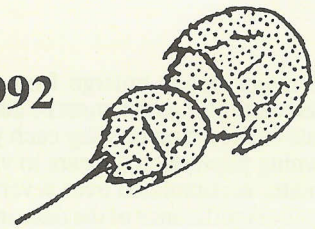


Limulus Spawning Activity on Delaware Bay Shores, 16 May 1992

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



ABSTRACT

On May 16th 1992, the spawning population of the American horseshoe crab along the shores of Delaware Bay was estimated to be 399,000. This estimate was based on a survey of 22 beaches: 13 in Delaware and 9 in New Jersey. The average male-to-female ratio at the water's edge was 3.13. About 72% of the total number of spawners were found on the New Jersey shoreline of the bay. The PM estimate was 2.04 times greater than the AM high tide estimate.

Introduction

The American horseshoe crab, *Limulus polyphemus*, is most abundant in the Delaware Bay area. The bay provides an excellent habitat for the horseshoe crab: extensive sandy beaches and low amplitude wave action essential for successful spawning; an environment suitable for the development and hatching of the larvae; broad intertidal flats for a nursery ground for the young, and temperate waters within the mid-range of the horseshoe crab's distribution.

Large numbers of crabs from the continental shelf and the deep waters of Delaware Bay migrate to the shores to spawn each year in May and June. This spawning ritual provides the ideal opportunity to count the animals, at the water's edge.

The census is a credit to the large volunteer group that has surveyed Delaware Bay beaches for three years at the peak of the horseshoe crab spawning season. It is important to obtain such information on *Limulus* so that its protection, as a species valued for its important role in medicine and ecology, can be balanced by fishery managers with the increased harvest of the females for bait.

Procedure

The census was conducted on May 16, 1992, the day pre-selected as the most probably date for maximum spawning due to the high tides associated with the full moon. The census was conducted twice during the day, in the AM and PM, at the times of the highest tides. A routine sampling method and a rapid survey were employed.

Briefly, the instructions for routine sampling consisted of 7 steps. **Step 1.** Arrive at the sampling area at least one hour prior to high tide. Establish the base sampling station by picking an easily accessible site on the beach and marking it with a stake. Then, to either left or right of the base stake, mark off and stake a 5-meter

section of beach. **Step 2.** Estimate the length of the beach where the crabs are known to spawn. **Step 3.** Establish additional 5-meter stations depending on the length of the beach and the spawning history (number of crabs in previous years). The number of the stations should be sufficient to: (1) provide data from one end of the beach to the other and (2) account for at least 10% of the anticipated spawners. **Step 4.** Remove all stranded (overturned and burrowed-in) crabs. After the census of the spawning crabs, record the number and sex of the newly stranded crabs. **Step 5.** Use the tally sheets provided. Give information on location and sampling team (names and addresses), as indicated. **Step 6.** Count the spawners within each 5-meter section of the beach. Record the total numbers of males and females on the tally sheet. If there are no crabs within a 5-meter sample area, it is important that this fact is recorded as a zero (0). **Step 7.** Clear sampling gear, etc., from the beach.

The rapid survey consisted of a visual survey of the entire length of the assigned beach. The observer rapidly paced off 15 meters (about 45 feet) along the beach. At the end of each 5-meter segment, the observer estimated the density of spawners within an area of 1 square meter according to diagrams (FIGURE 1).

