few nights due to the COVID-19 restrictions. For the 2021 Survey, one beach in New Jersey, Fortescue, was not covered due to lingering restrictions. Also in 2021, Woodland, a Delaware beach, was permanently removed from the surveyed beaches due to continuing access problems. This year, 2022, the number of beaches surveyed was less than the traditional number, as South Bowers in Delaware and Higbees beach in New Jersey were not surveyed due to a shortage of volunteers.

The omission of data from the beaches in 2021 and 2022 affects the calculated estimates for the Volunteer Report, lessening their numbers due to the lack of data from the beaches not surveyed. The effect would vary depending on the level of spawning activity for the individual beach; the impact would be more significant if the beach exhibited good spawning activity. Secondly, the effect would change depending on the magnitude of the yearly estimates. If an estimate remains among the highest without the data from the beaches, trending is not substantially affected, but trending becomes more difficult if the lack of data lowers an already low estimate.

The 2022 Survey estimates are among the highest recorded, even without the data from the two beaches. Trends in spawning abundance is one of the more valuable outputs from the survey data, and comparisons were made using the 2021 and 2022 estimates denoted by asterisk notations. The notations indicate that the estimates were affected by the missing beach data. The 2021 estimates will be noted with an asterisk, *, and the 2022 estimates will be indicated with a double asterisk, **.

Methods

Horseshoe crabs were enumerated in the months of May and June 2022 along the shores of the Delaware Bay. Twenty-one beaches were represented in this year's count (11 along the state of Delaware's coast and 10 along the coast of New Jersey). The 11 Delaware beaches from south to north were Cape Henlopen, Broadkill, Primehook, Fowler, Slaughter, Big Stone, Bennetts Pier, North Bowers, Ted Harvey Wildlife Management Area (WMA), Kitts Hummock, and Pickering. New Jersey's 10 beaches included North Cape May, Townbank, Villas, Norburys Landing, South Cape Shore Lab, Highs, Pierces Point, Kimbles, Reeds, and Fortescue. Higbees Beach was not surveyed in 2022 due to a lack of volunteers.

The counts were conducted at high tide for the specific beach along the 21 beaches encompassing the full and new moons on the dates of May 14th, 16th, 18th, 28th, 30th, and June 1st, 12th, 14th, 16th, 26th, 28th, and 30th. Times of high tides at the

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mouth of Delaware Bay ranged from 7:47 pm to 11:33 pm, with the high tide approaching the northern beaches later into the night. (Table 6)

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 the 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.

One additional beach in New Jersey, Moores Beach was surveyed after beach restoration/replenishment. For Moores Beach, the length of 1000 meters was used to calculate the estimates of spawning horseshoe crabs.

Results

Twelve counts were conducted along 21 beaches resulting in 252 surveys scheduled. Of these, 248 surveys (98%) were performed, with four cancellations due to no beach (2) and no surveyors (2). No cancellations were recorded due to weather or access. (Table 1A and 1B)

Fourteen incomplete counts were recorded in Delaware, and four incomplete counts were recorded in New Jersey. The incomplete counts resulted from high tides limiting the beach area available for surveying. The incomplete counts in Delaware occurred May 18th (43 quadrats) and June 14th (70 quadrats) at Primehook, June 1st (62 quadrats) at Slaughter, June 1st (71 quadrats), June 14th (96 quadrats), June 28th (90 quadrats) and June 30th (98 quadrats) at North Bowers, June 1st (29 quadrats), June 16th (88 quadrats) and June 26th (97 quadrats) at Ted Harvey WMA and May 18th (97 quadrats), May 28th (97 quadrats), May 30th (94 quadrats) and June 1st (22 quadrats) at Kitts Hummock. The four incomplete counts in New Jersey occurred at Kimbles Beach on May 16th (50 quadrats), May 28th (75 quadrats), June 14th (42 quadrats), and June 16th (46 quadrats).

The May 30th estimate of 567,142** spawners along the 11 Delaware and the 10 New Jersey beaches was among the highest in the time series (1999-2022). The 2022 peak estimate is higher than the 2021 estimate that was adversely affected by weather related cancellations during peak spawning dates. The 2022 estimate is similar to the 2016 and 2017 estimates but lower than the 2018 and 2019 estimates. (Table 2 and Figure 2.)

The peak spawning estimate can be attributed to 58% spawning in Delaware and 42% in New Jersey. Spawning was heavily concentrated during May, with 90% of New Jersey's seasonal estimate and 82% of Delaware's seasonal estimate occurring in May. Specifically, the four dates of May 18th, May 28th, May 30th, and June 1st contributed 77% to the seasonal estimate in New Jersey. May 18th, 30th, and June 1st contributed 60% to Delaware's seasonal estimate. (Table 1A and 1B and Figure 1.)

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**Note Higbees, New Jersey and South Bowers, Delaware were not surveyed in 2022, affecting the survey estimates.

The densities of horseshoe crabs were categorized according to four levels of spawning activity. No spawning activity equals 0 crabs, low activity equals less than five crabs per square meter, moderate activity equals 5 to 10 crabs per square meter, and high activity equals greater than ten crabs per square meter. The data is analyzed in percentages since the number of dates and/or beaches may change yearly.

Most dates surveyed (55% in DE and 60% in NJ) recorded densities lower than five horseshoe crabs per square meter. Dates with zero horseshoe crabs were 2.5% in New Jersey and 3% in Delaware, some of the lowest percentages on record. The percentages of high densities (greater than ten crabs per square meter) in Delaware of 25% and New Jersey of 27% were close to or at the record percentages established in 2019 (Figure 3B). The percentage of dates not surveyed was the lowest on record (Figure 3A). (Table 3)

The greatest densities of the season in New Jersey were observed at Pierces Point of 35.87 and 33.72 horseshoe crabs per square meter on May 30th and May 18th, respectively (Table 1A). In Delaware, the highest densities of 31.78 and 31.34 crabs per square meter were recorded at Pickering on May 30th and May 28th, respectively (Table 1B).

