

The 2021 Delaware Bay Horseshoe Crab Spawning Survey

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Abstract

Counts of spawning horseshoe crabs were scheduled for 22 beaches along the Delaware Bay during the full and new lunar phases in May and June 2021. A total of 264 counts were planned, of which 227 counts were completed with 37 cancellations due to weather (26), no access (10), and no surveyors (1).

During past surveys, 24 beaches were surveyed, however Woodland beach in Delaware and Fortescue Beach in New Jersey were not surveyed in 2021. Woodland Beach was removed from the surveyed beaches in Delaware due to constant flooding along the road and the beach area. Fortescue Beach in New Jersey, surveyed by the State of New Jersey personnel, could not be surveyed in 2021 due to restrictions on field work caused by the COVID virus.

For the yearly survey reports (1999-2019), estimates were calculated from the beach counts, and those estimates were combined for state and baywide numbers. The state and baywide estimates were analyzed and compared to previous years to establish trends in the data series. The removal of Woodland from the surveyed beaches in Delaware had little to no effect on the overall numbers as spawning estimates from Woodland Beach were low. The seasonal estimate for Woodland beach averaged 888 spawning horseshoe crabs during the time series (1999-2019). The estimates ranged from zero in the years of 2008, 2015, 2018 and 2019 to a high estimate of 5,460 in the year 2006 (Figure 5).

Unlike Woodland's estimates, the estimates from Fortescue beach in New Jersey contributed substantially to previous years' state and baywide estimates and could potentially affect comparisons. The average estimate for Fortescue beach was 92,124 spawning horseshoe crabs over the 18 years, 1999 and 2003 to 2019. The range was from a low of 31,694 spawning horseshoe crabs in the year 2007 to a high of 175,448 in the year 2017 (Figure 4).

Previous survey reports focused on the spawning estimates and comparisons between years, however without the Fortescue data, only the 2021 seasonal estimate was considered. Roughly, the 2021 seasonal estimate for the Delaware Bay (New Jersey and Delaware) was 1,846,490* without New Jersey's Fortescue beach. The estimate was less than the record estimate of the 2019 year and falls within the mid range of the time series (1999-2019) with 13 estimates lower and 8 higher (Figure 2).

While the data cannot be compared to previous years in detail, the 2021 data highlighted the effect weather has on spawning numbers. The weather caused the

drastic rise and fall of spawning numbers throughout the 2021 season, and may have contributed to greater spawning activity in late June. In addition, the peak spawning count was recorded during the May 13th date, most likely due to the weather negatively impacting the subsequent counts in May and June. The date of May 13th was the earliest peak date recorded for the time series (1999-2019).

Introduction

Since its inception in 1999, our survey has made tremendous strides and is considered the premier method to estimate 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 their time and efforts to learn, count, enter and analyze the data acquired from the survey.

Methods

The 2021 Delaware Bay Survey was scheduled for 22 beaches along the Delaware Bay shore. The beaches include 12 beaches along the state of Delaware's coast, Pickering, Kitts Hummock, Ted Harvey Wildlife Management Area (WMA), North Bowers, South Bowers, Bennetts Pier, Big Stone, Slaughter, Fowler, Primehook, Broadkill and Cape Henlopen, and 10 along the coast of New Jersey, Reeds, Kimbles, Pierces Point, Highs, South Cape Shore Lab, Norburys Landing, Villas, Townbank, North Cape May and Higbees.

The dates for counting were May 9th, 11th, 13th, 24th, 26th, 28th and June 8th, 10th, 12th, 22nd, 24th, 26th. Times of high tides ranged from 7:30pm to 11:19pm 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. (Table 2)

Moore's beach, one of the replenished beaches in New Jersey, was surveyed in the year 2021. The data from Moore's beach was recorded, however the data was not incorporated into the Delaware Bay Horseshoe Crab Spawning Survey data. The survey/beach length of 900 meters was used to calculate the approximate number of spawning crabs on this beach.

Results

Along the 22 beaches, 264 surveys were scheduled for 12 dates, 144 in Delaware and 120 in New Jersey. Of these, 227 counts were completed with 37 cancellations due to weather (26), no access (10), and no surveyors (1). The majority of the weather cancellations occurred on three dates, May 28th, May 29th

and June 8th. On the May 28th and 29th dates, 12 counts in Delaware and 11 counts in New Jersey were cancelled due to weather and/or no access. On the June 8th date, four counts in Delaware and five counts in New Jersey were cancelled due to weather. (Tables 1A and 1B, Figures 1A and 1B and Figure 3A)

Eleven incomplete counts were recorded in Delaware and New Jersey. Surveys were incomplete if fewer than 100 quadrats were counted. Severe weather and/or abnormally high tides are typically responsible for the incomplete counts. The incomplete counts in Delaware occurred May 26th at Slaughter beach (50 quadrats), May 26th and June 8th at Bennetts (51 and 61 quadrats respectively) and May 13th, June 22nd and June 26th at North Bowers (95, 94 and 90 quadrats respectively). In New Jersey, the incomplete counts were recorded May 13th at Higbees (50 quadrats), May 26th at Villas (45 quadrats), June 8th at Kimbles (44 quadrats), and May 26th and May 28th at Reeds Beach (51 and 50 quadrats respectively).

