The 2010 Delaware Bay Horseshoe Crab Spawning Survey

Benjie Lynn Swan
William Hall
Carl N. Shuster, Jr.

Abstract

Each May and June, the shores of Delaware Bay play host to thousands of spawning horseshoe crabs. In this time frame, on 12 nights coinciding with the new and full moon phases, the yearly Delaware Bay horseshoe crab survey is conducted. All systematic counts are taken in or near darkness at high tides along 25 beaches – 12 in New Jersey and 13 in Delaware.

Of the scheduled 300 survey dates, 256 (85 percent) of the dates were completed. Cancellations occurred due to: flooding (7), weather (23), volunteer unavailability (8), or miscellaneous (6).

The single day peak estimate of 472,759 (New Jersey's estimate of 193,463 and Delaware's estimate of 279,296) was attained on May 29th, two days following the full moon. This peak estimate is approximately 100,000 horseshoe crabs less than the 2009 estimate. A secondary high estimate of 444,733 horseshoe crabs was achieved two weeks prior, May 16th, two days following the new moon.

The grand total of seasonal activity for both states was 1,558,217. The seasonal estimate was comparable to the 2008 total of 1,578,618 horseshoe crabs and less than the 2009, 2007 and 2006 estimates of 2,049,200, 1,947,372 and 1,885,355 individuals respectively. It is surmised that the cancellation of two dates during the peak activity may have contributed to the overall lower seasonal estimated number. Additionally, the 2010 male to female sex ratio of 4.25 was lower (meaning fewer males per females) than the previous four years, 2006 to 2010. The lower sex ratio may also be the effect of wave conditions caused by the storms, as fewer males are able to surround the females during rough waters.

Introduction

Since its inception in 1999, our survey has made tremendous strides and is now 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 to count, enter and analyze the data reaped from the results of the survey.

Methods

Horseshoe crabs were enumerated in the months of May and June 2010 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 Delaware beaches from north to south were Woodland, Pickering, Kitts Hummock, Ted Harvey Wildlife Management Area (WMA), North Bowers, South Bowers, Bennetts Pier, Big Stone, Slaughter, Fowler, Primehook, Broadkill, and Cape Henlopen. New Jersey beaches included Sea Breeze, Fortescue, Gandys, Reeds, Kimbles, Pierces Point, Highs, South Cape Shore Lab, Norburys Landing, Villas, Townbank and North Cape May.

Counts were taken simultaneously on both New Jersey and Delaware beaches coinciding with the peak high tides and following the new and full moons. The dates of counting were: May 12, 14, 16, 25, 27, 29 and June 10, 12, 14, 24, 26, and 28. High tide times ranged from 7:39 p.m. to 11:24 p.m., allowing adjustments for tidal flow entering the bay. All counts initiate with the onset of the high tide on one kilometer of preset beach. Where one contiguous kilometer of beach is not available, adjustments are made to place quadrats closer to each other resulting in a total of 100 quadrats surveyed for each beach.

Results

Coverage by the volunteers accounted for 85 percent, or 256, of the entire 300 scheduled counts. In New Jersey, 29 dates were cancelled with the majority (17) due to two thunder and lightening storms on May 14th and May 27th. The remaining cancellations were due to no surveyors (five), no access (two) and miscellaneous reasons (five). Sea Breeze counting was canceled on six dates as no volunteers were available (four), no access (one) and weather (one). (Table 1A)
Fifteen cancellations occurred in Delaware during the 2010 spawning season. Of these, three were canceled for volunteer unavailability, six due to weather, five for no access and one for miscellaneous reason. The thunder and lightening storm on May 14th canceled many counts on the Delaware side as well. During the second storm of May 27th flooding prevented access to many of the Delaware beaches. (Table 1B)

This year's (2010) estimate of spawners along Delaware and New Jersey's shores was a decrease compared to 2009 (Table 2). The peak activity was recorded May 29th with 472,759 individuals estimated, the highest count of the 12 nights in New Jersey and the second highest count in Delaware. Delaware's peak was achieved on May 16th with 302,683 horseshoe crabs estimated. This estimate coupled with New Jersey's estimate of 142,050 spawners on this date created a

comparable single day peak of 444,733 horseshoe crabs on May 16th. (Table 1 and Figure 1)

In New Jersey, 86% of the seasonal spawning occurred in the month of May with 63% on only two days, May 16th and May 29th with 142,050 and 193,463 spawners respectively. Spawning activity in New Jersey for the overall season was the highest at South Cape Shore Lab with 100,144 individuals and the second highest at Norburys Landing with 85,706 spawners, still both considerably less than the 2009 estimates of 167,508 and 132,751 respectively. Most of the remaining beaches had considerably lower estimates than last year with the exception of Sea Breeze. Sea Breeze was 42,059 this year, higher than last year's estimate of 31,812 horseshoe crabs. The highest density was achieved at Gandys with 23.79 horseshoe crabs per square meter on May 29th, the peak survey date. (Table 1A and Figure 1)

