

**Horseshoe Crab Spawning Activity in Delaware Bay:  
a preliminary report on 2001 and a comparison from 1999 to 2001**  
**Report to the ASMFC Horseshoe Crab Technical Committee**

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**Introduction**

The Atlantic State Marine Fisheries Commission (ASMFC) sponsored a workshop on horseshoe crab surveys in January 1999. The workshop resulted in recommendations for the design and implementation of a statistically valid survey of spawning horseshoe crabs in the mid-Atlantic region. In Delaware Bay, the recommendations were used to redesign the volunteer-based spawning survey that began in 1990. Funds were awarded from the USGS State Partnership Program in 1999, the U.S. Fish and Wildlife Service in 2000, and the Delaware Division of Fish and Wildlife in 2001 to implement the Delaware Bay Horseshoe Crab Spawning Survey. During those years, Ms. Benjie Swan (Limuli Labs) and Dr. Bill Hall (Univ. of Delaware) have been contracted to coordinate the survey.

The Delaware Bay Horseshoe Crab Spawning Survey was designed to accomplish several important objectives: (1) provide a reliable index of spawning activity to monitor the temporal and spatial distribution of horseshoe crab spawning activity for comparing baywide spawning among years, beach-level spawning within Delaware Bay, and distributions of spawning horseshoe crabs and shorebirds; (2) increase our understanding of the relationship between environmental factors (tidal height and wave height) and spawning activity; and (3) promote public awareness of the central role of horseshoe crabs in shorebird population dynamics, Atlantic coast fisheries, and human health through production of *Limulus* amoebocyte lysate (LAL).

With this report, we continue an annual series of statistical reports on the survey. Results from 1999 along with a detailed description and evaluation of the survey design were presented in a project final report, which is now in published form (Smith et al. 2002). A summary and comparison of results from 1999 and 2000 was submitted to the Technical Committee one year ago (Smith, Millard, and Bennett 2001).

This and previous reports are intended to complement the ongoing series of reports that have been issued by the survey coordinators, Ms. Swan and Dr. Hall in cooperation with Dr. Carl Shuster.

### Preliminary results from 2001

In 2001, 22 beaches were surveyed on as many as 12 tides during May and June. The number of tides per beach sampled ranged from 4 to 12, and the total number of tides sampled for all beaches was 225. Twelve of the beaches were in Delaware and 10 were in New Jersey. (Note that Cape Henlopen, which would have brought the total to 13 Delaware beaches, was surveyed only on 5/24/01, so it was not included in this report.) The index of spawning activity calculated for each beach for 1999 to 2001 is shown in the Appendix.

The temporal pattern in 2001 was similar to previous years with spawning activity higher in NJ than in DE during the first lunar period followed by periods with spawning activity as high or higher in DE than in NJ (Figure 1). The first lunar period was a full moon (May 7, 2001). State-specific indices are shown in Table 1, and the baywide index is in Table 2.