The combined peak activity for the Delaware Bay was recorded on the May 13th date and most likely was the result of weather events later in the season that caused the subsequent survey counts to be low. The weather either cancelled the survey counts or hindered the horseshoe crabs' spawning behavior, resulting in low estimates. The May 13th date was the earliest peak date of spawning in the time series (1999-2021). Previously, the earliest peak date was May 16th, recorded in the year 2015.

The weather events also caused the spawning activity to be quite different between the New Jersey and Delaware shorelines. The peak estimates in New Jersey were May 24th (135,994) and June 10th (149,289). The two peak estimates along with the May 13th estimate (100,250) contributed 49% to New Jersey's seasonal estimate. Weather cancellations in New Jersey occurred May 26th (67,719 estimate), May 28th (61,723 estimate) and June 8th (53,213 estimate). (Table 1A and Figure 1A)

The peak estimate in Delaware occurred May 13th (302,720) with a second lesser peak estimate, June 8th (214,529), representing 49% of Delaware's seasonal estimate. Delaware's spawning numbers were drastically reduced May 24th (14,400 estimate) and May 28th (3,671 estimate) due to weather events. (Table 1B and Figure 1B)

A replenished beach, Moores Beach, was surveyed with the peak spawning estimate of 21,879 achieved on June 12th and a lesser number of 20,979 was estimated for June 10th. The estimates from these two dates contributed 52% to the seasonal estimate at Moores beach. Two counts, May 26th and May 28th, were canceled due to no access. (Table 1A) The data from Moores Beach is separate from the data derived from the 22 beaches surveyed since 1999 and was not included in the overall analysis.

The greatest densities of the season in New Jersey were observed at Pierces Point of 31.08 horseshoe crabs per square meter on May 13th and at Reeds Beach of 34.45 horseshoe crabs per square meter on May 26th (Table 1A). In Delaware, the highest densities were at Slaughter of 31.29 horseshoe crabs per square meter on May 13th and at Pickering of 32.87 horseshoe crabs per square meter on May 26th (Table 1B).

The densities for each count were categorized; no spawning activity equals 0 crabs, low activity equals less than 5 crabs per square meter, moderate activity equals 5 to 10 crabs per square meter, and high activity equals greater than 10 crabs per square meter. The data is analyzed in percentages since the number of dates and/or beaches may change yearly.

The majority of the dates surveyed (58% in DE and 53% in NJ) recorded densities lower than five horseshoe crabs per square meter. Eleven dates with zero horseshoe crabs were recorded in Delaware and only two dates with zero horseshoe crabs (2%) were recorded in New Jersey. High densities of greater than 10 crabs per square meter (31%) were recorded during the 2021 season (15% in Delaware and 16% in New Jersey) (Figure 3B).

Summary

In both Delaware and New Jersey, few horseshoe crabs were recorded on the first count of May 9th, spawning numbers increased May 11th and large groups were observed on most of the beaches by May 13th. Weather interfered with the next round of counts, May 24th, 26th and 28th. Due to windy conditions along the Delaware side of the Bay on May 24th, few horseshoe crabs were observed. Large and very large groups were observed during the May 26th, May 28th and June 8th counts in Delaware and New Jersey, although many counts were cancelled due to lightening. Fifty percent of the scheduled counts (33 of 66) were cancelled during the May 26th, May 28th and June 8th dates. Moderate numbers continued to be evident on the June 10th and June 12th dates. Spawning activity lasted until the end of the season with good counts recorded during the June 26th survey.

Roughly, the 2021 seasonal estimate for the Delaware Bay (New Jersey and Delaware) was 1,846,490* without New Jersey's Fortescue beach. The estimate was less than the record estimate of the 2019 year and falls within the mid range of the time series (1999-2019) with 13 estimates lower and 8 higher (Figure 2).

Discussion

Weather greatly affected the 2021 Delaware Bay horseshoe crab spawning activity. For the time series of the years 1999-2019, the earliest peak date of spawning, May 13th, was recorded for the 2021 season and was most likely due to the low spawning activity during the rest of the season due to weather events. Good spawning also lingered into the last round of counts in late June, with many

spawning horseshoe crabs observed during the last count of June 26th. The seasonal activity in New Jersey and Delaware were quite different from each other due to the 2021 weather events.

Thank you to the volunteers!