In Delaware, 77% of the spawning activity was recorded in May. The dates of May 16th and May 29th contributed to 57% of the year's spawning numbers. The highest seasonal activity occurred on Big Stone beach, estimated to be 182,650 spawners, considerably decreased from last year's estimate of 284,500. Estimates at Slaughter (157,440) and Pickering (124,850) were comparable to the 2009 estimates of 154,560 at Slaughter and 143,560 at Pickering. The 2010 estimates for the three southern beaches of Broadkill (40,575), Primehook (84,320) and Fowlers (70,470) showed marked increases over 2009 estimates of 14,940, 58,380 and 20,490 respectively. In contrast, the northern beaches exhibited considerable decreases: at South Bowers, an estimate of 80,270 for 2010, decreased from 154,698 in 2009 and at Kitts Hummock, a 2010 estimate of 80,290 down from 111,540 horseshoe crabs in 2009. A decrease was also noted at Bennetts Pier; however, it was attributed to four of the six dates in May not being surveyed. Slaughter Beach had the highest density of 29.05 crabs per meter, May 16th. Similar to other years, a close second was at Pickering with 28.34 crabs per meter on May 29th. (Table 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 then analyzed in percentages since dates and/or beaches may change yearly. As in previous years, the majority of the dates surveyed (56 percent in DE and 60 percent in NJ) showed horseshoe crabs densities lower than five crabs per meter. In New Jersey, high densities were noted on 8% of the survey dates. High and moderate densities of horseshoe crabs were observed in Delaware at comparable percentages to other years (Table 3 and Figure 3).

Dates with zero crabs (14 (9%) in Delaware and 7 (5%) in New Jersey) were few in number this year (Table 3 and Figure 3). Delaware's most northern beach, Woodland Beach rendered zero counts during five of the 11 dates surveyed. Four other dates with zero in Delaware were recorded May 12th, the first day of the

counting. Zero crabs were observed on New Jersey's most southern beaches at the start of the season and New Jersey's most northern beaches at the end of the season. (Table 1)

The 2010 seasonal estimate of 1,558,217 is most comparable to the 2008 estimate of 1,578,618 and a decrease over last year's estimate (2,049,200), 2007's estimate (1,947,372) and 2006's estimate (1,885,355). However, the 2010 estimate is greater than estimates from the earlier preceding years 1999-2005. (Table 4 and Figure 4)

The 2010 male to female ratio was 4.25 – lower than the previous four year ratios of 4.53 (2006), 4.90 (2007), 4.90 (2008) and 5.04 (2009) and higher than the years preceding (1999 to 2005) with ratios of 3.72, 3.67, 3.38, 3.48, 3.61, 3.85 and 3.89 respectively. (Sex ratios are computed by averaging the total number of males and females counted throughout the entire season.) Estimating the number of males and females by utilizing the 4.25 ratio and the 2010 seasonal estimate resulted in 1,261,414 males and 296,803 females spawning. (Table 5 and Figure 5)

Discussion

This year's seasonal spawning estimate of 1,558,217 was lower than the previous few years possibly due to adverse weather causing a large number of beach cancellations. Counting on two dates, May 14th and May 27th, was canceled on 18 of the 25 beaches and 12 of the 25 beaches, respectively. Cancellations may occur throughout the spawning season and dates missed each year range from 8% to 31% (Table 3), however what is more significant is the time the cancellations occur. If the cancelled dates occur during the peak of spawning and no data is recorded, the cumulative seasonal number is reduced by higher numbers. The estimated seasonal number for 2010 was substantially lower than the previous few years and may have been the result of not recording two days of significant spawning numbers.

In reviewing the data from 1999 to 2010, the only other year with two dates canceled during the peak spawning was 2003. The cancellations were not as severe as in 2010 with only 11 and 7 counts of the 25 beaches canceled. Interestingly, the 2003 seasonal estimate was the lowest of the survey estimates from 1999-2010. Other years, specifically 2001, 2005, 2007 and 2009, only one of the days around the peak spawning activity was cancelled for many beaches. For the years, 2007 and 2009, the seasonal estimate remained high, 1,947,372 and 2,049,200, respectively.

The number of males and females counted during the entire season resulted in a sex ratio of 4.25 for the year 2010. This lower sex ratio may be an effect of the stormy weather as fewer males are able to surround a female during considerable wave action. Whether or not we can attribute the substantial decline of overall numbers and particularly the males to the weather will be further advanced with

the 2011 survey. Populations of species can only be assessed with several decades of data to gain any insight of trends.

Acknowledgements

Every year we are overwhelmed with the dedication and perseverance of our volunteers and this year was no exception. Surveying, by far is not a glamorous activity, and also one that goes relatively unnoticed. Our yearly thank you isn't enough. With everyone's help we achieve the arduous task of keeping track of tens of thousands of horseshoe crabs over many, many years. Always remember our findings will be archived for generations to come and these future generations will at some time or another; silently or vocally thank <u>all</u> of us for our endeavors.