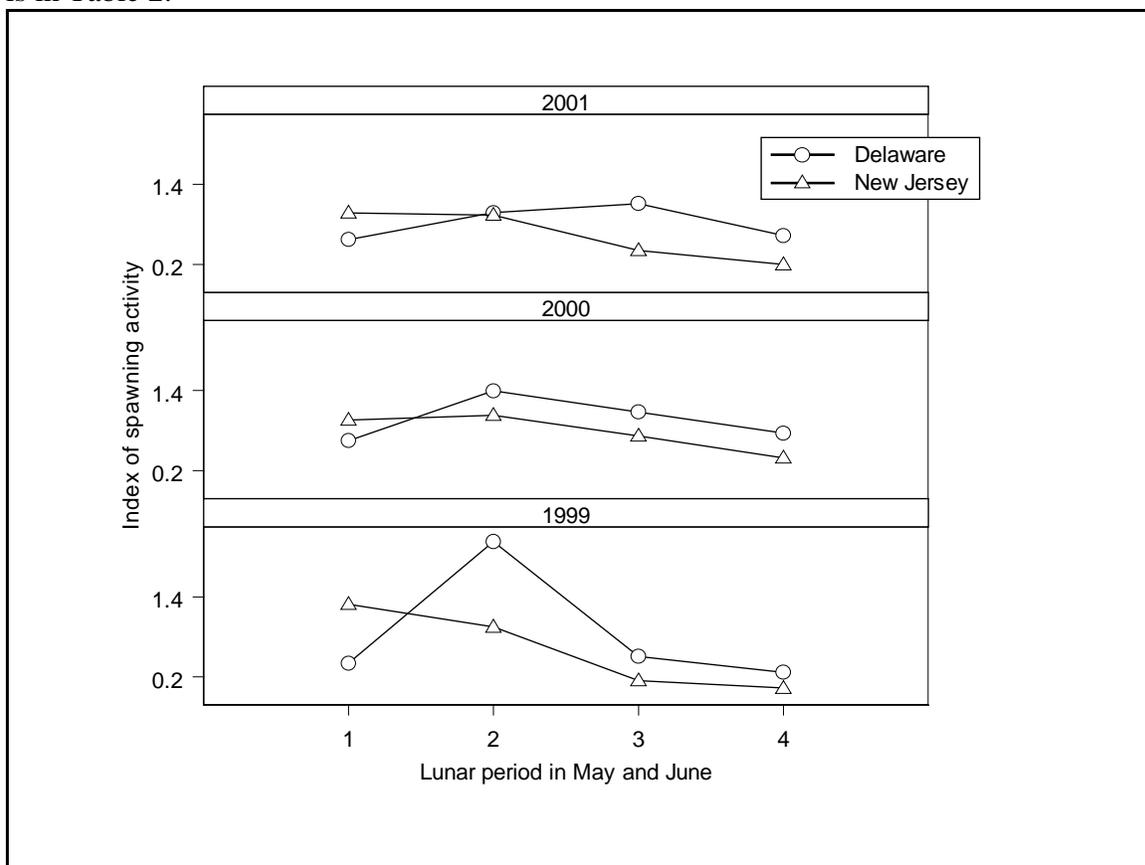


Figure 1. Index of spawning activity for Delaware Bay in each of the 4 lunar periods in May and June for 1999 to 2001. The index is the number of spawning females within 1 m of high tide line on beach index sites. Surveys were conducted within 3 days of the new or full moons, and these periods were termed 'lunar periods'. The index is shown separately for beaches in Delaware (DE) and New Jersey (NJ).

### Comparison from 1999 to 2001

*Corrections to 1999 and 2000 estimates* – A review of data from 1999 and 2000 indicated the need to make 2 corrections. In 1999 data, South Bowers was surveyed only one night and because of this we removed it from the analysis for 1999. This correction affected the Delaware ISA (from 1.053 to 0.939) and the baywide ISA (from 0.832 to 0.774). In previous analysis of 2000 data, the beach length for East Point was incorrectly entered as 1 km when it is actually 0.1 km. This correction affected the New Jersey ISA (from 0.686 to 0.777) and the baywide ISA (from 0.851 to 0.896).

*Data availability* – The analyses of 1999 and 2000 data have been finalized. Thus, we have made the data (summarized to the beach level) and the spreadsheets, which calculate ISA, available on internet at [http://aegis.er.usgs.gov/groups/stats/Limulus/ISA\\_data.htm](http://aegis.er.usgs.gov/groups/stats/Limulus/ISA_data.htm).

*Comparison of spawning activity* – There are no apparent trends in the survey results for 1999 to 2001 (Figures 2 to 4). However, conclusions about population trends of iteroparous species, such as horseshoe crabs, should not be on made on short time series.