The 2022 seasonal activity for the Delaware Bay was 2,608,111** (1,205,144** New Jersey, 1,402,967** Delaware). The seasonal estimate was the third greatest estimate in the time series, slightly below the 2018 estimate of 2,865,087 and below the 2019 estimate of 3,397,246 (Table 4 and Figure 4). The seasonal activity of 1,205,144** for the New Jersey side of the Bay was the third highest estimate, slightly below the record estimates of 2016 of 1,271,102 and the 2019 estimate of 1,291,799 in the time series (1999-2022). Delaware's seasonal estimate of 1,402,967** is the fourth highest estimate, below the 2007 estimate of 1,450,837, the 2018 estimate of 1,675,841, and the 2019 record estimate of 2,105,447 in the time series (1999-2022) (Table 4). Big Stone (due to its long expanse), Slaughter and Pickering beaches in Delaware, and Villas, Norburys Landing, and Pierces Point beaches in New Jersey had the greatest estimates of spawning crabs. (Table 1A and 1B and Table 2).

The 2022 average sex ratio of 5.22** for the entire Delaware Bay combined with the seasonal estimate equated to 419,310** female horseshoe crabs spawning along the survey beaches. The estimate of female spawners is the fourth highest estimate in the time series (1999-2022), below the 2019 estimate of 532,484, the 2018 estimate of 438,087, and the 2016 record estimate of 444,351 (Table 5 and Figure 5A). The male numbers were the third highest in the time series, less than the record 2019 estimate of 2,864,762 and the 2018 estimate of 2,427,000 (Table 5 and Figure 5B).

Summary

During the 2022 spawning season, the horseshoe crab numbers along the Delaware Bay shore were among the highest in the 23-year time series (1999-2022). In 2022, the weather was favorable for surveying with no weather cancellations, and the

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trend of a high percentage of spawning densities continued. Most seasonal spawning occurred in May, 82% in Delaware and 90% in New Jersey. Spawning decreased considerably in June, with few densities exceeding five crabs per square meter.

Discussion

The survey data has been without the counts from the "usual" beaches for the past few years. In 2020, the Survey was curtailed due to COVID restrictions limiting participation, and a partial survey of six beaches was conducted on select dates. For 2021, Fortescue beach in New Jersey was not surveyed due to lingering restrictions, and Woodland beach in Delaware was removed from the beach list due to access issues. For the 2022 Survey, Higbees Beach in New Jersey and South Bowers in Delaware were not surveyed due to a lack of volunteers.

The data collection allows the comparison between years and the analysis of trends. The Delaware Bay survey of spawning horseshoe crabs began in 1990 and standardized in 1999, and its continuance has resulted in a set of data spanning 23 years. The data has been reported in two forms, the Index of Spawning Activity (ISA), the number of females per square meter, and horseshoe estimates for the Volunteer survey report.

For the Volunteer Survey Report, the data from the individual beaches have a varying effect on the final estimates and their comparison with other years. Two beaches in New Jersey were permanently removed from the beach survey list, Sea Breeze in 2010 due to flooding and road access issues and Gandys in 2018 due to lack of beach area and road access issues. One beach in Delaware, Woodland, was removed in 2019 due to road access issues. The estimates from the three beaches were low and contributed little to the overall estimates during the time series (Figure 6B).

Two beaches in New Jersey, Fortescue, and Higbees, and one in Delaware, South Bowers, were not surveyed in 2021 and 2022 due to a shortage of volunteers but will continue to be surveyed. Spawning numbers at Higbees, New Jersey add very little to the overall estimates; however, Fortescue and South Bowers numbers contribute substantially to the results (Figure 6A). Even without the missing beach data, the 2022 estimates were among the highest in the 23-year time series.

Heartfelt thank you to the volunteers!

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**Note Higbees, New Jersey and South Bowers, Delaware were not surveyed in 2022, affecting the survey estimates.

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*Note Fortescue Beach, New Jersey and Woodland, Delaware were not surveyed in 2021, affecting the survey estimates.

**Note Higbees, New Jersey and South Bowers, Delaware were not surveyed in 2022, affecting the survey estimates.

Figure 1. New Jersey and Delaware Spawning Estimates During 2022 Survey

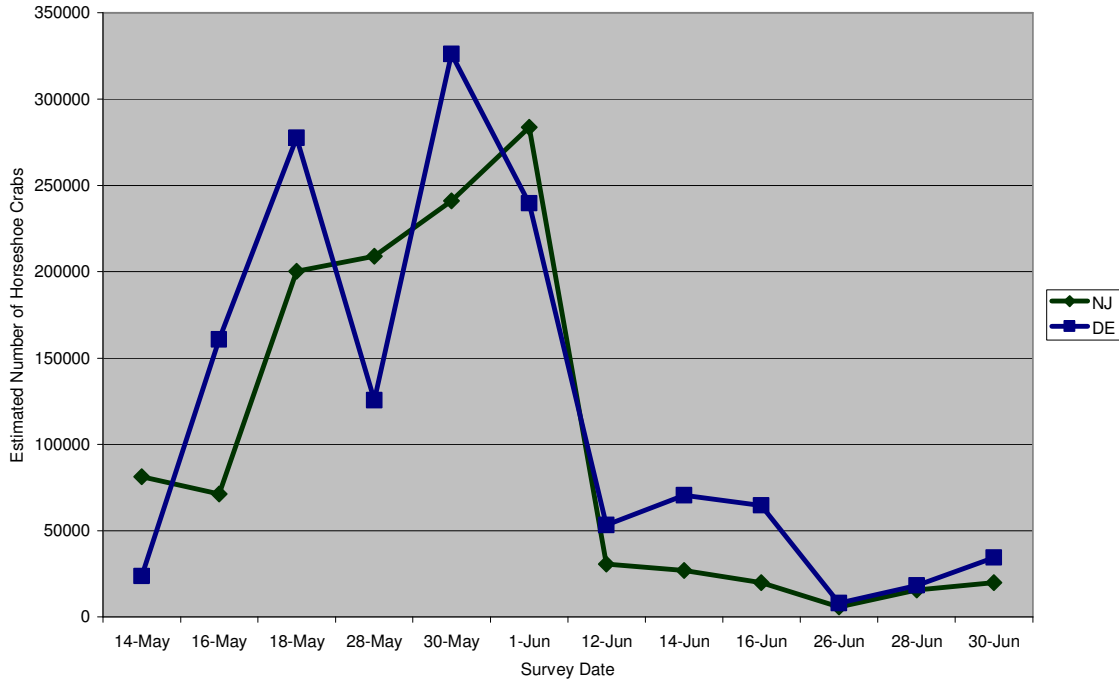
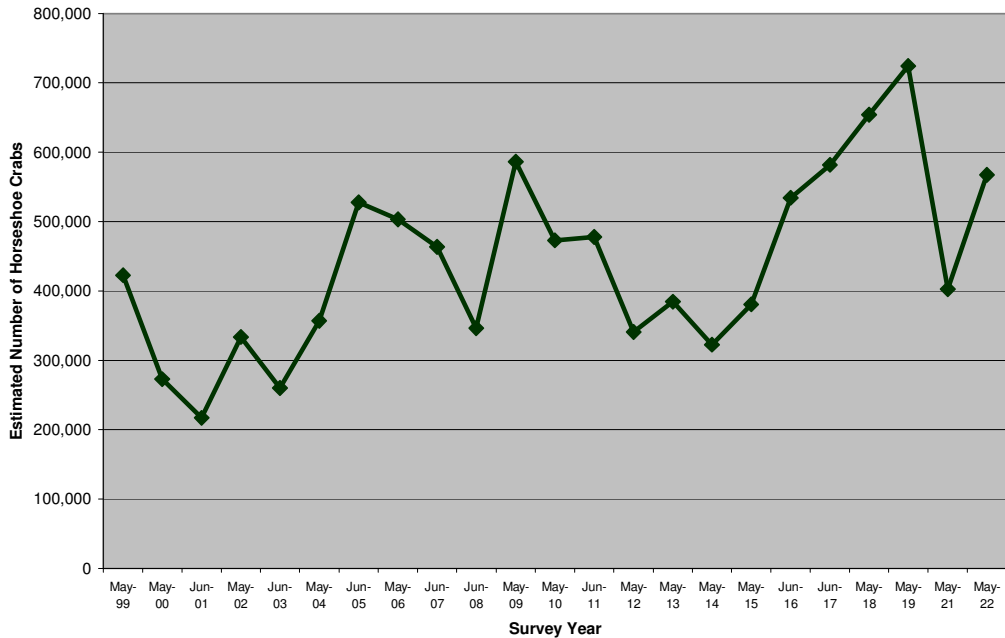