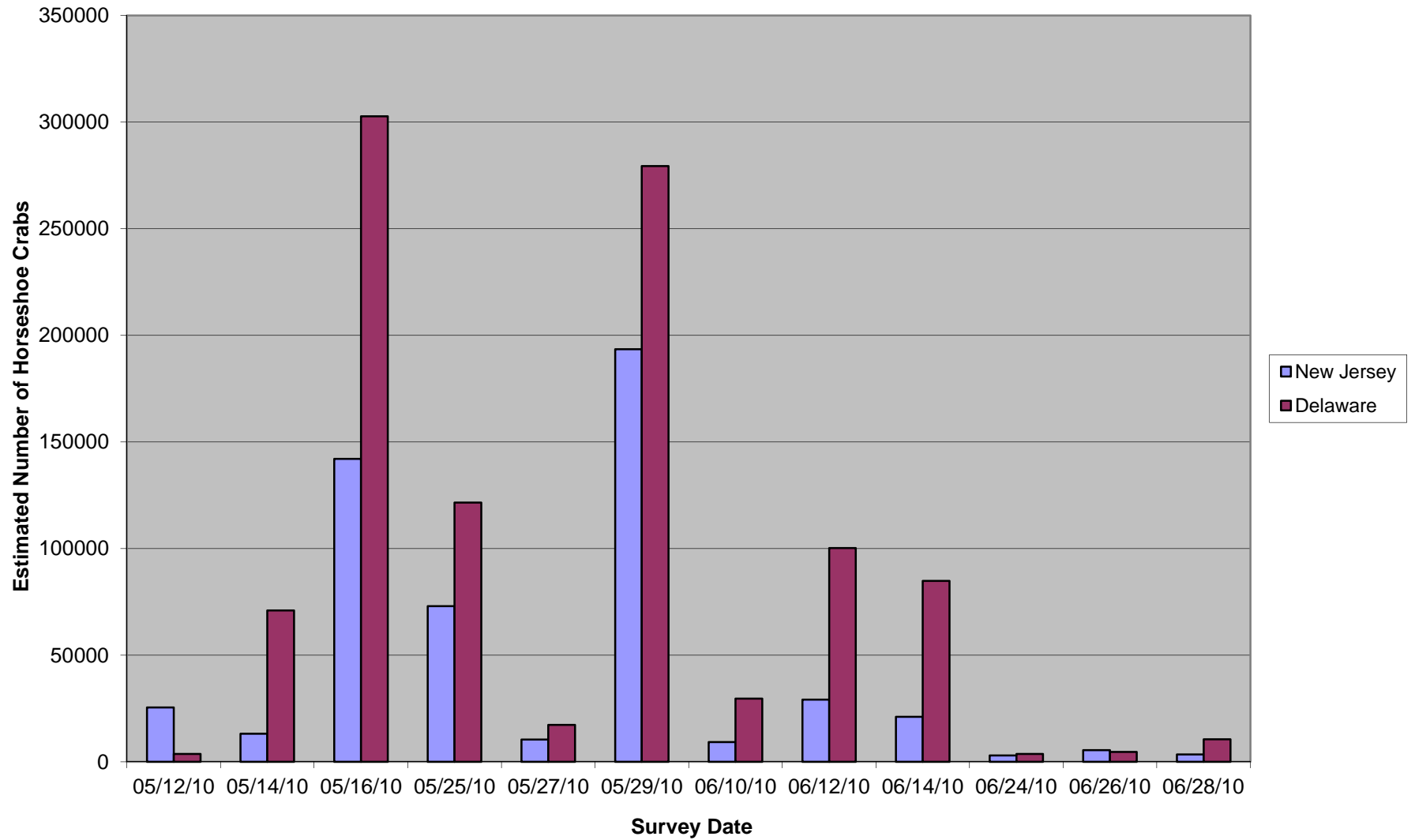Figure 1. New Jersey and Delaware Spawning Estimates During 2010 Survey

