The Partial 2020 Delaware Bay Horseshoe Crab Spawning Survey
Spawning Surveys of Six Delaware Bay Beaches

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Abstract

The 2020 Delaware Bay Horseshoe Crab Survey was drastically curtailed due to restrictions in place for the COVID-19 virus. Instead of the customary 25 beaches, six beaches were surveyed, five beaches in Delaware and one beach in New Jersey. The State of Delaware surveyed Bennetts Pier and Pickering Beach. William Hall, the Lead Survey Coordinator for Delaware, surveyed South Bowers. Delaware Sea Grant and Delaware Wildlands surveyed Big Stone Beach, and Delaware National Estuarine Research Reserve (DNERR) surveyed Ted Harvey Wildlife Management Area (WMA). Benjie Swan, the Coordinator for the overall survey, counted at Highs Beach, New Jersey. Personnel from the State of New Jersey were restricted from fieldwork and could not survey at Fortescue beach in 2020.

A total of 63 counts were scheduled for the 2020 Delaware Bay Horseshoe Crab Survey. The survey was planned for 12 dates at Bennetts Pier and Pickering Beach in Delaware and at Highs Beach in New Jersey, and for nine dates, May 20th, 22nd, 24th and June 3rd, 5th, 7th, 19th, 21st, 23rd, at South Bowers, Big Stone Beach, and Ted Harvey WMA in Delaware. The early counts of May 5th, 7th, and 9th were not scheduled for these three beaches due to restrictions on field work at that time. Of the 63 counts, ten (15.9%) were canceled due to weather (2), no access/ beach flooding (4), and no surveyors (4).

Spawning activity along Delaware's coast was greatest surrounding the full moon date of June 5th. On the date of June 5th, Big Stone (82,450), South Bowers (37,191), and Ted Harvey WMA (27,930) beaches achieved their peak estimate of the season. The greatest estimate for Pickering Beach (40,630) occurred on June 3rd, two days before the full moon, and for Bennetts Pier (8,788) on June 7th, two days after the full moon.

In New Jersey at Highs Beach, the peak estimate of 15,832 spawning individuals was achieved on May 24th, and a close second of 13,192 was estimated on June 7th. Unfortunately, the count of June 5th was canceled, and may have had the greatest spawning activity of the season.

Many of the counts (38.1%) were in densities of less than five horseshoe crabs per square meter, similar to previous years. Four of the six counts with no spawners (9.5%) were recorded on the May 20th date due to windy conditions. Densities of more than ten horseshoe crabs per square meter (28.6%) were observed during the second and third round of counts, mid-May and early June. The highest densities were encountered at Pickering Beach of 40.63 horseshoe crabs per square meter on June 3rd and 37.34 crabs per square meter on June 5th.

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 their time and efforts to learn, count, enter and analyze the survey's data.

Methods

Horseshoe crabs were enumerated in the months of May and June 2020 along the shores of the Delaware Bay. Six beaches were represented in this year's count (five along the state of Delaware's coast and one along New Jersey's coast). The five Delaware beaches from south to north were Big Stone, Bennetts Pier, South Bowers, Ted Harvey Wildlife Management Area (WMA), and Pickering Beach. The one New Jersey beach was Highs Beach.

The counts were coordinated with the tidal progression along the six beaches encompassing the new and full moons on the dates of May 5th, 7th, 9th, 20th, 22nd, 24th, and June 3rd, 5th, 7th, 19th, 21st, and 23rd. Times of high tides ranged from 7:39 pm to 11:18 pm, with the high tide approaching the northern beaches later into the night. (Table 3)

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 using the reduced number of quadrats and then analyzed the same way as complete counts.