Figure 2. Peak Estimates of Spawning Horseshoe Crabs Years 1999-2022 (No Survey Data for 2020)



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Figure 3. A. Percentages of Dates Missed - Delaware Bay Horseshoe Crab Survey Years 1999-2022
 Note No Survey Data for 2020

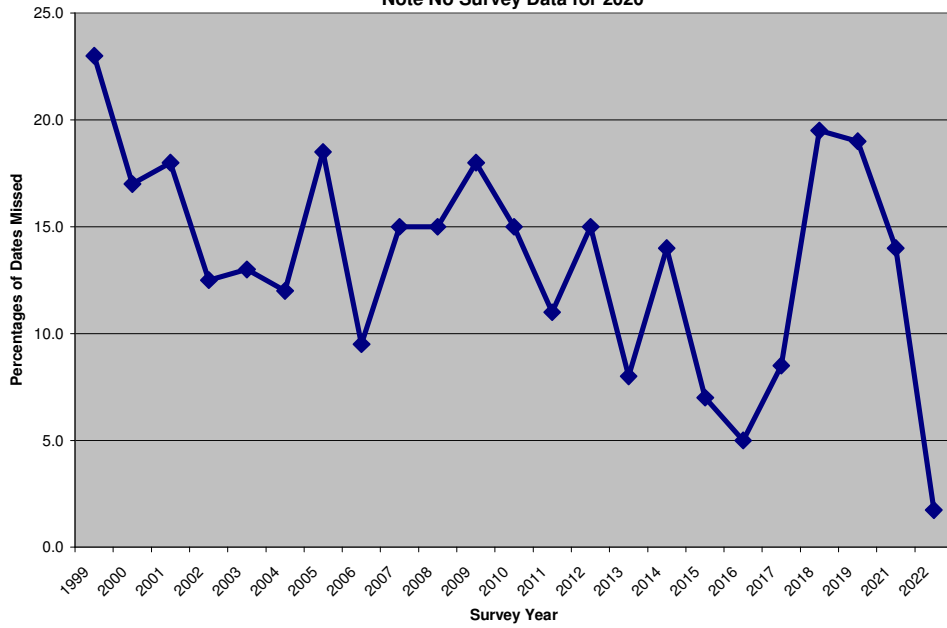
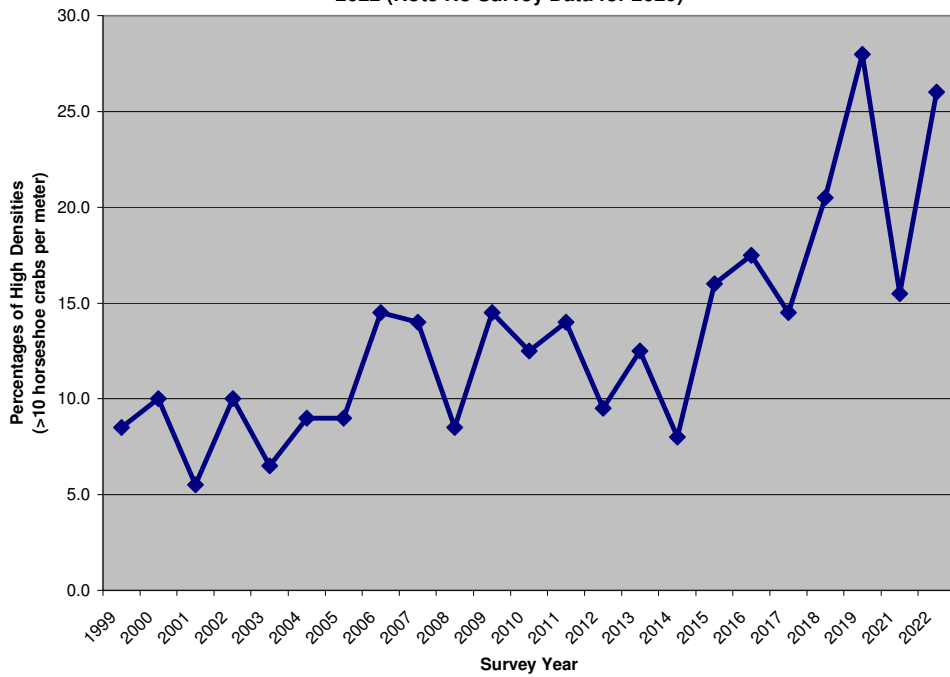


Figure 3.B. Percentages of High Densities - Delaware Bay Horseshoe Crab Survey Years 1999-2022 (Note No Survey Data for 2020)



*Note Fortescue Beach, New Jersey and Woodland, Delaware were not surveyed in 2021, affecting the survey estimates.

