Today's date: 12/3/2012

Project number: M/D-1201

Project title: Critical Horseshoe Crab Habitats in the Great Bay Estuary

Project initiation date: 3/6/2012

Project completion date: 10/31/2012

Type of project: Research

N.H. Sea Grant funds: $6000

Principal investigator: Win Watson

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Partner(s) and affiliation(s) (List any collaborators, sponsors, industry partners, municipalities, etc., associated with this project):
UNH Marine Docents and Coastal Research Volunteers: UNH Marine Program; United States Fish and Wildlife (providing tags)

Brief project overview/abstract:
The American horseshoe crab (*Limulus polyphemus*) is a valuable marine resource in the commercial fisheries and the biomedical field. However, their populations have been in decline in areas along the Atlantic coast due to overharvesting. Effective management of this species depends on accurate information about the size of local populations as well as the habitats that are critical for each life history stage. While intermittent efforts have been made to monitor the horseshoe crab populations in Great Bay estuary, NH, little is still known about the size of the resident population, their spatial distribution, the most important spawning areas and the characteristics of the habitats where juveniles reside. To goal of this Development Project was to both develop the tools necessary to investigate this important subject, and initiate the most important aspects of the research. During the summer of 2012, visual spawning surveys and behavioral studies were conducted in order to understand the potential areas where horseshoe crabs develop and spawn in Great Bay. We also tested the use of remote controlled planes for conducting these surveys. Over 2000 adult horseshoe crabs were counted in three major spawning areas. In addition, for the first time, we were able to identify areas where there were an abundance of juvenile horseshoe crabs. After testing a suction method, we settled on the use of SCUBA divers and this was much more effective. We have now taken the first big step towards completing a comprehensive study of essential habitats for multiple stages of a horseshoe crab's life history in the Great Bay estuary. In addition, we have developed the tools and volunteer network necessary to complete this work in a more comprehensive manner.
Objectives:

The main objective of this proposal was to identify the critical habitats used by horseshoe crabs in the Great Bay estuary, throughout all their life history stages. We achieved (and will continue to achieve) this objective by: 1) Conducting visual surveys of spawning horseshoe crabs during the height of their spawning season; 2) Performing tag/recapture studies at these spawning beaches to estimate the size of the adult horseshoe crab population in the estuary; 3) Identifying areas where juvenile horseshoe crabs reside, to test the hypothesis that the areas near mating beaches serve as important nursery habitats for juveniles; and 4) Conducting laboratory studies to determine if horseshoe crabs use olfactory cues to locate mating beaches.

A secondary goal of this project was to integrate the Great Bay estuary into the larger New England and Atlantic Coast Annual *Limulus* Survey. First, we sought to identify the locations within the Great Bay estuary where the majority of horseshoe crabs spawn. Second, we planned to organize and develop a monitoring program that is consistent in scope and methods with the surveys currently being conducted in other states. Finally, we sought to initiate this survey so that we could identify ways to improve it in the future.

The third major goal of this proposal was to develop the tools necessary for a more comprehensive study on this subject and demonstrate that these approaches are suitable for addressing these questions. In particular, we planned to: 1) Demonstrate that in NH horseshoe crabs spawn as often during the day, as the night, and therefore aerial surveys, using radio-controlled planes equipped with video cameras, could be an effective technique for identifying spawning beaches and quantifying spawning activity; 2) Test the potential for using planes to conduct spawning surveys; 3) Determine if it is possible to use Tag-recapture methods to estimate the size of the *Limulus* population in the Great Bay estuary; 4) Develop an effective mechanism for conducting juvenile horseshoe crab surveys and; 5) Determine if behavioral assays can be used to help identify some of the cues that horseshoe crabs use to assess suitable spawning beaches.

Project findings/progress to date:

1) Horseshoe crab Spawning Surveys

We focused our attention on 3 major spawning areas in the Great Bay estuary: Sandy Point, Greenland; Adam’s Point, Durham; Great Bay Marina, Newington. Surveys were conducted at every daytime high tide, with exception of the days around the full/new moon periods where surveys were conducted during both day and night high tides.

Over the course of May and June, a total of 2,323 adult horseshoe crabs were observed. Surges in horseshoe crabs sighted corresponded to increases in water temperature. We saw more crabs in areas at the head of Great Bay (Sandy Point), than in Little Bay (Great Bay Marina), even though the beach at the marina appeared to provide a more suitable habitat for spawning.

There were more horseshoe crabs sighted during the day than at night. For example, at Sandy Point, we counted an average of 51.9 ± 17.0 animals during the day, versus an average of 6.91 ± 3.04, at night (Fig. 1). Whether surges of horseshoe crabs spawning corresponded with the full/new moon cycles remains inconclusive. These data confirm our previous studies demonstrating that, in NH, horseshoe crabs do not prefer to mate at night. This means that aerial surveys are, in fact, quite feasible.
Figure 1. Average number of horseshoe crabs observed during the night, vs. day, high tides in 2012.