Results

Along the six beaches, 63 surveys were scheduled, 51 in Delaware and 12 in New Jersey. Of these, 53 surveys (84%) were conducted with ten cancellations due to weather (2), no access (4), and no surveyors (4). The two weather cancellations occurred May 9th and June 5th at Highs Beach. The last four survey dates at Ted Harvey WMA were canceled due to lack of surveyors. (Table 1A and1B)

Spawning activity along Delaware's coast was greatest surrounding the full moon date of June 5th. Big Stone (82,450), South Bowers (37,191), and Ted Harvey WMA (27,930) achieved their peak estimate of the season on the date of June 5th. The greatest estimate at Pickering Beach (40,630) occurred on June 3rd, two days before the full moon, and at Bennetts Pier (8,788) on June 7th, two days after the full moon. (Table 1B)

In New Jersey, Highs Beach's peak estimate of 15,832 spawning horseshoe crabs was achieved on May 24th and a close second of 13,192 occurred June 7th. The count of June 5th was canceled and most likely would have been the date with the peak estimate of the season. The two estimates from the May 24th and June 7th dates contributed 50% to the seasonal estimate at Highs Beach. (Table 1A)

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 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.

The majority of the survey dates (38.1%) recorded densities lower than five horseshoe crabs per square meter, similar to previous years. None of the ten counts at Highs Beach and six of the Delaware dates recorded zero crabs. In Delaware, the highest densities of 40.63 and 37.34 crabs per square meter were recorded at Pickering on June 3rd and June 5th, respectively (Table 1B).

Observations of tagged horseshoe crabs during the survey counts numbered 13, all alive. Eight recaptures were found at Pickering, one at South Bowers, and four at Ted Harvey WMA. This year, few observations were made due to COVID19 restrictions reducing the tagging effort and the survey volunteers' surveillance. (Table 2)

Summary

In general, the 2020 spawning season was slow to start due to unusually low water temperatures for that time of year. The spawning activity peaked in the beginning of June during the third lunar phase and lingered into the latter part of June, the last lunar phase. During the second lunar phase, the first of the three counts (May 20th) was adversely affected by weather and the next two counts recorded moderate numbers. The majority of the seasonal spawning (85%) was observed in June and can be attributed partly to the greater number of counts conducted in June (36 dates compare to 27 dates in May). (Figure 1)

The 2020 survey data were not compared to previous years' estimates as only six beaches, one-fourth of the customary beaches were surveyed. Simply, multiplying the data by 4 (6 beaches multiplied by 4 =24) is not acceptable for comparison as all beaches are not equal in spawning activity. The survey results from the years 1999-2019 reveal the differences in spawning activity among the Delaware Bay beaches with the middle beaches containing the greatest numbers of spawners.

It may be more beneficial to compare the seasonal estimates from a single beach over the time series as long as the majority of the 12 dates were counted each year. Pickering Beach was surveyed in the year 2020 and was surveyed in preceding years 2000 to 2019 with few dates cancelled. Pickering Beach was recognized as one of the main spawning beaches as early as the year 1991, and it has continued to be one of the beaches with the greatest spawning activity during the time series. The estimates from Pickering Beach in Delaware were graphed with previous years' estimates for the time series, years 2000 - 2020. Reviewing the estimates at Pickering Beach, roughly three levels of spawning activity are shown. Low levels during the years 2000 to 2007, moderate levels through to the year 2013, low estimates in 2014 and 2015 and higher spawning activity during recent years 2016 to 2020. (Figure 2)

Discussion

Aside from the beaches not being alike in spawning activity, the tides or days that spawning occurs differ as well based on the accumulated survey data. Horseshoe crabs generally spawn on both of the two daily high tides in Delaware Bay with greater numbers usually observed during the night high tide. Dates around the four lunar phases in May and June (two new moon dates and two full moon dates) are expected to exhibit the greatest spawning activity. The peak of spawning activity usually occurs during the second lunar phase in May or the third lunar phase (early June), with the first and last moon phases containing the lower estimates.

The survey attempts to estimate the number of spawning individuals during the months of May and June when the horseshoe crabs have migrated from deep water to near shore locations to spawn. Surveys are conducted at nighttime and around the moon dates when spawning is expected to be the greatest. Since spawning is governed by weather, three counts surrounding the lunar period are sampled: two days prior, the day of, and two days after a full/new moon phase. Multiple survey nights were designed to achieve a representative count and reduce variance if adverse weather conditions arise. Adverse weather conditions include cold water temperatures that deter the horseshoe crabs from approaching the near shore especially in the early part of the spawning season, windy conditions that deter the horseshoe crabs from coming onto the beach to spawn and very high tides that cause beach flooding creating fast moving water along the water's edge preventing the horseshoe crabs from settling in.