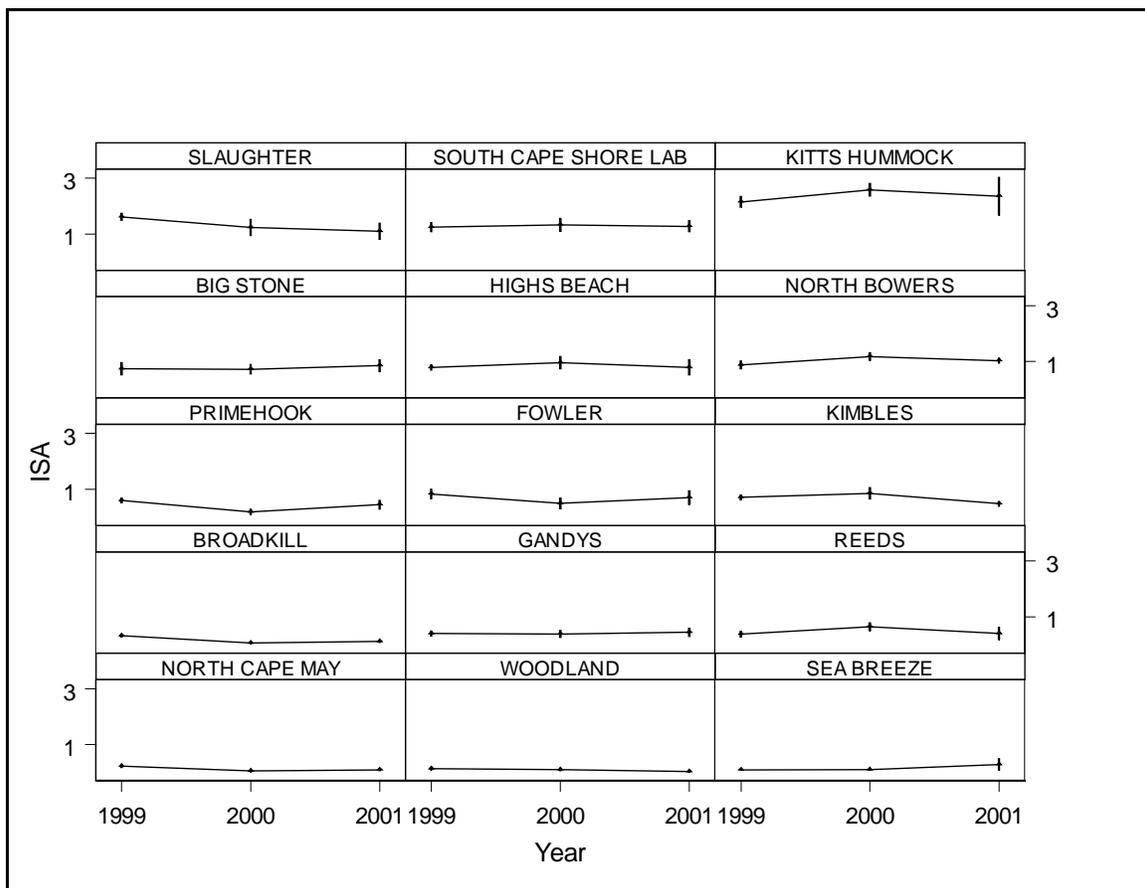


Figure 2. Beach-specific index of spawning activity (ISA) for the 15 beaches that have been surveyed 1999, 2000, and 2001. Vertical bars represent ISA  $\pm$  SE.