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Figure 4. Seasonal Estimates of Horseshoe Crabs Years 1999-2022
 No Survey Data for 2020

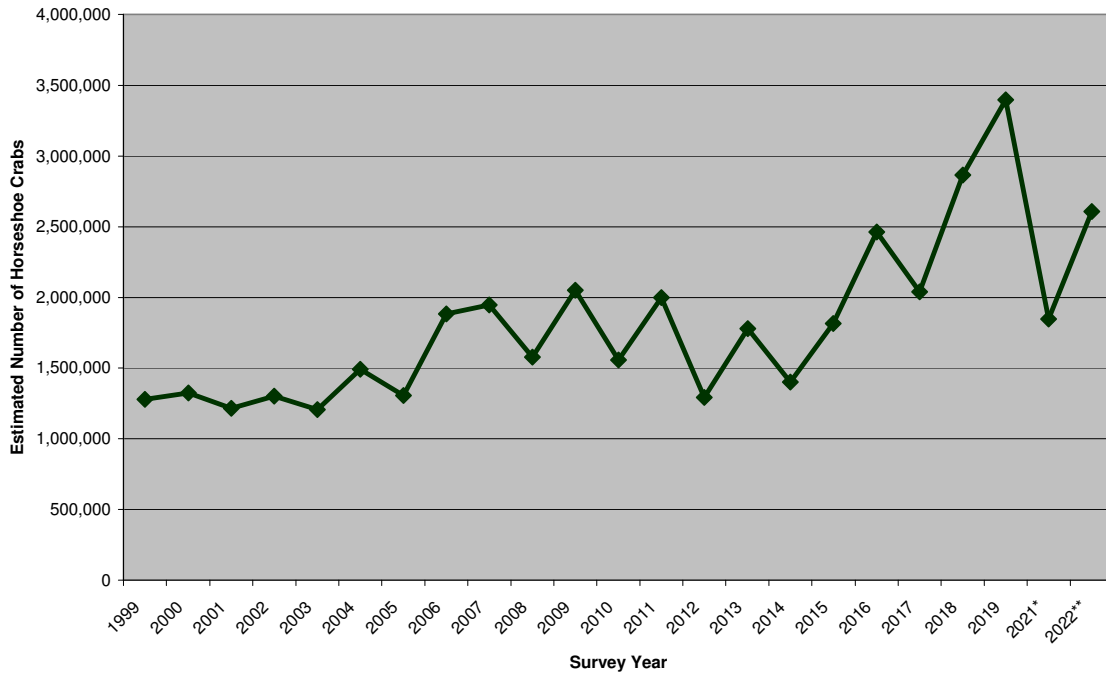
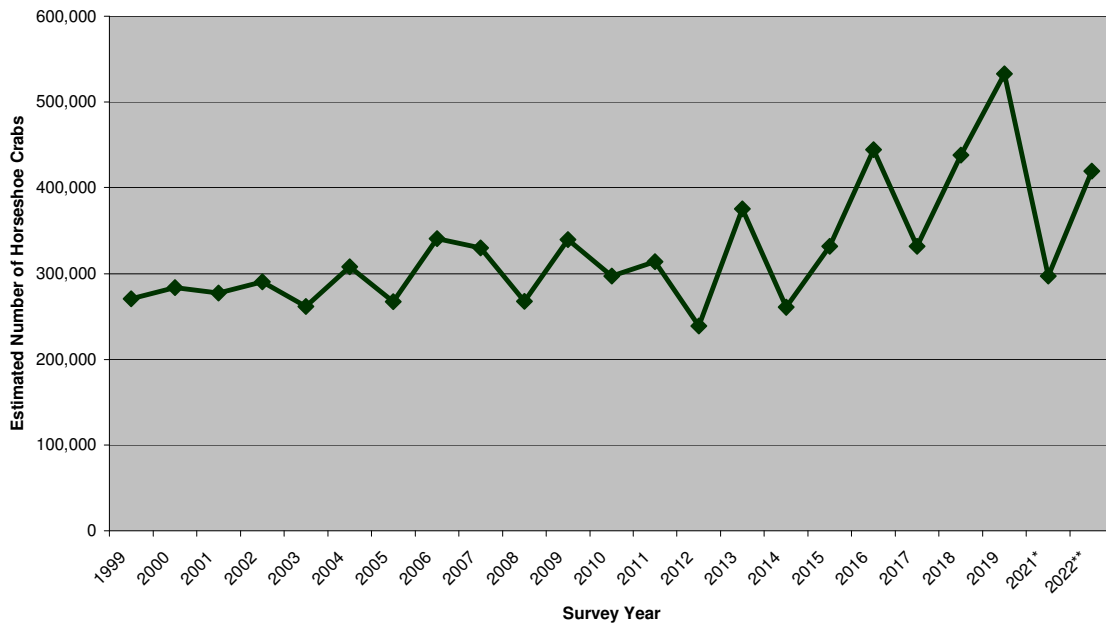


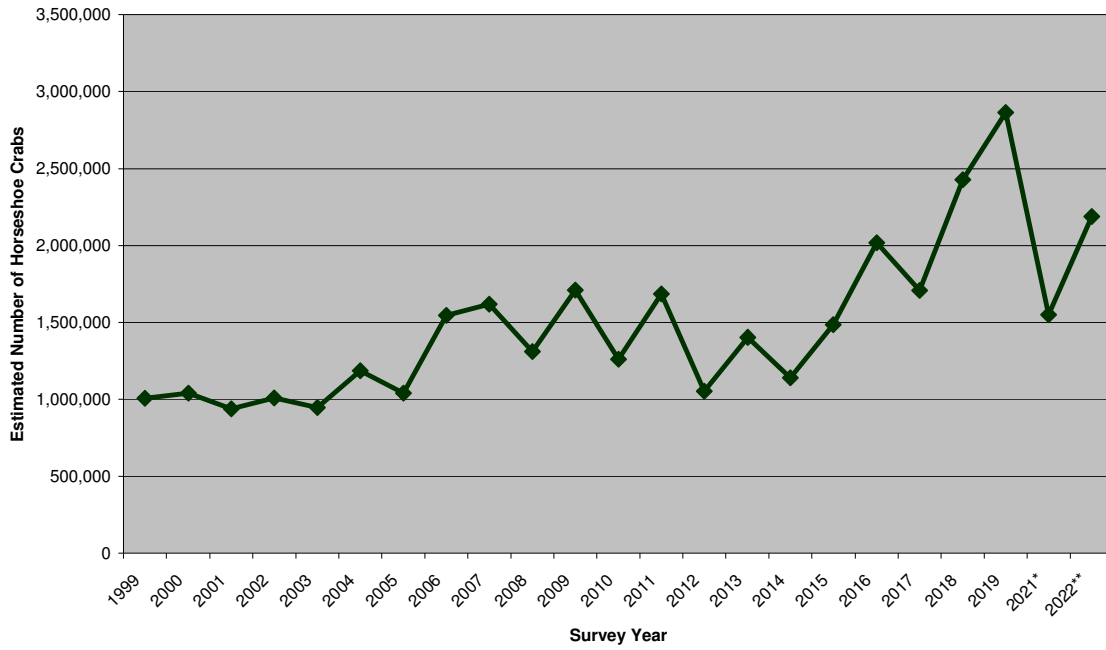
Figure 5. A. Seasonal Estimates of Female Horseshoe Crabs
 1999-2022
 (No Survey Data for 2020)