Not only does weather adversely affect the spawning activity, weather conditions also interfere with the volunteers' ability to survey. Volunteers are instructed not to survey during lightening storms, and flooding conditions may prevent the surveyors from accessing the beach. These weather-related occurrences result in missed or cancelled counts. When the data is analyzed, the cancelled dates are equivalent to zero counts, even though there may be zero, few or many horseshoe crabs on the beach. Thus, it is important to distinguish the cancelled dates from dates that volunteers were able to survey but counted zero horseshoe crabs. Cancelled dates are often more indicative of poor weather conditions for spawning than a declining population.

Each year, the survey data is analyzed two different ways, and is reported via a Volunteer Survey Report and a Statistical Report. The Volunteer Survey Report extrapolates the densities of horseshoe crabs per length of the survey beach, attempting to make the numbers more realistic to the volunteers. The Statistical Survey Report reports the Index of Spawning Activity (ISA), the number of females or males per one square meter, thus lowering the coefficient of variation to determine significance. Missed/cancelled dates contribute a non meaningful zero which skews the data. Without taking into account the weather conditions, it is difficult to compare yearly estimates without adding an explanation. A future goal of the Survey is to incorporate weather conditions into the trend analysis.

Listing of Figures

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Figure 1. Spawning Estimates from Six Delaware Bay Beaches During 2020 Survey