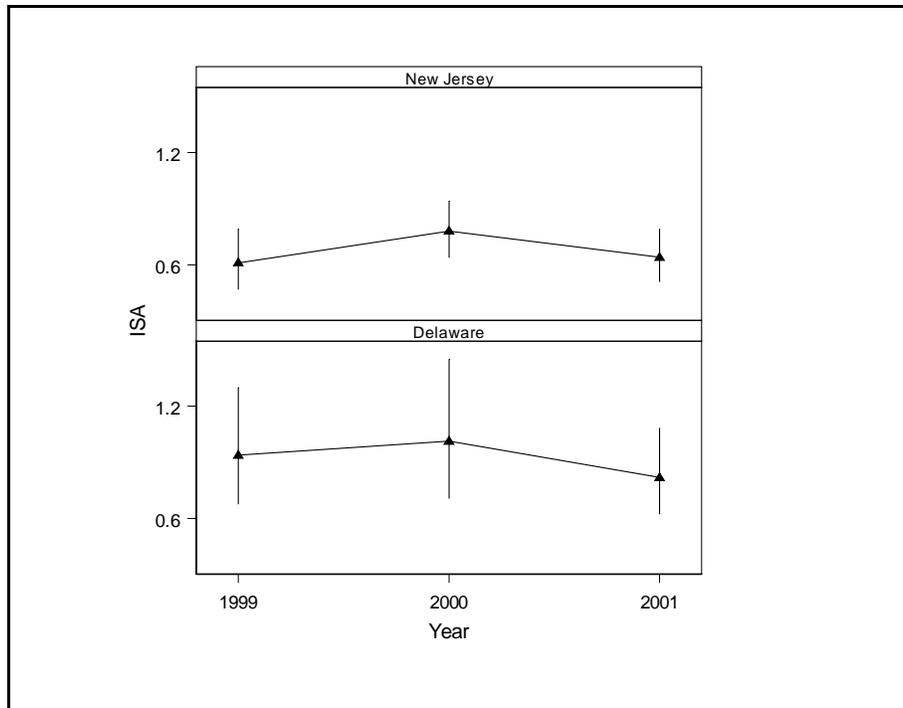


Figure 3. State-specific index of spawning activity (ISA) for New Jersey and Delaware for 1999, 2000, and 2001. Vertical bars show 90% confidence intervals.

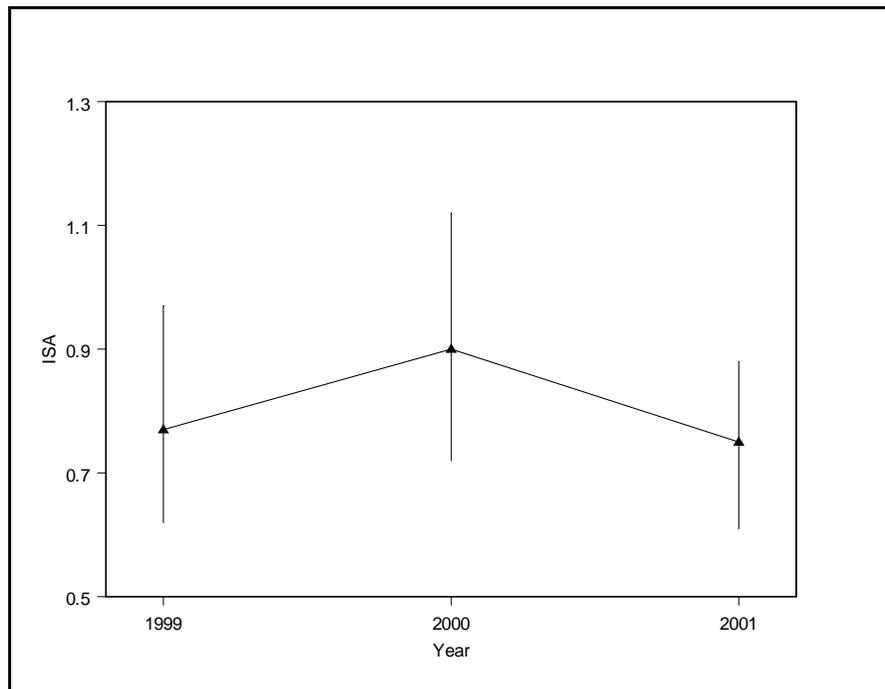


Figure 4. Baywide index of spawning activity (ISA) for 1999, 2000, and 2001. Vertical bars show 90% confidence intervals.

Table 1. Index of spawning activity (ISA) computed for May and June 1999, 2000, and 2001. Index is shown separately for Delaware and New Jersey.

Year	Delaware		New Jersey	
	ISA	90% CI	ISA	90% CI
1999	0.94	0.68, 1.30	0.61	0.47, 0.79
2000	1.01	0.71, 1.45	0.78	0.64, 0.94
2001	0.82	0.63, 1.08	0.64	0.51, 0.79

Table 2. Index of spawning activity (ISA) for the Delaware Bay in 1999, 2000, and 2001. Standard error (SE) and 90% confidence intervals are also presented.