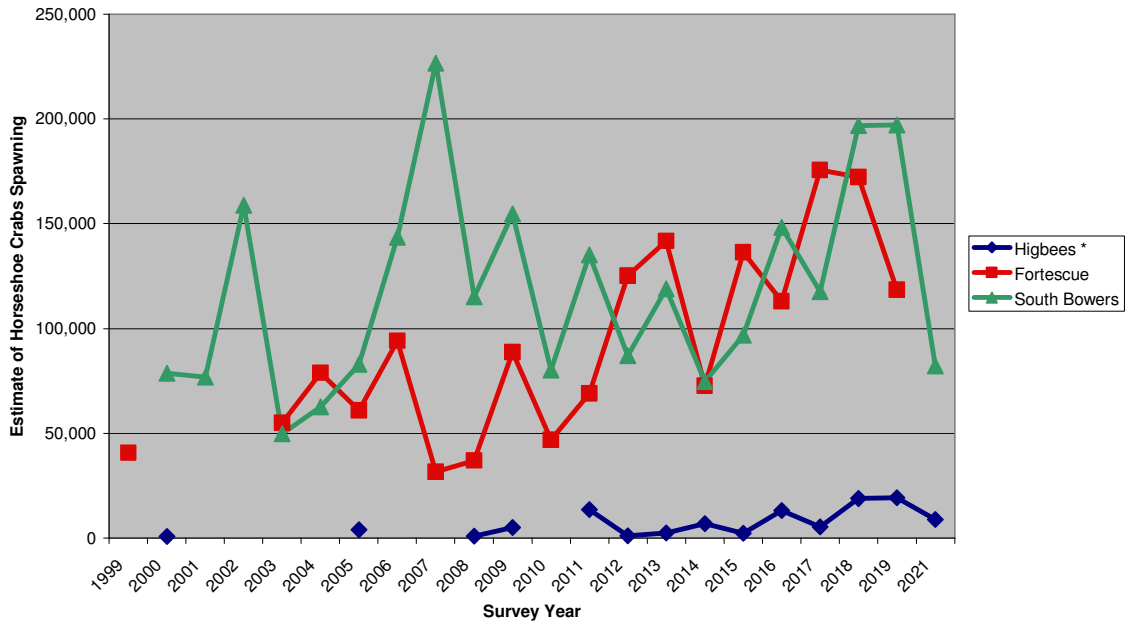
*Note Fortescue Beach, New Jersey and Woodland, Delaware were not surveyed in 2021, affecting the survey estimates.

**Note Higbees, New Jersey and South Bowers, Delaware were not surveyed in 2022, affecting the survey estimates.

**Figure 5. B. Seasonal Estimates of Male Horseshoe Crabs
1999-2022
(No Survey Data for 2020)**



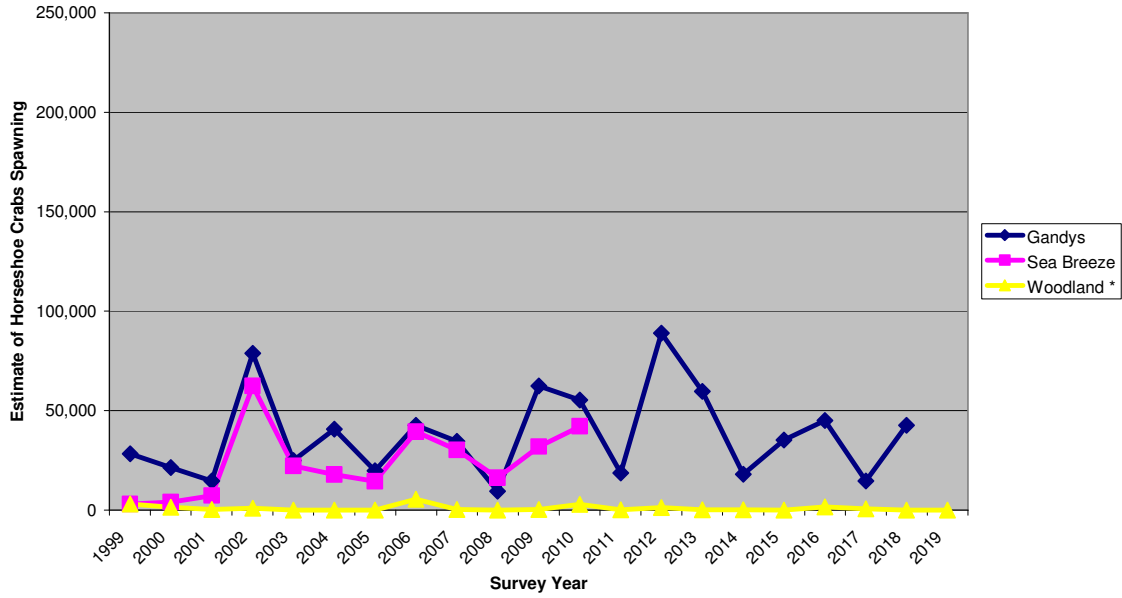
**Figure 6. A. Range of Estimates for Beaches Not Surveyed in 2021 and 2022
Fortescue Beach Not Surveyed in 2021
Higbees and South Bowers Not Surveyed in 2022**



*Note Fortescue Beach, New Jersey and Woodland, Delaware were not surveyed in 2021, affecting the survey estimates.

**Note Higbees, New Jersey and South Bowers, Delaware were not surveyed in 2022, affecting the survey estimates.

Figure 6. B. Range of Estimates for Beaches No Longer Surveyed
Gandys Beach, New Jersey Last Year Surveyed 2018
Sea Breeze, New Jersey Last Year Surveyed 2010
Woodland, Delaware Last Year Surveyed 2019



*Note Fortescue Beach, New Jersey and Woodland, Delaware were not surveyed in 2021, affecting the survey estimates.