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Figure 1. A. New Jersey Spawning Estimates During Delaware Bay Horseshoe Crab 2021 Survey

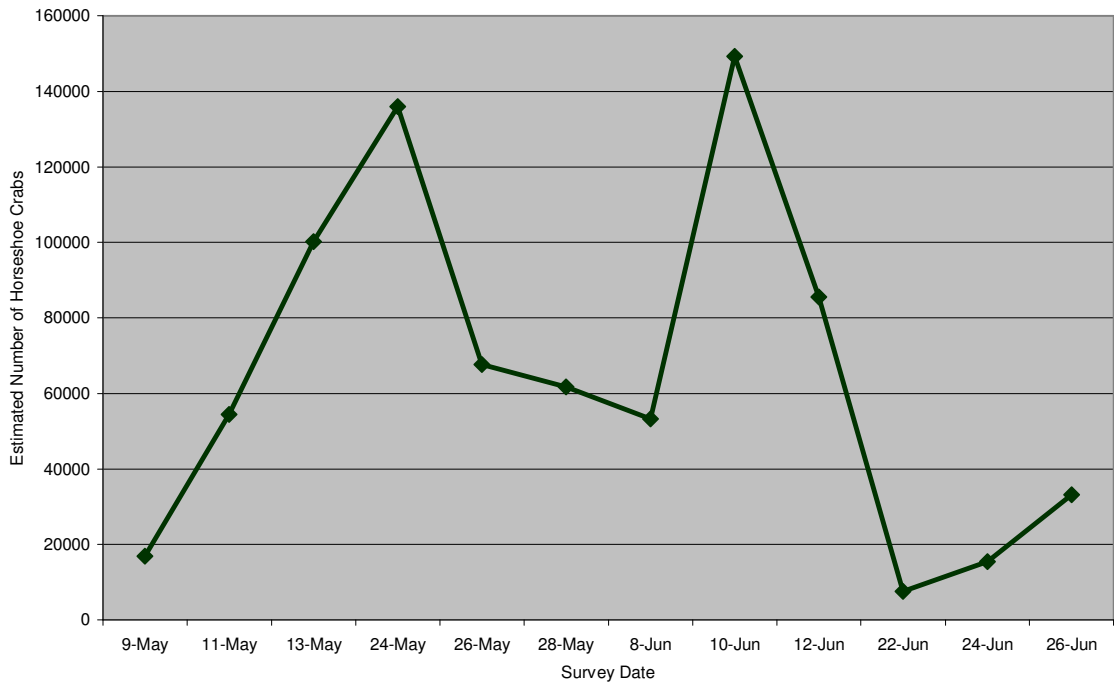
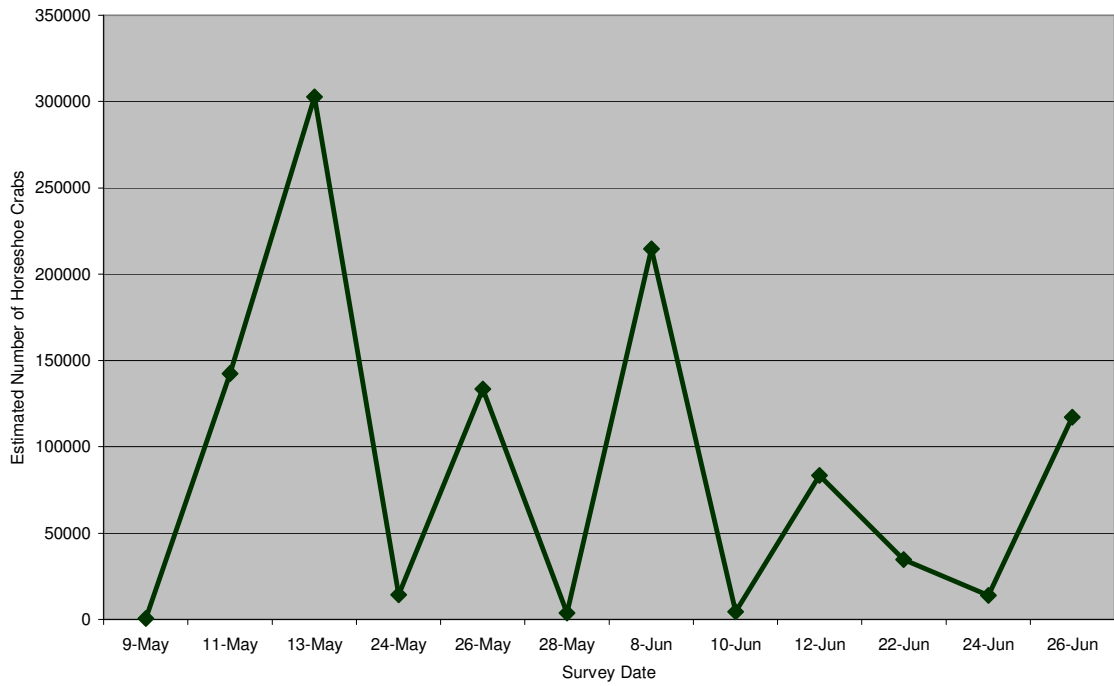
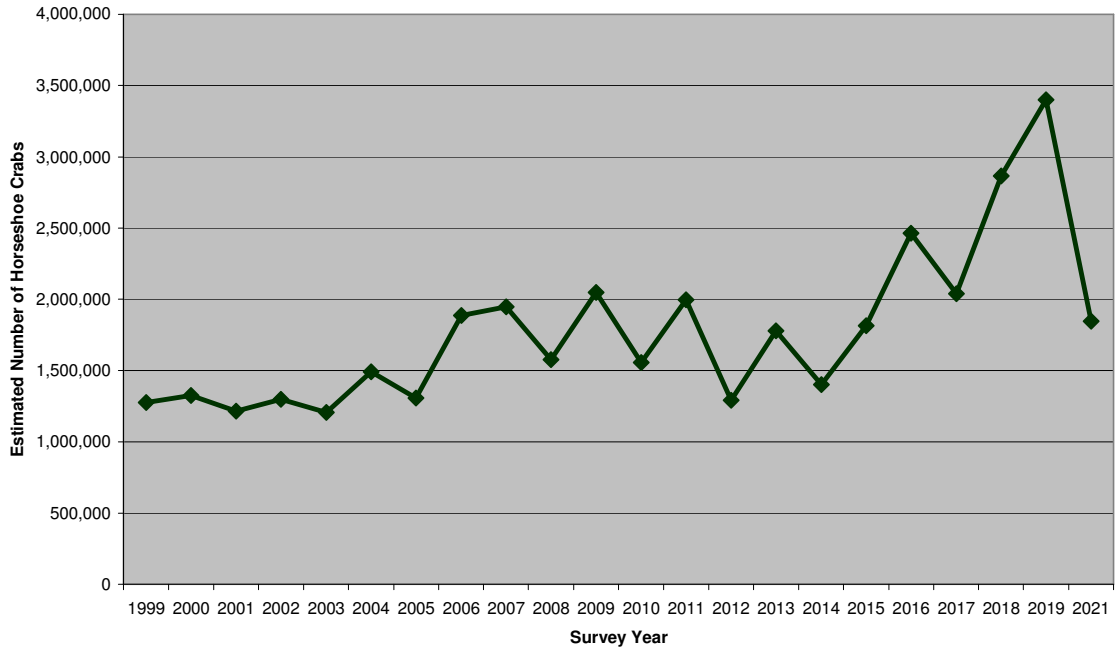