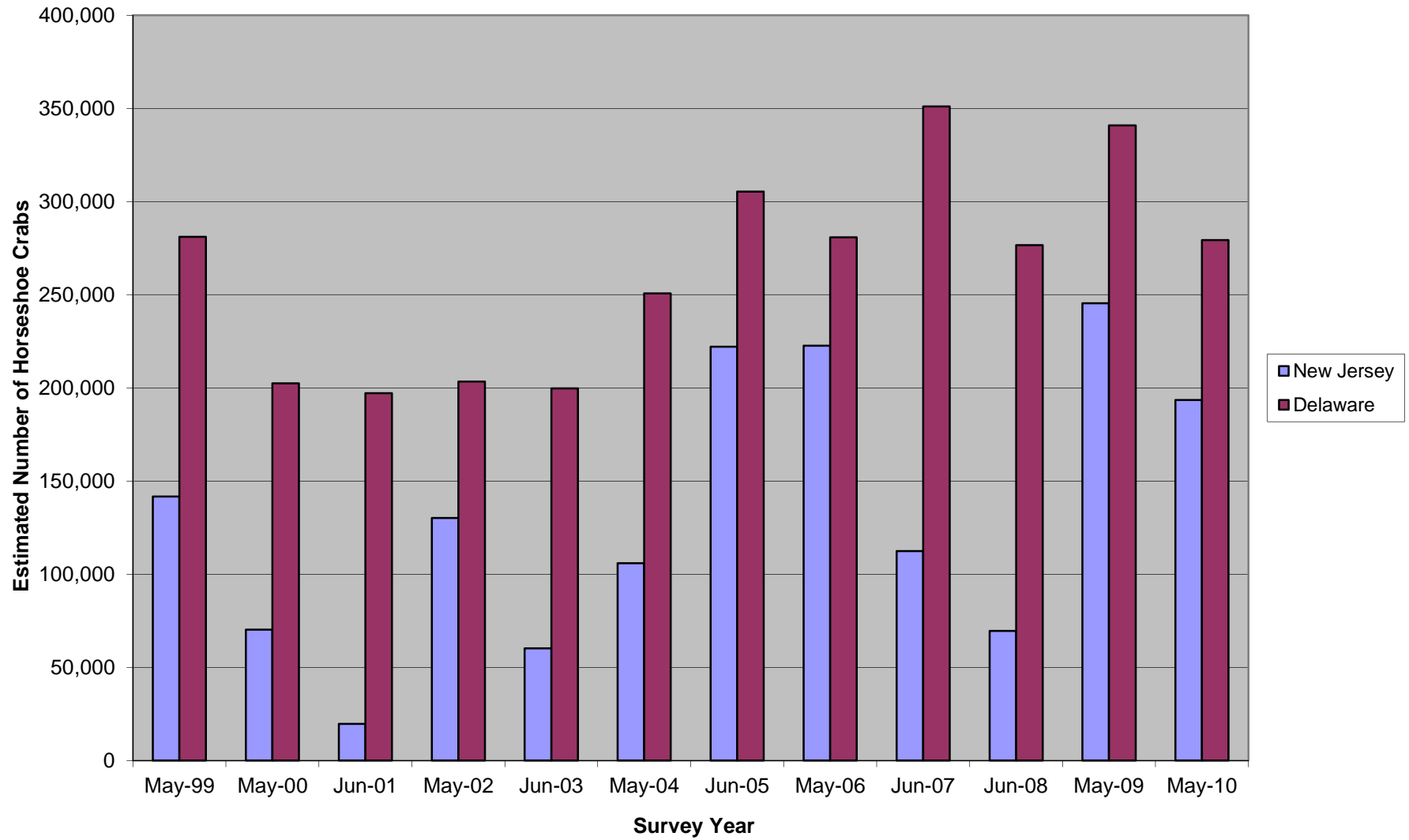**Figure 2. Peak Estimates of Spawning Horseshoe Crabs 1999-2010**

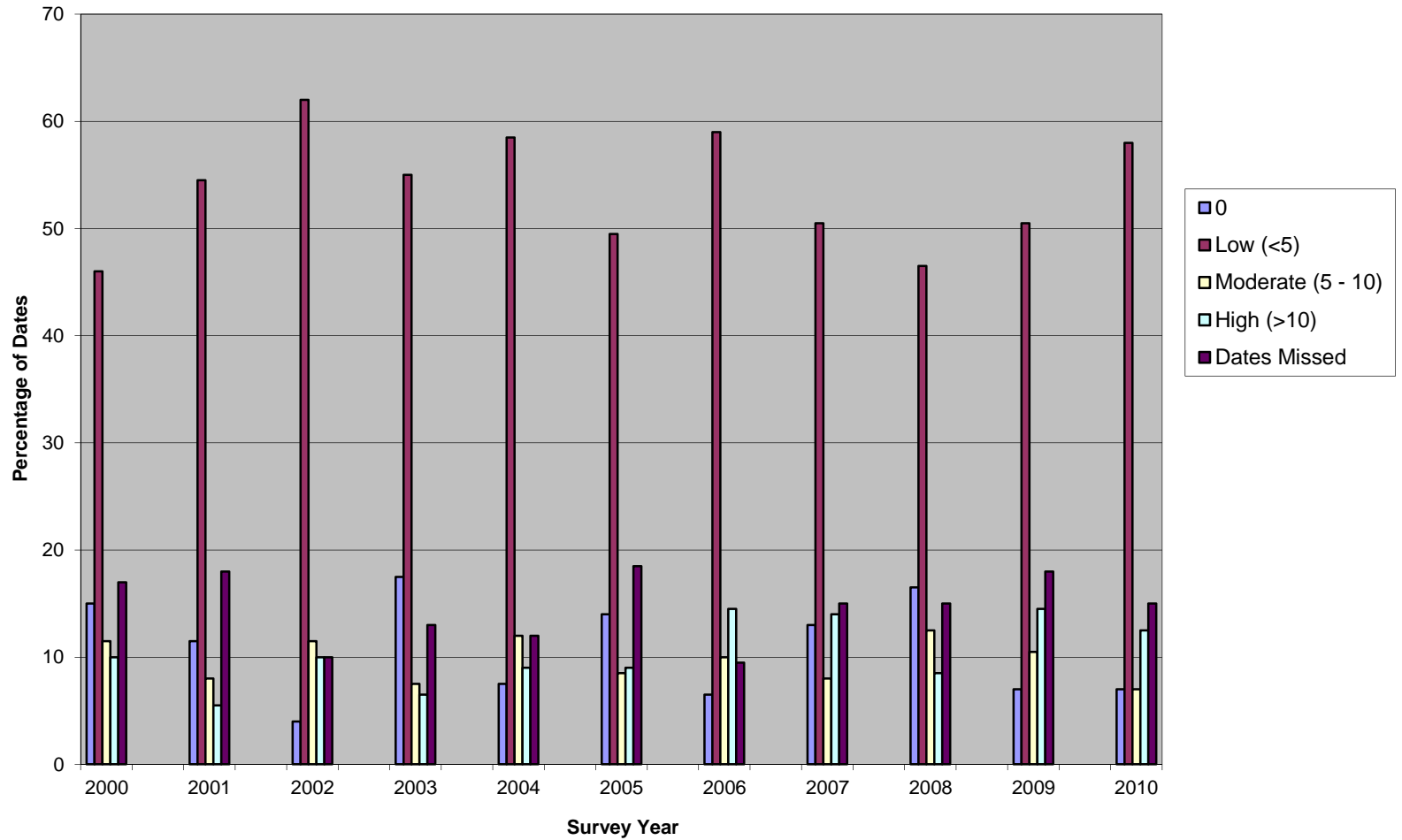Figure 3. Percentages of Horseshoe Crabs 1999-2010