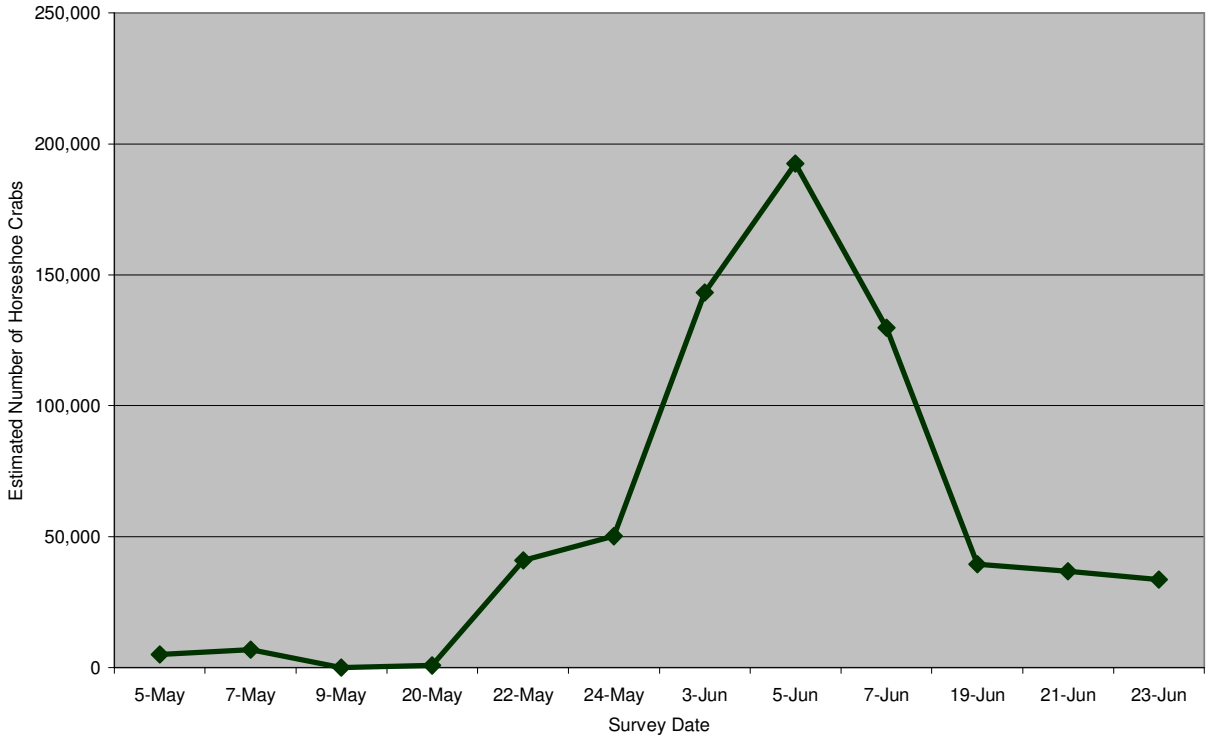

Figure 2 Survey Estimates at Pickering Years 2000-2020

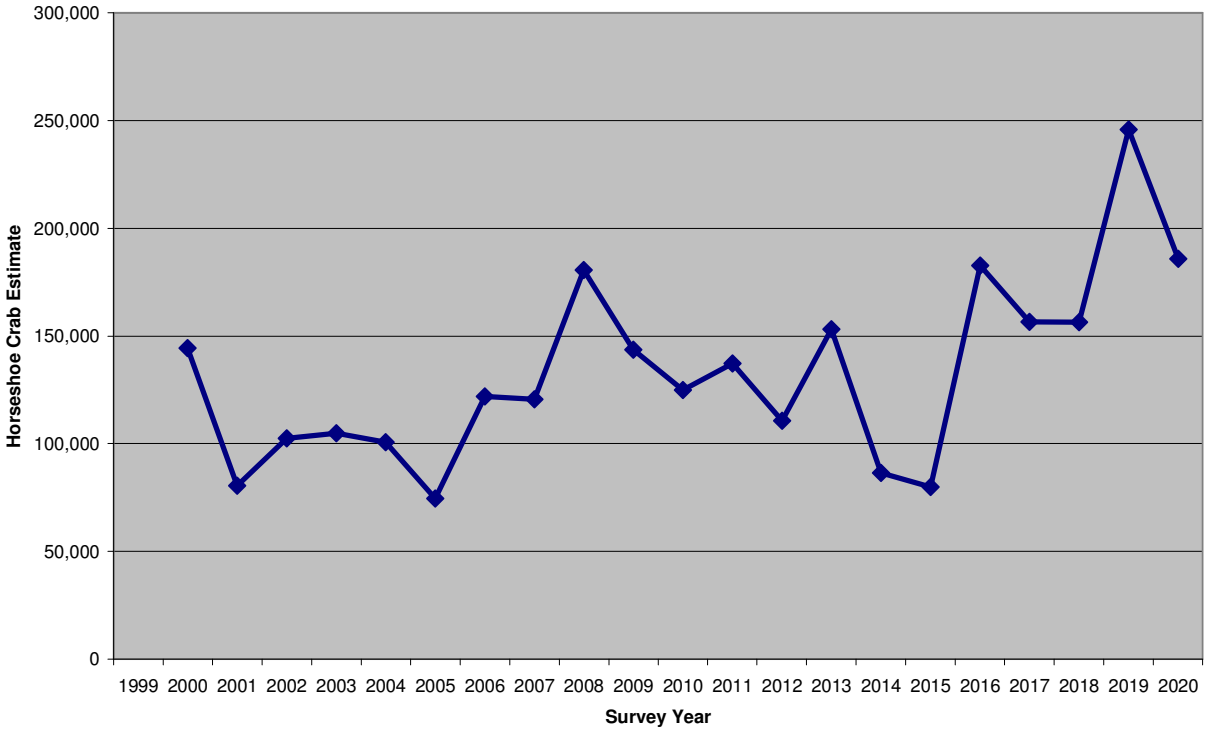

Table 1A. 2020 Survey Results – Densities and Estimates -New Jersey Beaches

Moon Phase	Full-2	Full	Full+2	New-2	New	New+2	
Date	5-May	7-May	9-May	20-May	22-May	24-May	
Highs * (0.8 km)							
Density of HSC, Crabs/m	3.36	2.34 cc-ns		1.06	12.30	19.79	
Estimated Number of HSC	2,688	1,872		848	9,840	15,832	
Moon Phase	**Full-2**	**Full**	**Full+2**	**New-2**	**New**	**New+2**	**Totals**
Date	**3-Jun**	**5-Jun**	**7-Jun**	**19-Jun**	**21-Jun**	**23-Jun**	
Highs * (0.8 km)							
Density of HSC, Crabs/m	10.57 cc-ns		16.49	3.84	2.78	0.44	
Estimated Number of HSC	8,456		13,192	3,072	2,224	352	58,376