Figure 1. B. Delaware Spawning Estimates During Delaware Bay Horseshoe Crab 2021 Survey



**Figure 2. Seasonal Estimates of Horseshoe Crabs 1999-2021
(No Data for Survey Year 2020)**



**Figure 3. A. Percentages of Dates Missed - Delaware Bay Horseshoe Crab Survey Years 1999-2021
Note No Survey Data for 2020**

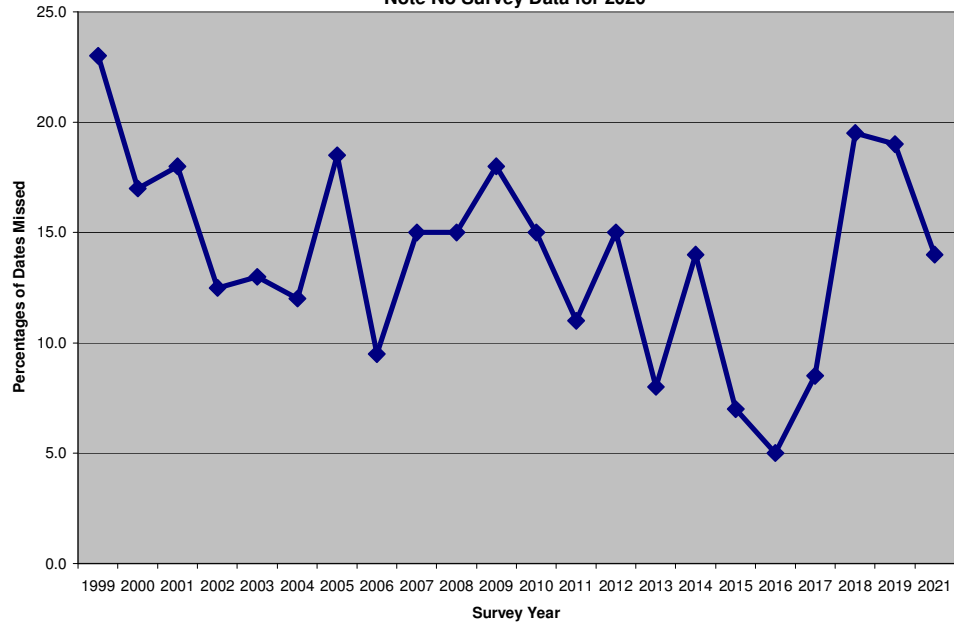


Figure 3.B. Percentages of High Densities - Delaware Bay Horseshoe Crab Survey Years 1999-2021 (Note No Survey Data for 2020)