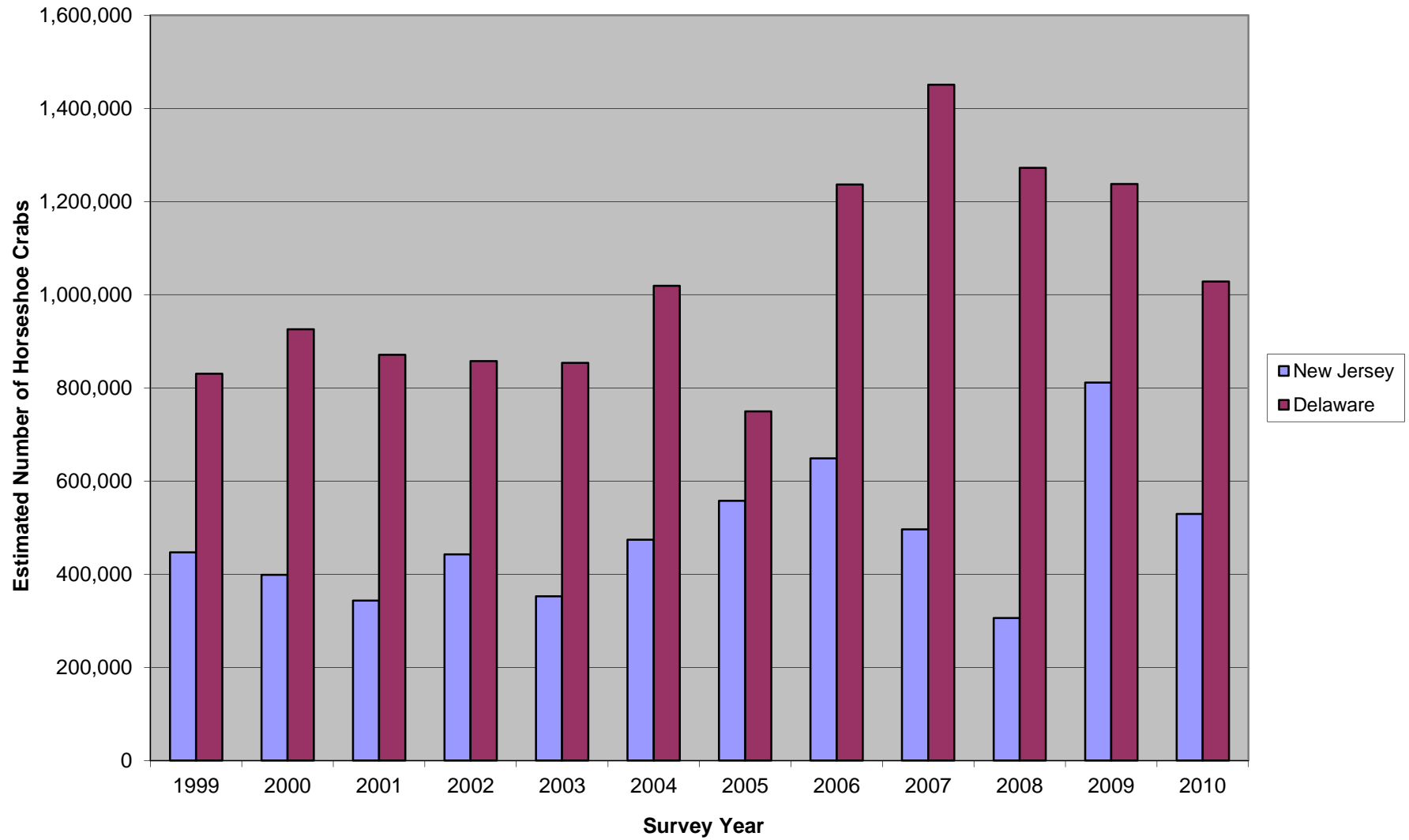**Figure 4. Seasonal Estimates of Spawning Horseshoe Crabs**