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Table 1A. 2022 Survey Results – Densities and Estimates -New Jersey Beaches (2 pages)

Moon Phase Date	Full-2 14-May	Full 16-May	Full+2 18-May	New-2 28-May	New 30-May	New+2 1-Jun
North Cape May * (3 km)						
Density of HSC, Crabs/m	0.00	0.02	0.00	0.21	0.77	3.62
Estimated Number of HSC	0	60	0	630	2,310	10,860
Townbank (2.3 km)						
Density of HSC, Crabs/m	0.02	0.06	0.22	1.56	5.65	11.19
Estimated Number of HSC	46	138	506	3,588	12,995	25,737
Villas (2 km)						
Density of HSC, Crabs/m	1.55	2.55	11.83	10.24	18.57	20.56
Estimated Number of HSC	3,100	5,100	23,660	20,480	37,140	41,120
Norburys Landing (2.43 km)						
Density of HSC, Crabs/m	7.35	8.85	24.30	20.71	28.50	23.69
Estimated Number of HSC	17,861	21,506	59,049	50,325	69,255	57,567
South CSL * (2.2 km)						
Density of HSC, Crabs/m	4.20	cc- nobch	13.36	13.90	0.49	22.08
Estimated Number of HSC	9,240		29,392	30,580	1,078	48,576
Highs * (0.8 km)						
Density of HSC, Crabs/m	10.77	6.54	9.15	21.18	25.36	20.42
Estimated Number of HSC	8,616	5,232	7,320	16,944	20,288	16,336
Pierces Point (0.7 km)						
Density of HSC, Crabs/m	24.07	32.62	33.72	32.23	35.87	29.15
Estimated Number of HSC	16,849	22,834	23,604	22,561	25,109	20,405
Kimbles (1 km)						
Density of HSC, Crabs/m	2.01	3.56	19.62	17.56	cc-ns	16.63
Estimated Number of HSC	2,010	3,560	19,620	17,560		16,630
Reeds * (1.53 km)						
Density of HSC, Crabs/m	3.61	4.59	11.79	9.93	18.90	16.62
Estimated Number of HSC	5,523	7,023	18,039	15,193	28,917	25,429
Fortescue * (2.6 km)						
Density of HSC, Crabs/m	6.93	2.21	7.32	11.93	16.88	8.09
Estimated Number of HSC	18,018	5,746	19,032	31,018	43,888	21,034
Totals						
	81,263	71,198	200,222	208,879	240,980	283,693
Moon Phase Date	Full-2 14-May	Full 16-May	Full+2 18-May	New-2 28-May	New 30-May	New+2 1-Jun
Restored Beach						
Moores (1 km)						
Density of HSC, Crabs/m	3.71	8.24	11.08	20.46	20.00	23.26
Estimated Number of HSC	3,710	8,240	11,080	20,460	20,000	23,260

*Note Fortescue Beach, New Jersey and Woodland, Delaware were not surveyed in 2021, affecting the survey estimates.

**Note Higbees, New Jersey and South Bowers, Delaware were not surveyed in 2022, affecting the survey estimates.

Table 1A. 2022 Survey Results – Densities and Estimates -New Jersey Beaches (2 pages)

Moon Phase Date	Full-2 12-Jun	Full 14-Jun	Full+2 16-Jun	New-2 26-Jun	New 28-Jun	New+2 30-Jun	Totals
North Cape May * (3 km)							
Density of HSC, Crabs/m	0.06	0.18	0.39	0.02	0.00	0.08	5.35
Estimated Number of HSC	180	540	1,170	60	0	240	16,050
Townbank (2.3 km)							
Density of HSC, Crabs/m	0.72	1.09	1.07	0.06	0.14	0.34	22.12
Estimated Number of HSC	1,656	2,507	2,461	138	322	782	50,876
Villas (2 km)							
Density of HSC, Crabs/m	3.01	2.76	2.32	0.21	1.70	2.73	78.03
Estimated Number of HSC	6,020	5,520	4,640	420	3,400	5,460	156,060
Norburys Landing (2.43 km)							
Density of HSC, Crabs/m	0.85	1.44	cc-ns	0.54	1.75	2.65	120.63
Estimated Number of HSC	2,066	3,499		1,312	4,253	6,440	293,131
South CSL * (2.2 km)							
Density of HSC, Crabs/m	1.01	2.53	0.34	0.38	1.93	2.16	62.38
Estimated Number of HSC	2,222	5,566	748	836	4,246	4,752	137,236
Highs * (0.8 km)							
Density of HSC, Crabs/m	1.79	0.91	0.70	0.27	1.75	0.98	99.82
Estimated Number of HSC	1,432	728	560	216	1,400	784	79,856
Pierces Point (0.7 km)							
Density of HSC, Crabs/m	16.98	8.30	11.26	2.80	1.49	0.19	228.68
Estimated Number of HSC	11,886	5,810	7,882	1,960	1,043	133	160,076
Kimbles (1 km)							
Density of HSC, Crabs/m	1.41	0.74	0.76	0.15	0.27	0.73	63.44
Estimated Number of HSC	1,410	740	760	150	270	730	63,440
Reeds * (1.53 km)							
Density of HSC, Crabs/m	2.12	0.82	0.83	0.34	0.22	0.10	69.87
Estimated Number of HSC	3,244	1,255	1,270	520	337	153	106,901
Fortescue * (2.6 km)							
Density of HSC, Crabs/m	0.20	0.29	0.19	0.06	0.17	0.16	54.43
Estimated Number of HSC	520	754	494	156	442	416	141,518
Totals	30,635	26,919	19,985	5,768	15,712	19,890	1,205,144
Moon Phase Date	Full-2 12-Jun	Full 14-Jun	Full+2 16-Jun	New-2 26-Jun	New 28-Jun	New+2 30-Jun	Totals
Restored Beach							
Moores (1 km)							
Density of HSC, Crabs/m	1.72	4.82	cc- noacc	0.04	no data	1.7	95.03
Estimated Number of HSC	1,720	4,820		40		1,700	95,030

*Note Fortescue Beach, New Jersey and Woodland, Delaware were not surveyed in 2021, affecting the survey estimates.