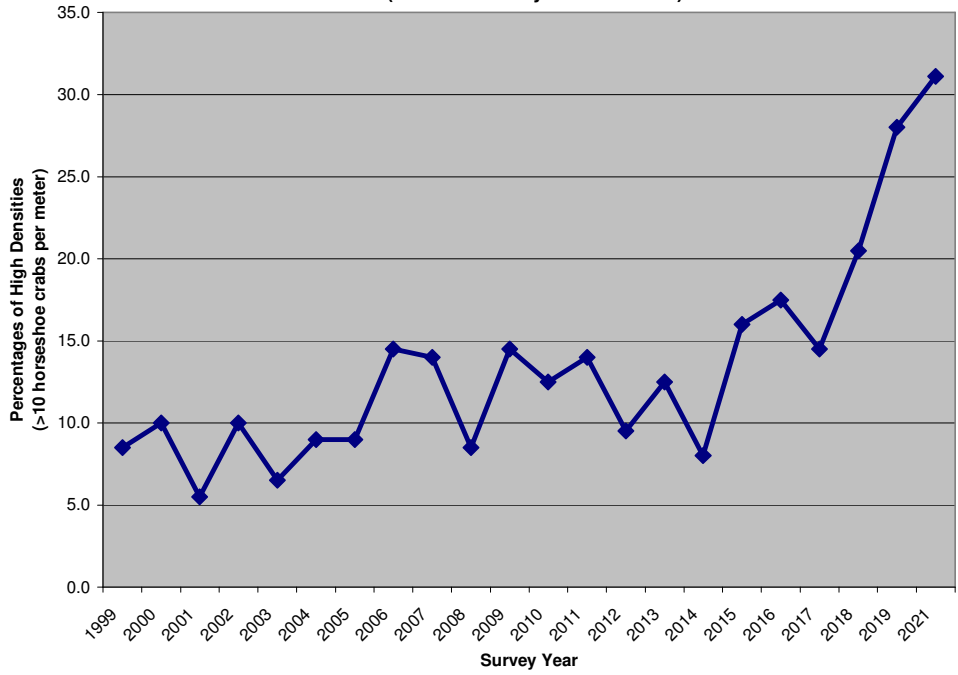


Figure 4. Seasonal Estimates of Horseshoe Crabs 1999-2019 at Fortescue Beach

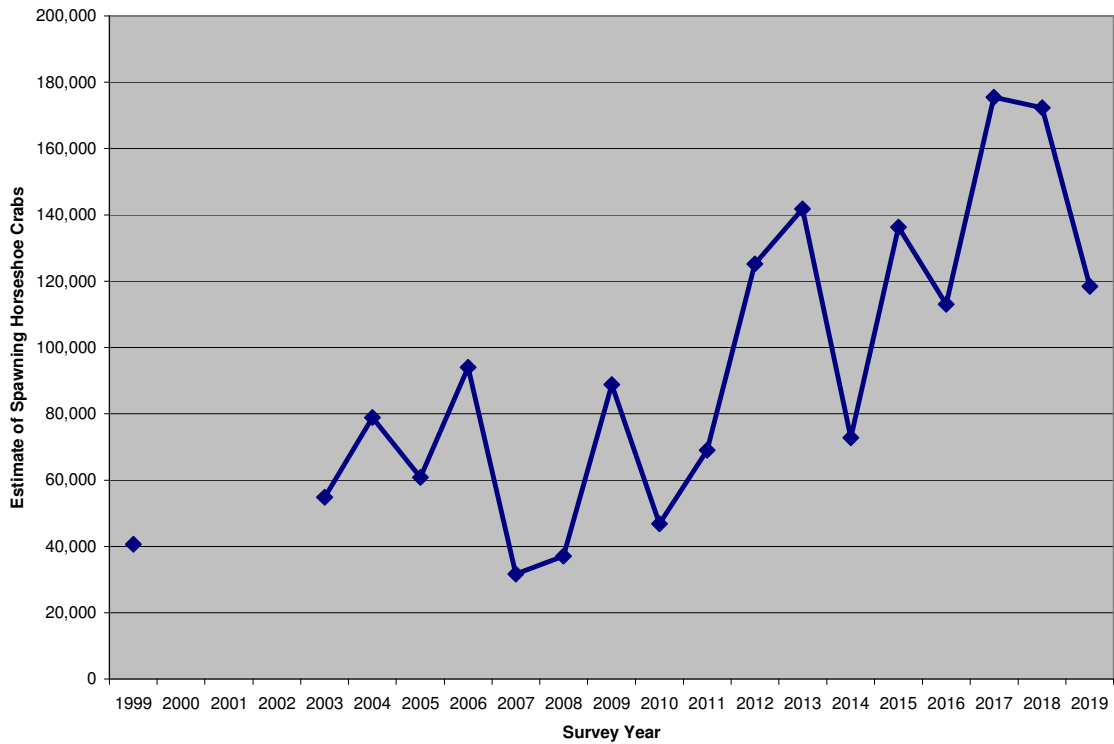


Figure 5. Seasonal Estimates at Woodland Beach Survey Years 1999-2019

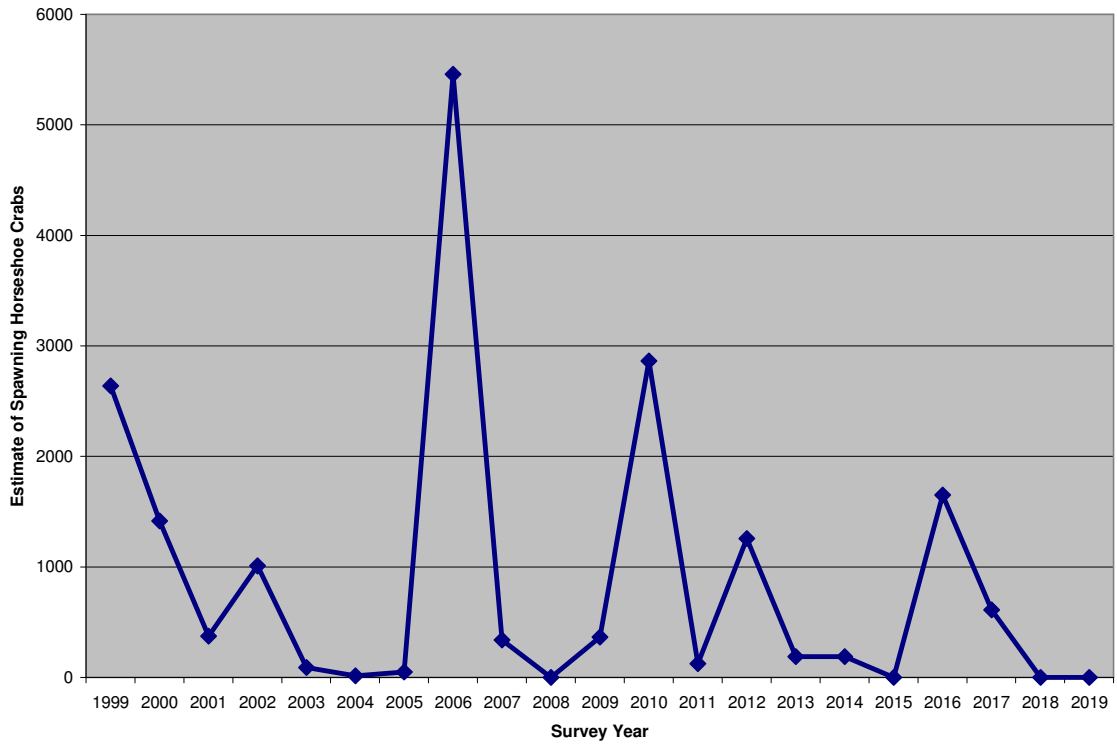


Table 1A. 2021 Survey Results – Densities and Estimates -New Jersey Beaches (2 pages)

Moon Phase Date	New-2 9-May	New 11- May	New+2 13-May	Full-2 24-May	Full 26-May	Full+2 28- May
Higbees * (0.98 km)						
Density of HSC, Crabs/m	0.03	0.02	0.12	0.66	cc-weath	cc- weath
Estimated Number of HSC	29	20	118	647		
North Cape May * (3 km)						
Density of HSC, Crabs/m	0.02	0.01	0.02	0.41	0.23	0.39
Estimated Number of HSC	60	30	60	1,230	690	1,170
Townbank (2.3 km)						
Density of HSC, Crabs/m	0.03	0.02	0.10	1.35	cc-weath	0.97
Estimated Number of HSC	69	46	230	3,105		2,231
Villas (2 km)						
Density of HSC, Crabs/m	0.25	0.99	5.91	4.40	7.16	cc- weath
Estimated Number of HSC	500	1,980	11,820	8,800	14,320	
Norburys Landing (2.43 km)						
Density of HSC, Crabs/m	1.18	7.54	16.05	6.43	cc-weath	cc- weath