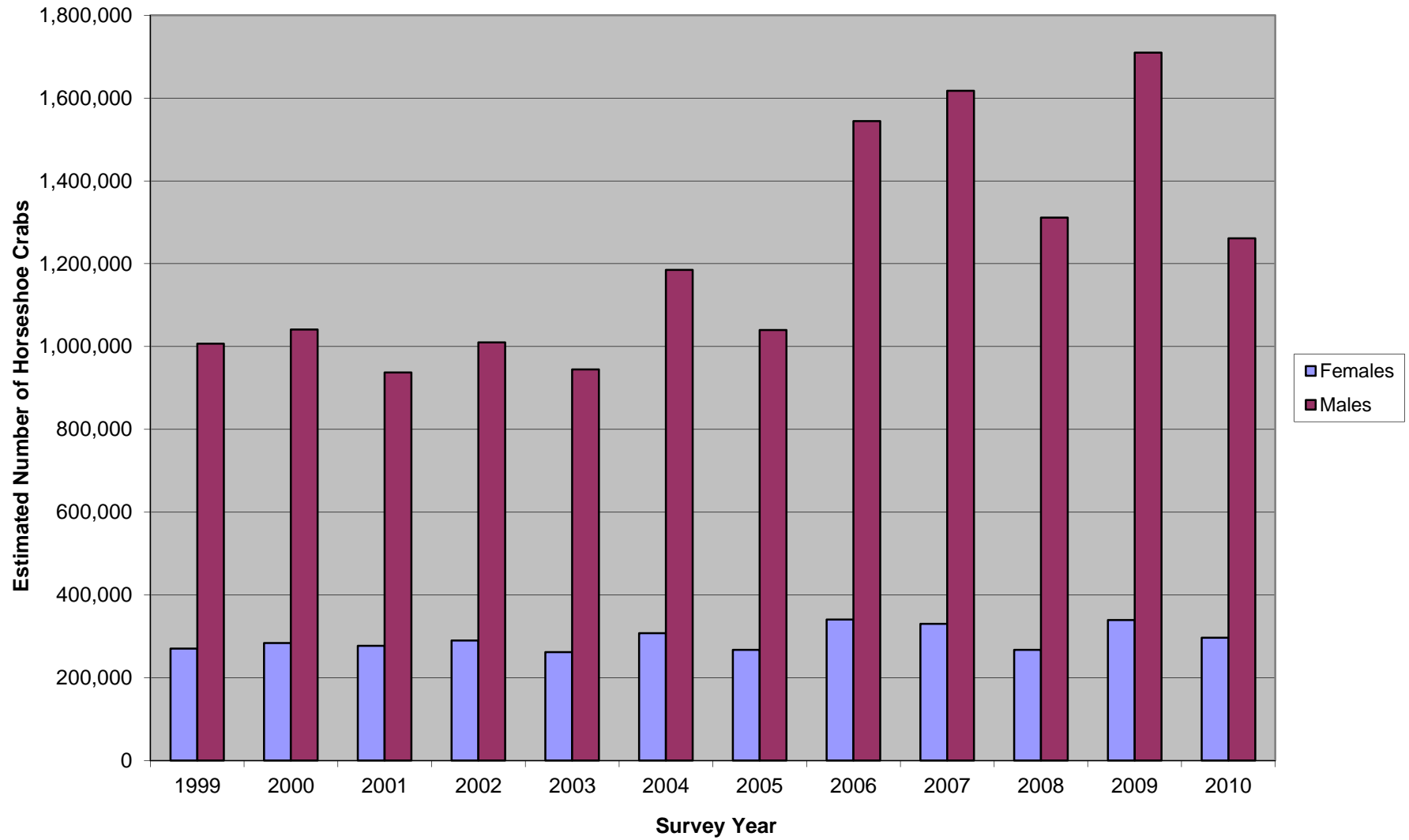**Figure 5. Seasonal Estimates of Male and Female Horseshoe Crabs 1999-2010**