Year	ISA	SE	CV (%)	90% CI
1999	0.77	0.1054	13.6	0.62, 0.97
2000	0.90	0.1191	13.3	0.72, 1.12
2001	0.73	0.0811	11.1	0.61, 0.88

### Cited

- Smith, D.R., M.J. Millard, and S. Bennett. 2001. Horseshoe crab spawning activity in Delaware Bay: 1999 – 2000. Report to the Atlantic States Marine Fisheries Commission Horseshoe Crab Technical Committee.
- Smith, D. R., P. S. Pooler, B. L. Swan, S. Michels, W. R. Hall, P. Himchak, and M. J. Millard. 2002. Spatial and temporal distribution of horseshoe crab (*Limulus polyphemus*) spawning in Delaware Bay: implications for monitoring. *Estuaries* 25(1):115-125.

Appendix. Index of spawning activity (ISA), standard error (SE), and number of tides sampled (n) for beaches surveyed in the Delaware Bay Horseshoe Crab Spawning Survey from 1999 to 2001.

State	Beach	1999			2000			2001		
		ISA	SE	n	ISA	SE	n	ISA	SE	n
DE	Bennetts Pier	.	.	.	0.2515	0.0655	6	0.6399	0.1534	11
	Big Stone	0.7463	0.1635	7	0.7290	0.1633	9	0.8563	0.2085	11
	Broadkill	0.3197	0.0394	12	0.0638	0.0215	11	0.1170	0.0262	11
	Fowlers	0.8280	0.1611	9	0.4933	0.1878	11	0.7033	0.2341	10
	Kitts Hummock	2.1510	0.1887	12	2.5830	0.2164	8	2.3545	0.6702	10
	Lewes	.	.	.	.	.	.	0.0838	0.0748	8
	North Bowers	0.8806	0.1813	4	1.1819	0.1302	11	1.0383	0.0835	11
	Pickering	.	.	.	3.3047	0.5451	10	1.6244	0.2718	11
	Prime Hook	0.5984	0.0718	6	0.1872	0.0904	8	0.4446	0.1523	11
	Slaughter	1.6190	0.1097	3	1.2338	0.2873	12	1.0963	0.2842	11
	South Bowers	.	.	.	0.9196	0.1214	8	0.8433	0.3693	9
	Woodland	0.1368	0.0494	10	0.1033	0.0339	12	0.0292	0.0124	12
NJ	East Point	.	.	.	0.3458	0.1260	10	.	.	.
	Fortescue	0.2473	0.0352	11	.	.	.	.	.	.
	Gandys	0.4014	0.0846	11	0.3922	0.1182	12	0.4521	0.1410	11
	Higbees	.	.	.	0.0361	0.0159	11	.	.	.
	Highs Beach	0.7892	0.0884	12	0.9594	0.2162	11	0.795	0.2616	11
	Kimbles	0.7063	0.0813	11	0.8521	0.1992	9	0.4773	0.0741	11
	Norburys	.	.	.	.	.	.	0.4600	0.1626	10
	North Cape May	0.2250	0.0438	12	0.0500	0.0317	10	0.0904	0.0287	10
	Pierces Point	.	.	.	0.6128	0.1301	8	.	.	.
	Raybins	0.0259	0.0095	9	.	.	.	.	.	.
	Reeds	0.3808	0.0974	12	0.6468	0.1362	11	0.4049	0.2171	10
	Sea Breeze	0.0947	0.0071	4	0.1039	0.0175	9	0.2842	0.2001	4
	Cape Shore Lab	1.2452	0.1578	12	1.3311	0.2251	12	1.2775	0.1896	12
	Sunset	.	.	.	.	.	.	0.1139	0.0197	11
	Townbank	.	.	.	0.7363	0.2146	11	0.3958	0.1268	9