Estimated Number of HSC	2,867	18,322	39,002	15,625		
South CSL * (2.2 km)						
Density of HSC, Crabs/m	0.06	1.21	1.43	16.16	cc-weath	4.91
Estimated Number of HSC	132	2,662	3,146	35,552		10,802
Highs * (0.8 km)						
Density of HSC, Crabs/m	0.40	4.12	3.69	12.71	cc-weath	7.92
Estimated Number of HSC	320	3,296	2,952	10,168		6,336
Pierces Point (0.7 km)						
Density of HSC, Crabs/m	1.68	24.88	31.08	26.61	cc-weath	15.12
Estimated Number of HSC	1,176	17,416	21,756	18,627		10,584
Kimbles (1 km)						
Density of HSC, Crabs/m	0.41	3.06	6.28	23.10	cc-weath	cc- noacc
Estimated Number of HSC	410	3,060	6,280	23,100		
Reeds * (1.53 km)						
Density of HSC, Crabs/m	7.39	4.93	9.73	12.51	34.45	20.00
Estimated Number of HSC	11,307	7,543	14,887	19,140	52,709	30,600
Totals	16,871	54,375	100,250	135,994	67,719	61,723
Moon Phase Date	New-2 9-May	New 11- May	New+2 13-May	Full-2 24-May	Full 26-May	Full+2 28- May
Replenished Beach-Moores						
Density of HSC, Crabs/m	0.00	3.77	7.21	10.32	cc-noacc	cc- noacc
Estimated Number of HSC	0	3,393	6,489	9,288		