Table 1B. 2020 Survey Results – Densities and Estimates - Delaware Beaches

Moon Phase	Full-2	Full	Full+2	New-2	New	New+2	
Date	5-May	7-May	9-May	20-May	22-May	24-May	
Big Stone * (5.0 km)							
Density of HSC, Crabs/m	No Survey	No Survey	No Survey	0.00	0.48	0.08	
Estimated Number of HSC				0	2,400	400	
Bennetts Pier (2.6 km)							
Density of HSC, Crabs/m	0.02	0.12	0.00	0.00	0.00	cc-ns	
Estimated Number of HSC	52	312	0	0	0		
South Bowers (2.3 km)							
Density of HSC, Crabs/m	No Survey	No Survey	No Survey	0.00	1.55	cc-ns	
Estimated Number of HSC				0	3,565		
Ted Harvey WMA (1.0 km)							
Density of HSC, Crabs/m	No Survey	No Survey	No Survey	0.01	15.11	9.88	
Estimated Number of HSC				10	15,110	9,880	
Pickering (1 km)							
Density of HSC, Crabs/m	2.36	4.61	0.04	0.00	10.03	24.02	
Estimated Number of HSC	2,360	4,610	40	0	10,030	24,020	
Totals	2,412	4,922	40	10	31,105	34,300	

Moon Phase	Full-2	Full	Full+2	New-2	New	New+2	
Date	3-Jun	5-Jun	7-Jun	19-Jun	21-Jun	23-Jun	Totals
Big Stone * (5.0 km)							
Density of HSC, Crabs/m	8.49	16.49	15.10	0.31	1.53	1.03	
Estimated Number of HSC	42,450	82,450	75,500	1,550	7,650	5,150	217,550
Bennetts Pier (2.6 km)							
Density of HSC, Crabs/m	0.16	2.88	3.38	1.05	cc-ns	2.10	
Estimated Number of HSC	416	7,488	8,788	2,730		5,460	25,246
South Bowers (2.3 km)							
Density of HSC, Crabs/m	12.62	16.17	cc-ns	9.95	5.74	4.83	
Estimated Number of HSC	29,026	37,191		22,885	13,202	11,109	116,978
Ted Harvey WMA (1.0 km)							
Density of HSC, Crabs/m	22.30	27.93	cc-ns	cc-ns	cc-ns	cc-ns	
Estimated Number of HSC	22,300	27,930					75,230
Pickering (1 km)							
Density of HSC, Crabs/m	40.63	37.34	32.29	9.30	13.74	11.62	
Estimated Number of HSC	40,630	37,340	32,290	9,300	13,740	11,620	185,980
Totals	134,822	192,399	116,578	36,465	34,592	33,339	620,984

Table 2. Tagged Horseshoe Crabs Observed During Surveys 2007-2020

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
2018	260	55	205	42	218	240	20*	0
2019	322	77	245	54	268	296	26	0
2020	**13**	**13**	**0**	**5**	**8**	**13**	**0**	**0**
Totals	**2489**	**855**	**1634**	**547**	**1929**	**2329**	**160**	**50**

* Tallied as dead, not reported as alive or dead.

Table 3. 2020 Survey Dates and Times Based on NOAA Tables

Lunar Date	Survey Date	Time of High Water@ Breakwater
Full Moon 7-May	**Tues, May 5**	7:59 pm (5.2 ft)
	Thu, May 7	9:39 pm (5.7 ft)
	Sat, May 9	11:17 pm (5.5 ft)
New Moon 22-May	**Wed, May 20**	8:18 pm (4.6 ft)
	Fri, May 22	9:33 pm (4.9 ft)
	Sun, May 24	10:51 pm (4.9 ft)
Full Moon 5-Jun	**Wed, June 3**	7:39 pm (5.3 ft)
	Fri, June 5	9:20 pm (5.6 ft)
	Sun, June 7	10:57 pm (5.4 ft)
New Moon 21-Jun	**Fri, June 19**	8:25 pm (4.8 ft)
	Sun, June 21	9:50 pm (5.1 ft)
	Tues, June 23	11:18 pm (5.1 ft)