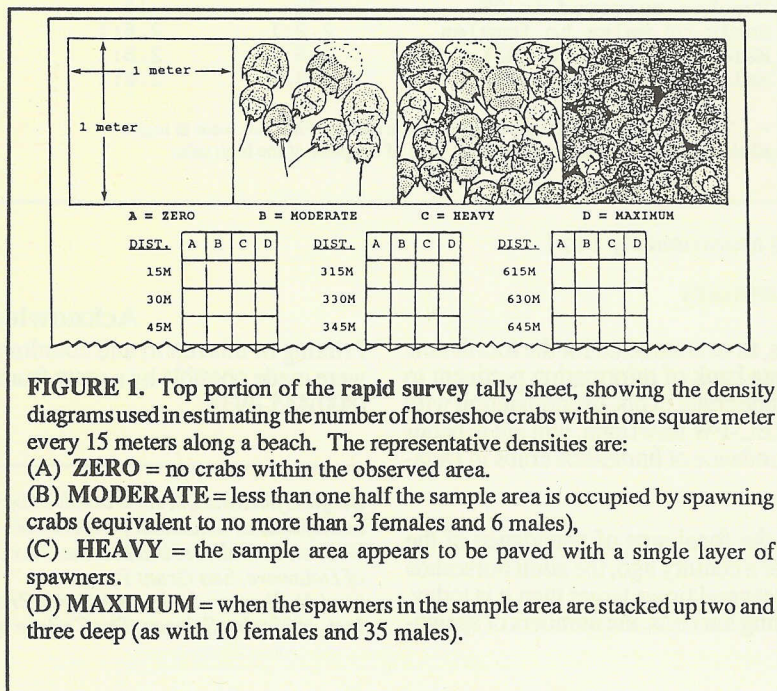
Results

A total of 399,000 horseshoe crabs were estimated to be spawning on the shores of Delaware Bay during the AM and PM high tides on May 16, 1992. A comparison of the 1990, 1991, and 1992 data has been tabulated (TABLE 1). These data were compiled from the results of the routine sampling method each year.

The rapid survey was introduced in 1992 and conducted on some of the beaches in conjunction with the routine census. On those beaches where both methods were employed, the estimated number of crabs from the routine census was 283,000, while the rapid sampling estimate was 205,000.

Discussion

The 1992 census data exhibit a sharp decrease in spawning crabs, in comparison with the estimates for the two previous years. Part of this decrease probably was directly due to weather conditions. Prior to the census date, May 16, the weather was cold and stormy, resulting in high amplitude waves and low water temperatures. The crabs migrating from the shelf and the crabs that wintered in the bay may have been prevented from coming ashore by the rough waters. Generally, the main environmental factors influencing spawning intensity are light, temperature, and wave amplitude.



Two major points emerge from an examination of the annual census data: (1) caution must be taken when assigning significance to data collected on one day each year, and (2) the horseshoe crab spawning population appears to vary from year to year. Clearly, estimates accumulated over several years are necessary to determine the significance of the data and to gain a better understanding of the size of the horseshoe crab population.

The 1993 census will include improved and more extensive sampling. The standardization of the routine sampling method involves using a string to measure off 100-meter sections on either side of the landmark stake. Three 5-meter segments have been marked on the string. If the spawning intensity is high, crabs will be counted only within these randomly selected 5-meter segments. When the crabs are not numerous, the entire 200 meters will be surveyed. Several beaches have been selected as annual reference stations and will be sampled several times during the spawning season: New Jersey—Highs, Cooks, Moores, and Fortesque; Delaware—Kitts Hummock, Pickering, Bowers, and Bombay Hook (Kelly Island). These beaches have been the sites of intense spawning during the last three years.

The one-day census was designed to obtain a baseline estimate of the spawning population. Additional activities can be conducted to expand the data base so that, ultimately, an estimate can be made of the entire adult population in Delaware Bay. One such activity will be added in 1993—the marking of spawners to determine the number of times that individuals return to a beach on successive tides. In addition, a large number of horseshoe crabs will be tagged during this period for further tag/recovery information.

Independent of this census, important information is being compiled by the Delaware Department of Natural Resources and Environmental Control—Division of Fish and Wildlife (DNREC—FW). Horseshoe crabs have been caught in a 30-foot benthic finfish trawl. These surveys were reinstated in 1990, March through December. Three years of the trawl data have established that: (1) horseshoe crabs are in Delaware Bay year-round, at least March-December and (2) the ratio of males to females is approximately 1 to 1.