Table 1A. 2021 Survey Results – Densities and Estimates -New Jersey Beaches (2 pages)

Moon Phase	New-2	New	New+2	Full-2	Full	Full+2	
Date	8-Jun	10-Jun	12-Jun	22-Jun	24-Jun	26-Jun	Totals
Higbees * (0.98 km)							
Density of HSC, Crabs/m	cc-weath	2.58	3.32	0.03	0.45	1.76	
Estimated Number of HSC		2,528	3,254	29	441	1,725	8,791
North Cape May * (3 km)							
Density of HSC, Crabs/m	0.54	0.69	0.97	0.00	0.25	0.32	
Estimated Number of HSC	1,620	2,070	2,910	0	750	960	11,550
Townbank (2.3 km)							
Density of HSC, Crabs/m	4.20	8.01	2.68	0.00	0.50	1.95	
Estimated Number of HSC	9,660	18,423	6,164	0	1,150	4,485	45,563
Villas (2 km)							
Density of HSC, Crabs/m	cc-weath	10.80	3.64	0.01	1.37	3.77	
Estimated Number of HSC		21,600	7,280	20	2,740	7,540	76,600
Norburys Landing (2.43 km)							
Density of HSC, Crabs/m	cc-weath	13.58	11.84	cc-noacc	0.93	3.89	
Estimated Number of HSC		32,999	28,771		2,260	9,453	149,299
South CSL * (2.2 km)							
Density of HSC, Crabs/m	cc-weath	19.09	8.40	0.13	0.43	1.01	
Estimated Number of HSC		41,998	18,480	286	946	2,222	116,226
Highs * (0.8 km)							
Density of HSC, Crabs/m	cc-weath	8.49	3.01	0.14	0.45	2.17	
Estimated Number of HSC		6,792	2,408	112	360	1,736	34,480
Pierces Point (0.7 km)							
Density of HSC, Crabs/m	26.82	15.56	13.58	9.76	8.63	6.06	
Estimated Number of HSC	18,774	10,892	9,506	6,832	6,041	4,242	125,846
Kimbles (1 km)							
Density of HSC, Crabs/m	6.36	3.02	3.89	0.19	cc-noacc	cc-noacc	
Estimated Number of HSC	6,360	3,020	3,890	190			46,310
Reeds * (1.53 km)							
Density of HSC, Crabs/m	10.98	5.86	1.90	0.06	0.49	0.52	
Estimated Number of HSC	16,799	8,966	2,907	92	750	796	166,495
Totals	53,213	149,289	85,570	7,561	15,438	33,158	
Moon Phase	New-2	New	New+2	Full-2	Full	Full+2	781,159
Date	8-Jun	10-Jun	12-Jun	22-Jun	24-Jun	26-Jun	Totals
Replenished Beach-Moores							
Density of HSC, Crabs/m	17.82	23.31	24.31	0.12	1.77	1.03	
Estimated Number of HSC	16,038	20,979	21,879	108	1,593	927	80,694

Table 1B. 2019 Survey Results – Densities and Estimates - Delaware Beaches (2 pages)

Moon Phase Date	New-2 9-May	New 11-May	New+2 13-May	Full-2 24- May	Full 26-May	Full+2 28- May
Cape Henlopen (1.5 km)						
Density of HSC, Crabs/m	0.00	0.12	0.27	0.99	4.77	cc- noacc
Estimated Number of HSC	0	180	405	1,485	7,155	
Broadkill (1.5 km)						
Density of HSC, Crabs/m	0.00	0.04	3.24	0.04	0.10	cc- weath
Estimated Number of HSC	0	60	4,860	60	150	
Primehook * (2.0 km)						
Density of HSC, Crabs/m	0.02	1.21	18.87	0.51	cc- weath	0.67
Estimated Number of HSC	40	2,420	37,740	1,020		1,340
Fowler * (3 km)						
Density of HSC, Crabs/m	0.00	0.00	0.19	0.00	2.73	0.11
Estimated Number of HSC	0	0	570	0	8,190	330
Slaughter * (3 km)						
Density of HSC, Crabs/m	0.02	19.91	31.29	0.02	15.16	cc- noacc
Estimated Number of HSC	60	59,730	93,870	60	45,480	
Big Stone * (5.0 km)						
Density of HSC, Crabs/m	0.04	1.06	11.72	0.10	cc- weath	cc- noacc
Estimated Number of HSC	200	5,300	58,600	500		
Bennetts Pier (2.6 km)						
Density of HSC, Crabs/m	0.00	0.33	4.16	0.03	15.27	0.00
Estimated Number of HSC	0	858	10,816	78	39,702	0
South Bowers (2.3 km)						
Density of HSC, Crabs/m	0.00	4.44	7.81	0.04	cc- weath	cc- noacc
Estimated Number of HSC	0	10,212	17,963	92		
North Bowers * (1.3 km)						
Density of HSC, Crabs/m	0.02	5.06	8.72	6.75	cc- weath	0.07
Estimated Number of HSC	26	6,578	11,336	8,775		91
Ted Harvey WMA (1.0 km)						
Density of HSC, Crabs/m	0.02	18.26	23.26	0.23	cc- weath	0.04
Estimated Number of HSC	20	18,260	23,260	230		40
Kitts Hummock * (1.0 km)						
Density of HSC, Crabs/m	0.02	23.42	19.89	0.33	cc- weath	1.87
Estimated Number of HSC	20	23,420	19,890	330		1,870
Pickering (1 km)						
Density of HSC, Crabs/m	0.00	15.49	23.41	1.77	32.87	cc- noacc
Estimated Number of HSC	0	15,490	23,410	1,770	32,870	
Totals	366	142,508	302,720	14,400	133,547	3,671
Moon Phase	New-2	New	New+2	Full-2	Full	Full+2
Date	9-May	11-May	13-May	24- May	26-May	28- May