Table 1. 2010 Survey Results- Densities and Estimates

A. New Jersey Beaches (*Indicates beaches surveyed every year)

Moon Phase	New-2	New	New+2	Full-2	Full	Full+2	New-2	New	New+2	Full-2	Full	Full+2	
Date	12-May	14-May	16-May	25-May	27-May	29-May	10-Jun	12-Jun	14-Jun	24-Jun	26-Jun	28-Jun	Totals
North Cape May * (3 km)													
Density of HSC, Crabs/m	0	0	0.05	0.02	cancel	0.08	0.04	0.05	0.32	0.11	0.09	0.01	
Estimated Number of HSC	0	0	150	60	0	240	120	150	960	330	270	30	2,310
Villas (2 km)													
Density of HSC, Crabs/m	0.17	6.6	3.6	0.42	0.9	4.01	0.22	1.67	1.13	0.28	0.31	0.51	
Estimated Number of HSC	340	13200	7200	840	1800	8020	440	3340	2260	560	620	1020	39,640
Townbank (2.3 km)													
Density of HSC, Crabs/m	0	cancel	0.8	0.43	1.15	4.77	1.07	cancel	0.84	cancel	0.64	0.2	
Estimated Number of HSC	0	0	1840	989	2645	10971	2461	0	1932	0	1472	460	22,770
Norburys Landing (2.43 km)													
Density of HSC, Crabs/m	2.83	cancel	13.25	0.51	cancel	12.99	0.66	1.82	2.14	0.25	0.24	0.58	
Estimated Number of HSC	6877	0	32198	1239	0	31566	1604	4423	5200	608	583	1409	85,706
South CSL * (2.2 km)													
Density of HSC, Crabs/m	2.54	cancel	11.53	7.47	cancel	17.77	0.34	3.14	1.55	0.38	0.69	0.11	
Estimated Number of HSC	5588	0	25366	16434	0	39094	748	6908	3410	836	1518	242	100,144
Highs * (0.8 km)													
Density of HSC, Crabs/m	3.19	cancel	13.05	4.32	cancel	12.78	0.33	1	0.18	0.14	0.11	0.22	
Estimated Number of HSC	2552	0	10440	3456	0	10224	264	800	144	112	88	176	28,256
Pierces Point (0.7 km)													
Density of HSC, Crabs/m	4.65	cancel	18.91	9.88	cancel	15.13	1.68	1.09	4.29	0.25	cancel	cancel	
Estimated Number of HSC	3255	0	13237	6916	0	10591	1176	763	3003	175	0	0	39,116
Kimbles (1 km)													
Density of HSC, Crabs/m	0.81	cancel	4.57	6.06	cancel	12.76	0.47	1.24	0.38	cancel	0.05	0.1	
Estimated Number of HSC	810	0	4570	6060	0	12760	470	1240	380	0	50	100	26,440
Reeds * (1.53 km)													
Density of HSC, Crabs/m	2.29	cancel	11.9	1.31	cancel	9.04	0.29	0.6	0.72	0.14	0.48	0.04	
Estimated Number of HSC	3504	0	18207	2004	0	13831	444	918	1102	214	734	61	41,019
Fortescue (2.6 km)													
Density of HSC, Crabs/m	0.58	cancel	3.73	3.52	2.32	4.86	0.57	1.55	0.8	0.07	0.01	0	
Estimated Number of HSC	1508	0	9698	9152	6032	12636	1482	4030	2080	182	26	0	46,826
Gandys * (1.2 km)													
Density of HSC, Crabs/m	0.85	cancel	8.24	12.13	cancel	23.79	0.03	0.56	0.5	0	cancel	0	
Estimated Number of HSC	1020	0	9888	14556	0	28548	36	672	600	0	0	0	55,320
Sea Breeze * (1.65 km)													
Density of HSC, Crabs/m	cancel	cancel	5.61	6.88	cancel	9.08	cancel	3.85	cancel	cancel	0.07	0	
Estimated Number of HSC	0	0	9257	11352	0	14982	0	6353	0	0	116	0	42,059
Totals	25,454	13,200	142,050	73,059	10,477	193,463	9,245	29,596	21,071	3,017	5,477	3,499	529,606

Table 1. 2010 Survey Results - Densities and Estimates
B. Delaware Beaches (*Indicates Beaches Surveyed Every Year)

Moon Phase	New-2	New	New+2	Full-2	Full	Full+2	New-2	New	New+2	Full-2	Full	Full+2	
Date	12-May	14-May	16-May	25-May	27-May	29-May	10-Jun	12-Jun	14-Jun	24-Jun	26-Jun	28-Jun	Totals
Cape Henlopen (1.5 km)													
Density of HSC, Crabs/m	0.01	cancel	2.01	2.59	2.84	10.59	0	0	0.59	0.34	0.34	0.38	
Estimated Number of HSC	15	0	3015	3885	4260	15885	0	0	885	510	510	570	29,535
Broadkill (1.5 km)													
Density of HSC, Crabs/m	0	cancel	6.88	0.96	1.09	5.74	1.27	4.23	5.05	0.72	0.36	0.75	
Estimated Number of HSC	0	0	10320	1440	1635	8610	1905	6345	7575	1080	540	1125	40,575
Primehook * (2.0 km)													
Density of HSC, Crabs/m	0.74	cancel	15.52	1.7	0.46	10.11	0.98	5.79	6.28	0.11	0.09	0.38	
Estimated Number of HSC	1480	0	31040	3400	920	20220	1960	11580	12560	220	180	760	84,320
Fowler * (3 km)													
Density of HSC, Crabs/m	cancel	cancel	10.37	0.04	cancel	5.01	0.33	4.04	3.62	0.02	0	0.06	
Estimated Number of HSC	0	0	31110	120	0	15030	990	12120	10860	60	0	180	70,470
Slaughter * (3 km)													
Density of HSC, Crabs/m	0.29	cancel	29.05	0.87	0.57	14.08	0.88	2.78	3.1	0.34	0.2	0.32	
Estimated Number of HSC	870	0	87150	2610	1710	42240	2640	8340	9300	1020	600	960	157,440
Big Stone * (5.0 km)													
Density of HSC, Crabs/m	0	cancel	9.63	3.04	1.07	12.59	2.27	5.65	2.08	0.03	0.03	0.14	
Estimated Number of HSC	0	0	48150	15200	5350	62950	11350	28250	10400	150	150	700	182,650
Bennetts Pier (2.6 km)													
Density of HSC, Crabs/m	cancel	cancel	cancel	0.41	0.1	cancel	0.38	3.26	4.26	0.05	0.21	0.63	
Estimated Number of HSC	0	0	0	1066	260	0	988	8476	11076	130	546	1638	24,180
South Bowers (2.3 km)													
Density of HSC, Crabs/m	0.04	cancel	11.21	9.39	cancel	11.7	0.31	0.9	0.6	0.04	0.19	0.52	
Estimated Number of HSC	92	0	25783	21597	0	26910	713	2070	1380	92	437	1196	80,270
North Bowers * (1.3 km)													
Density of HSC, Crabs/m	0	10.57	11	13.05	0.64	13.32	0.78	1.94	1.45	0.14	0.25	0.18	
Estimated Number of HSC	0	13741	14300	16965	832	17316	1014	2522	1885	182	325	234	69,316
Ted Harvey WMA (1.0 km)													
Density of HSC, Crabs/m	0.06	16.24	15.54	15.17	1.08	16.47	1.27	5.87	6.36	0.21	0.82	2.76	
Estimated Number of HSC	60	16240	15540	15170	1080	16470	1270	5870	6360	210	820	2760	81,850
Kitts Hummock * (1.0 km)													
Density of HSC, Crabs/m	1.24	13.16	15.29	15.76	0.24	23.5	1.99	3.05	5.69	0	0.18	0.19	
Estimated Number of HSC	1240	13160	15290	15760	240	23500	1990	3050	5690	0	180	190	80,290
Pickering (1 km)													
Density of HSC, Crabs/m	0	27.76	20.96	24.06	0.99	28.34	4.3	11.14	6.66	0	0.39	0.25	
Estimated Number of HSC	0	27760	20960	24060	990	28340	4300	11140	6660	0	390	250	124,850
Woodland * (0.5 km)													
Density of HSC, Crabs/m	0	0.28	0.05	0.51	cancel	3.65	0	0.87	0.37	0	0	0	
Estimated Number of HSC	0	140	25	255	0	1825	0	435	185	0	0	0	2,865
Totals	3,757	71,041	302,683	121,528	17,277	279,296	29,120	100,198	84,816	3,654	4,678	10,563	1,028,611