Summary

The results of the annual census, to be conducted for the fourth time in 1993, will contribute to a data bank of information pertinent to population dynamics of horseshoe crabs. This, in conjunction with tagging programs and the DNREC-FW trawl data, will aid in better understanding trends in the abundance of horseshoe crabs in Delaware Bay.

Historically, Delaware Bay is the focal area of abundance of the American horseshoe crab. Over a century ago, the adult horseshoe crab population in the bay was several times larger than it is today. After 100 years of ever-decreasing harvests, the numbers of spawn-

ing crabs were so few that commercial harvesting stopped in the 1960's. Since then, the population has been slowly rebuilding. But, there are two main negative factors acting against this repopulation: (1) an increasing harvest of the egg-laden females for eel and conch bait, and (2) the area available for spawning is diminishing, due to the construction of groins and bulkheads.

It is imperative, therefore, to continue to collect data on the Delaware Bay population of horseshoe crabs. Before the recent introduction of tagging, the census and the DNREC-FW trawl survey, a data bank relating to the population dynamics of the horseshoe crab was non-existent. Now we can look forward to the time when the accumulated data will make a significant contribution to decisions concerning the management of the species and its unique habitat.

1993 Census Announcements

The date selected for the 1993 census is Saturday, June 5th. The daylight saving times of the high tides at the reference station for Delaware Bay (Breakwater Harbor, DE) are 9:59 AM and 10:18 PM. The further up-bay, the later the time of occurrence of the high tides.

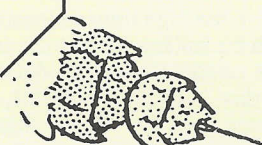
Three preparatory workshops will be conducted: (1) Saturday, May 22, at 10:00 AM in the Cannon Building, College of Marine Studies, University of Delaware, Lewes; (2) Saturday, May 22, at 2:00 PM in the Science Center Lecture Hall, Delaware State College, Dover, and (3) Wednesday, May 26, at 7:00 PM in the

Nature Center of Cape May, New Jersey. For additional information call or write: Benjie Lynn Swan (Limuli Laboratories, 7 Bay Avenue, Dias Creek, Cape May Court House, NJ 08210 or (609)465-6552 or William Hall (Sea Grant Program, College of Marine Studies, University of Delaware, DE 19958-1298 or (302)645-4253.

TABLE 1. Summary of estimates of spawning intensity on Delaware Bay shorelines, 1990-1992.

Item	8 June 1990	25 May 1991	16 May 1992
Individual spawners	1,240,700	1,224,800	399,100
Percent spawning in NJ	81%	57%	72%
Percent spawning in DE	19%	43%	28%
Individuals spawning on AM high tide*	317,400	318,200	134,000
Individuals spawning on PM high tide*	923,300	906,600	265,200
Ratio of individuals, PM versus AM high tide	2.9:1	2.85:1	2.04:1
Beaches surveyed in NJ	13	8	9
Beaches surveyed in DE	22	15	13
Ratio of males to females	2.2:1	2.6:1	3.1:1
Male/Female ratio (NJ)	2.6:1	2.5:1	4.1:1
Male/Female ratio (DE)	1.8:1	2.8:1	2.1:1

* The AM tides were during daylight hours and the PM tides were at night; all shoreline surveys were made at the time of the peak of the high tide.



Acknowledgement

Printing of this report and coordination of the 1993 census activity were made possible by a grant from the Delaware Estuary Program (800)445-4935.

Benjie Lynn Swan, M.S., is involved in research on the horseshoe crab and manufactures a medical product from its blood. William R. Hall, Jr. is a Marine Education Specialist with the University of Delaware, Sea Grant Program. Carl N. Shuster, Jr. is an Adjunct Professor of Oceanography, Virginia Inst. of Marine Science, The College of William & Mary.