**Note Higbees, New Jersey and South Bowers, Delaware were not surveyed in 2022, affecting the survey estimates.

Table 1B. 2022 Survey Results – Densities and Estimates - Delaware Beaches (2 pages)

Moon Phase Date	Full-2 14-May	Full 16-May	Full+2 18-May	New-2 28-May	New 30-May	New+2 1-Jun
Cape Henlopen (1.5 km)						
Density of HSC, Crabs/m	cc-nobch	1.94	3.08	6.93	8.65	6.52
Estimated Number of HSC		2,910	4,620	10,395	12,975	9,780
Broadkill (1.5 km)						
Density of HSC, Crabs/m	0.02	0.03	1.63	0.11	7.27	7.36
Estimated Number of HSC	30	45	2,445	165	10,905	11,040
Primehook * (2.0 km)						
Density of HSC, Crabs/m	0.03	0.35	10.95	0.18	13.34	8.83
Estimated Number of HSC	60	700	21,900	360	26,680	17,660
Fowler * (3 km)						
Density of HSC, Crabs/m	0.00	0.21	4.13	0.25	7.03	6.63
Estimated Number of HSC	0	630	12,390	750	21,090	19,890
Slaughter * (3 km)						
Density of HSC, Crabs/m	0.34	11.16	21.32	5.35	24.55	7.35
Estimated Number of HSC	1,020	33,480	63,960	16,050	73,650	22,050
Big Stone * (5.0 km)						
Density of HSC, Crabs/m	0.04	4.87	10.34	1.40	11.61	13.54
Estimated Number of HSC	200	24,350	51,700	7,000	58,050	67,700
Bennetts Pier (2.6 km)						
Density of HSC, Crabs/m	0.02	5.11	10.62	0.06	5.89	5.25
Estimated Number of HSC	52	13,286	27,612	156	15,314	13,650
North Bowers * (1.3 km)						
Density of HSC, Crabs/m	2.51	13.27	15.90	11.99	19.76	11.30
Estimated Number of HSC	3,263	17,251	20,670	15,587	25,688	14,690
Ted Harvey WMA (1.0 km)						
Density of HSC, Crabs/m	4.21	22.09	25.45	20.40	23.71	18.34
Estimated Number of HSC	4,210	22,090	25,450	20,400	23,710	18,340
Kitts Hummock * (1.0 km)						
Density of HSC, Crabs/m	4.55	18.92	19.85	23.42	26.32	19.23
Estimated Number of HSC	4,550	18,920	19,850	23,420	26,320	19,230
Pickering (1 km)						
Density of HSC, Crabs/m	10.31	27.10	27.02	31.34	31.78	25.58
Estimated Number of HSC	10,310	27,100	27,020	31,340	31,780	25,580
Totals	23,695	160,762	277,617	125,623	326,162	239,610
Moon Phase Date	Full-2 14-May	Full 16-May	Full+2 18-May	New-2 28-May	New 30-May	New+2 1-Jun

*Note Fortescue Beach, New Jersey and Woodland, Delaware were not surveyed in 2021, affecting the survey estimates.

**Note Higbees, New Jersey and South Bowers, Delaware were not surveyed in 2022, affecting the survey estimates.

Table 1B. 2022 Survey Results – Densities and Estimates - Delaware Beaches (2 pages)

Moon Phase Date	Full-2 12- Jun	Full 14- Jun	Full+2 16- Jun	New-2 26- Jun	New 28- Jun	New+2 30- Jun	Totals
Cape Henlopen (1.5 km)							
Density of HSC, Crabs/m	1.06	0.80	0.71	1.42	1.41	1.38	33.90
Estimated Number of HSC	1,590	1,200	1,065	2,130	2,115	2,070	50,850
Broadkill (1.5 km)							
Density of HSC, Crabs/m	0.02	0.11	0.18	0.05	0.00	0.03	16.81
Estimated Number of HSC	30	165	270	75	0	45	25,215
Primehook * (2.0 km)							
Density of HSC, Crabs/m	1.13	3.39	1.21	0.04	0.16	0.46	40.07
Estimated Number of HSC	2,260	6,780	2,420	80	320	920	80,140
Fowler * (3 km)							
Density of HSC, Crabs/m	0.23	0.39	0.63	0.00	0.03	0.16	19.69
Estimated Number of HSC	690	1,170	1,890	0	90	480	59,070
Slaughter * (3 km)							
Density of HSC, Crabs/m	0.84	1.75	1.66	0.65	1.76	5.49	82.22
Estimated Number of HSC	2,520	5,250	4,980	1,950	5,280	16,470	246,660
Big Stone * (5.0 km)							
Density of HSC, Crabs/m	2.52	3.34	2.91	0.00	0.02	0.06	50.65
Estimated Number of HSC	12,600	16,700	14,550	0	100	300	253,250
Bennetts Pier (2.6 km)							
Density of HSC, Crabs/m	3.12	1.25	4.00	0.06	0.03	1.02	36.43
Estimated Number of HSC	8,112	3,250	10,400	156	78	2,652	94,718
North Bowers * (1.3 km)							
Density of HSC, Crabs/m	0.71	0.68	1.75	0.19	0.70	0.52	79.28
Estimated Number of HSC	923	884	2,275	247	910	676	103,064
Ted Harvey WMA (1.0 km)							
Density of HSC, Crabs/m	6.81	7.91	12.88	2.08	5.00	5.77	154.65
Estimated Number of HSC	6,810	7,910	12,880	2,080	5,000	5,770	154,650
Kitts Hummock * (1.0 km)							
Density of HSC, Crabs/m	8.85	13.83	8.43	0.85	2.15	2.98	149.38
Estimated Number of HSC	8,850	13,830	8,430	850	2,150	2,980	149,380
Pickering (1 km)							
Density of HSC, Crabs/m	8.91	13.38	5.61	0.45	2.34	2.15	185.97
Estimated Number of HSC	8,910	13,380	5,610	450	2,340	2,150	185,970
Totals	53,295	70,519	64,770	8,018	18,383	34,513	1,402,967
Moon Phase Date	Full-2 12- Jun	Full 14- Jun	Full+2 16- Jun	New-2 26- Jun	New 28- Jun	New+2 30- Jun	Totals

*Note Fortescue Beach, New Jersey and Woodland, Delaware were not surveyed in 2021, affecting the survey estimates.