Table 2. Comparison of Data on Horseshoe Crabs Spawning on Delaware Bay Shores
Years 1999-2010

	29-May-10	24-May-09	3-Jun-08	1-Jun-07	27-May-06	8-Jun-05	21-May-04	14-Jun-03	28-May-02	5-Jun-01	18-May-00	30-May-99
Horseshoe Crabs	472,759	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	193,463	245,444	69,669	112,497	222,653	222,168	105,973	60,272	130,164	19,726	70,293	141,720
Delaware Estimate	279,296	340,854	276,650	351,090	280,782	305,352	250,766	199,685	203,389	197,203	202,477	281,055
Beaches in DE	13	13	13	13	13	13	13	13	13	13	11	9
Beaches in NJ	12	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	Big Stone	S. Bowers	Slaughter	Slaughter	Slaughter
	Slaughter	Slaughter	Slaughter	Slaughter	Slaughter	S. Bowers	Slaughter	Slaughter	Slaughter	Big Stone	Big Stone	Big Stone
	S. Bowers	S. Bowers	Pickering	S. Bowers	S. Bowers	Bennets	Pickering	Pickering	Big Stone			
	Pickering	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	South CSL	Townbank
	Norburys	Norburys	Norburys		Norburys	Norburys	Fortescue	Fortescue	Gandys			Norburys
	Gandys	Reeds			Fortescue	Villas	Norburys	Norburys	Sea Breeze			South CSL

Limuli Laboratories
5 Bay Avenue
Cape May Court Hose, NJ 08210

Table 3. Percentages of Horseshoe Crab Densities 1999-2010

Survey Year	State	0	Low (<5)	Percentage Moderate (5-10)	High (>10)	Dates Missed
1999	New Jersey	4	65	10	6	15
	Delaware	8	43	6	11	31
2000	New Jersey	16	54	10	5	14
	Delaware	14	38	13	15	20
2001	New Jersey	10	63	5	5	17
	Delaware	13	46	11	6	19
2002	New Jersey	3	61	10	8	13
	Delaware	5	63	13	12	7
2003	New Jersey	17	60	7	3	13
	Delaware	18	50	8	10	13
2004	New Jersey	5	63	9	8	14
	Delaware	10	54	15	10	10
2005	New Jersey	14	48	6	10	21
	Delaware	14	51	11	8	16
2006	New Jersey	5	64	8	12	11
	Delaware	8	54	12	17	8
2007	New Jersey	16	58	1	10	15
	Delaware	10	43	15	18	15
2008	New Jersey	21	51	8	0	19
	Delaware	12	42	17	17	11
2009	New Jersey	4	50	8	14	24
	Delaware	10	51	13	15	12
2010	New Jersey	5	60	6	8	20
	Delaware	9	56	8	17	10

Limuli Laboratories
5 Bay Avenue
Cape May Court House, NJ 08210

Table 4. Seasonal Estimates of Horseshoe Crabs 1999-2010

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

Table 5. Seasonal Estimates of Male and Female Horseshoe Crabs 1999-2010

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