Table 1B. 2021 Survey Results – Densities and Estimates - Delaware Beaches (2 pages)

Moon Phase Date	New-2 8-Jun	New 10-Jun	New+2 12-Jun	Full-2 22-Jun	Full 24-Jun	Full+2 26-Jun	Totals
Cape Henlopen (1.5 km)							
Density of HSC, Crabs/m	0.30	0.93	1.29	0.62	2.36	1.83	
Estimated Number of HSC	450	1,395	1,935	930	3,540	2,745	20,220
Broadkill (1.5 km)							
Density of HSC, Crabs/m	cc- weath	0.27	1.65	1.82	0.58	1.97	
Estimated Number of HSC		405	2,475	2,730	870	2,955	14,565
Primehook * (2.0 km)							
Density of HSC, Crabs/m	cc- weath	0.03	3.72	0.79	0.32	1.08	
Estimated Number of HSC		60	7,440	1,580	640	2,160	54,440
Fowler * (3 km)							
Density of HSC, Crabs/m	cc- weath	0.00	0.06	0.05	0.10	0.26	
Estimated Number of HSC		0	180	150	300	780	10,500
Slaughter * (3 km)							
Density of HSC, Crabs/m	29.56	0.73	8.02	2.95	0.35	18.52	
Estimated Number of HSC	88,680	2,190	24,060	8,850	1,050	55,560	379,590
Big Stone * (5.0 km)							
Density of HSC, Crabs/m	cc- weath	0.01	0.38	0.17	0.38	0.54	
Estimated Number of HSC		50	1,900	850	1,900	2,700	72,000
Bennetts Pier (2.6 km)							
Density of HSC, Crabs/m	0.10	0.02	cc-ns	0.59	0.06	7.19	
Estimated Number of HSC	260	52		1,534	156	18,694	72,150
South Bowers (2.3 km)							
Density of HSC, Crabs/m	16.57	cc-noacc	4.68	0.64	0.51	1.08	
Estimated Number of HSC	38,111		10,764	1,472	1,173	2,484	82,271
North Bowers * (1.3 km)							
Density of HSC, Crabs/m	15.86	0.02	2.88	1.23	0.08	0.66	
Estimated Number of HSC	20,618	26	3,744	1,599	104	858	53,755
Ted Harvey WMA (1.0 km)							
Density of HSC, Crabs/m	18.77	0.05	4.01	5.45	1.83	8.71	
Estimated Number of HSC	18,770	50	4,010	5,450	1,830	8,710	80,630
Kitts Hummock * (1.0 km)							
Density of HSC, Crabs/m	18.46	0.00	9.81	4.90	1.19	10.54	
Estimated Number of HSC	18,460	0	9,810	4,900	1,190	10,540	90,430
Pickering (1 km)							
Density of HSC, Crabs/m	29.18	0.13	17.19	4.62	1.10	9.02	
Estimated Number of HSC	29,180	130	17,190	4,620	1,100	9,020	134,780
Totals	214,529	4,358	83,508	34,665	13,853	117,206	
Moon Phase Date	New-2 8-Jun	New 10-Jun	New+2 12-Jun	Full-2 22-Jun	Full 24-Jun	Full+2 26-Jun	Totals
							1,065,331

Table 2. 2021 Survey Dates and Times

Lunar Date	Survey Date	Time of High Water@ Breakwater
New Moon	Sun, May 9	8:24 pm (4.6 ft)
11-May	Tues, May 11	9:33 pm (4.8 ft)
	Thurs, May 13	10:43 pm (4.8 ft)
Full Moon	Mon, May 24	7:51 pm (5.4 ft)
26-May	Wed, May 26	9:34 pm (5.8 ft)
	Fri, May 28	11:19 pm (5.6 ft)
New Moon	Tues, June 8	8:29 pm (4.7 ft)
10-Jun	Thurs, June 10	9:44 pm (4.8 ft)
	Sat, June 12	11:02 pm (4.8 ft)
Full Moon	Tues, June 22	7:30 pm (5.4 ft)
24-Jun	Thurs, June 24	9:19 pm (5.7 ft)
	Sat, June 26	11:04 pm (5.5 ft)