**Note Higbees, New Jersey and South Bowers, Delaware were not surveyed in 2022, affecting the survey estimates.

**Table 2. Comparison of Date on Horseshoe Crabs Spawning on Delaware Bay Shores
Years 1999-2022 (2 pages)
(No Survey Data for 2020)**

Peak Estimate	May 30	May 13	May 20	May 31	Jun 11	Jun 06	May 16	May 26	May 23	May 22	Jun 03	May 29
Year	2022	2021	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010
Number of Horseshoe Crabs	567,142**	402,970*	724,533	654,263	581,872	534,511	380,936	322,672	384,548	341,062	477,715	472,759
New Jersey Estimate	240,980**	100,250*	270,382	272,954	308,938	279,678	182,671	107,278	108,194	184,046	190,449	193,463
Delaware Estimate	326,162**	302,720	454,151	381,309	272,934	254,833	198,265	215,394	276,354	157,016	287,266	279,296
Number of Beaches Surveyed in DE	12	12	13	13	13	13	11	13	13	13	13	13
Number of Beaches Surveyed in NJ	10	10	11	12	12	12	12	12	12	12	12	12
Main Beaches in DE	Big Stone Slaughter Pickering	Slaughter Pickering	Big Stone Slaughter Pickering	Big Stone Slaughter South Bowers Pickering	Slaughter Big Stone Pickering	Big Stone South Bowers Pickering	Big Stone Slaughter South Bowers	Kitts Hummock Pickering Big Stone	Slaughter Pickering Big Stone	Pickering Ted Harvey S. Bowers	Big Stone S. Bowers Big Stone	Big Stone Slaughter S. Bowers Pickering
Main Beaches in NJ	Norburys Pierces Point Villas	Norburys Pierces Point Reeds	Reeds Norburys Pierces Point	South CSL Fortescue Norburys	Norburys South CSL Fortescue	Norburys South CSL Fortescue	Norburys South CSL Fortescue	Norburys Reeds Fortescue	Fortescue Norburys Gandys	Fortescue South CSL Gandys	South CSL Norburys Fortescue	South CSL Norburys Gandys

*Note Fortescue Beach, New Jersey and Woodland, Delaware were not surveyed in 2021, affecting the survey estimates.

**Note Higbees, New Jersey and South Bowers, Delaware were not surveyed in 2022, affecting the survey estimates.

**Table 2. Comparison of Date on Horseshoe Crabs Spawning on Delaware Bay Shores
Years 1999-2022 (2 pages)
(No Survey Data for 2020)**

Day	May 24	Jun 03	Jun 01	May 27	Jun 08	May 21	Jun 14	May 28	Jun 05	May 18	May 30
Year	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999
Number of Horseshoe Crabs	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	245,444	69,669	112,497	222,653	222,168	105,973	60,272	130,164	19,726	70,293	141,720
Delaware Estimate	340,854	276,650	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	13	13	11	9
Number of Beaches Surveyed in NJ	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	S. Bowers	Slaughter	Slaughter	Slaughter
	Slaughter	Slaughter	Slaughter	Slaughter	S. Bowers	Slaughter	Slaughter	Slaughter	Big Stone	Big Stone	Big Stone
	S. Bowers	Pickering	S. Bowers	S. Bowers	Bennets	Pickering	Pickering	Big Stone			
	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	Townbank
	Norburys	Norburys		Norburys	Norburys	Fortescue	Fortescue	Gandys			Norburys
	Reeds			Fortescue	Villas	Norburys	Norburys	Sea Breeze			South CSL

*Note Fortescue Beach, New Jersey and Woodland, Delaware were not surveyed in 2021, affecting the survey estimates.
 **Note Higbees, New Jersey and South Bowers, Delaware were not surveyed in 2022, affecting the survey estimates.

**Table 3. Percentages of Horseshoe Crab Densities 1999-2022
(No Survey Data for 2020)**

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
2018	New Jersey	3	49	13	17	17
	Delaware	3	44	8	24	22
2019	New Jersey	0	37	17	27	20
	Delaware	3	33	17	29	18
2021	New Jersey	2	53	13	16	16
	Delaware	8	58	7	15	12.5
2022	New Jersey	2.5	60	8	27	2.5
	Delaware	3	55	17	25	1

*Note Fortescue Beach, New Jersey and Woodland, Delaware were not surveyed in 2021, affecting the survey estimates.

**Note Higbees, New Jersey and South Bowers, Delaware were not surveyed in 2022, affecting the survey estimates.

**Table 4. Seasonal Estimates of Horseshoe Crabs 1999-2022
(No Survey Data for 2020)**

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
2018	1,189,246	1,675,841	2,865,087
2019	1,291,799	2,105,447	3,397,246
2021	781,159*	1,065,331	1,846,490*
2022	1,205,144**	1,402,967**	2,608,111**

*Note Fortescue Beach, New Jersey and Woodland, Delaware were not surveyed in 2021, affecting the survey estimates.

**Note Higbees, New Jersey and South Bowers, Delaware were not surveyed in 2022, affecting the survey estimates.

**Table 5. Sex Ratios and Estimates of Male and Female Horseshoe Crabs 1999-2022
(No Survey Data for 2020)**

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
2018	5.54	438,087	2,427,000
2019	5.38	532,484	2,864,762
2021	5.22	296,863*	1,549,627*
2022	5.22	419,310**	2,188,801**

*Note Fortescue Beach, New Jersey and Woodland, Delaware were not surveyed in 2021, affecting the survey estimates.

**Note Higbees, New Jersey and South Bowers, Delaware were not surveyed in 2022, affecting the survey estimates.

Table 6. Survey Dates and Times 2022

Lunar Date	Survey Date	Time of High Water@ Breakwater
Full Moon	Sat, May 14	8:14 pm (5.2 ft)
16-May	Mon, May 16	9:49 pm (5.7 ft)
	Wed, May 18	11:33 pm (5.6 ft)
New Moon	Sat, May 28	8.27 pm (4.9 ft)
30-May	Mon, May 30	9:40 pm (4.9 ft)
	Wed, June 01	10:56 pm (4.8 ft)
Full Moon	Sun, June 12	7:47 pm (5.4 ft)
14-Jun	Tues, June 14	9:33 pm (5.8 ft)
	Thurs, June 16	11:21 pm (5.6 ft)
New Moon	Sun, June 26	8:01 pm (4.7 ft)
28-Jun	Tues, June 28	9:19 pm (4.8 ft)
	Thurs, June 30	10:36 pm (4.8 ft)

*Note Fortescue Beach, New Jersey and Woodland, Delaware were not surveyed in 2021, affecting the survey estimates.

**Note Higbees, New Jersey and South Bowers, Delaware were not surveyed in 2022, affecting the survey estimates.