2) Aerial surveys

Josh Ildjani was hired as a consultant to test the potential for using planes equipped with video cameras to survey horseshoe crabs during the spawning season. We used the planes to fly over three major spawning sites and then watched the subsequent videos to determine if it was possible to count animals. While this method was, in fact, feasible (Fig. 2) it did not prove to be any faster or better than more traditional methods. Importantly, given the range of the system, it did not make it possible to survey are larger area faster, or to get to areas that we could not get to by boat, kayak or foot.

Figure 2. Image from video taken by remote controlled plane that was flying over the boat launch near JEL. The arrow is pointing to a pair of mating horseshoe crabs. A person is also visible on the boat launch.

3) Tag-Recapture Studies

Some of the animals sighted during spawning surveys were affixed with tags provided by United States Fish and Wildlife. As of November 2012, 211 horseshoe crabs were tagged and released and 30 were recaptured. Based on the Lincoln-Peterson Method, population sizes were estimated for the area near JEL Cove (482) and Sandy Point (2262). These data indicate the potential of this approach, but clearly more data are necessary to obtain an accurate estimate. It will also be important to determine how much movement is occurring between spawning beaches so that population estimates can be modified as necessary.

4) Juvenile Horseshoe Crab Surveys

Our original objective was to construct a suction-dredge device based on Burton et al.’s (2009) design that would obtain more than an order of magnitude more juvenile horseshoe crabs than
conventional trawls. We accomplished this task, but we failed to obtain juveniles with this approach. Most often the problem was related to debris, such as seagrass, clogging the device.

However, we did find a number of shells that came from juveniles that molted and we used these data to pick locations for conducting SCUBA surveys. This was very successful and so we went forward, using this method, to test the hypothesis that areas near mating beaches may serve as important nursery habitats for juveniles.

We did find juvenile horseshoe crabs throughout Great Bay, on the subtidal mudflats in about 6-8 ft of water, adjacent to mating beaches (Fig. 3). However, we did not find any juveniles found in Little Bay, even though there are several documented spawning beaches in Little Bay.

![Image]

**Figure 3.** The number of horseshoe crabs per square meter found at survey sites. Adam’s Point, Boat Launch (BL), and Sandy Point were surveyed twice. The red X denotes our spawning surveys areas.

In order to get an estimate of growth rate we compared the size of shells from molting and live juveniles. It appears, from these data, that juveniles grow about 30% larger each time they molt (Fig. 3). These findings are consistent with other studies of juvenile development (Seikiguchi 1988; Carmichael et al. 2003).
5) Behavioral Studies

In a controlled setting, the attraction of horseshoe crabs to two factor types of their spawning habitats were analyzed, sediment type and the salinity of the water. The sediments that were commonly found at spawning sites were sand, mud, and shale. Preliminary results showed when confronted with a choice between a mud and shale, females significantly preferred shale, spending an average of 57.7 ± 13.9% of total time in that area of the maze (n=3). When confronted with a choice between seawater and freshwater, both female (n=5) and male (n=8) horseshoe crabs showed no bias. However modifications to the experimental design need to be made in order to confirm this.

Accomplishments (Accomplishments are the key actions, activities or products resulting from Sea Grant projects. They are distinct from impacts in that they reflect ongoing activities or key results that may not yet have had a significant economic, societal and/or environmental benefit but lay the foundation for such a benefit. Accomplishments may evolve into impacts in the future.).

As a result of this project, we have had several accomplishments and breakthroughs. First, initiating the Great Bay Horseshoe Crab Spawning surveys, which will likely continue into the future. We hope this will become a key volunteer activity in NH and help prevent a decline in the horseshoe crab population. Moreover, if conducted properly, horseshoe crabs could be a good sentinel species in the estuary, and thus provide an index of certain impacts such as climate change and oil spills. We counted over 2000 horseshoe crabs during the summer of 2012, which far surpasses previous monitoring done by New Hampshire Fish and Game (600 crabs over the course of 4 years; Fischer pers. comm.). Second, we the tag-recapture program we started will, for the first time, make it possible to estimate the size of the horseshoe crab population in the estuary. Finally, we are just beginning to understand where the critical juvenile horseshoe crab habitats are located. In 2006, when the Great Bay Reserve of New Hampshire Reserve began a horseshoe crab monitoring project, they reported that no juveniles were
ever sighted (NHFG, 2010; Fischer pers. comm.). This year, using SCUBA divers, we successfully found juvenile horseshoe crabs throughout Great Bay. We captured, measured, and released a total of 63 juvenile horseshoe crabs ranging in size from 30 mm to 100 mm. We look forward to extending this work in 2013.

**Impacts** *(Impacts are significant economic, societal and/or environmental benefits of a project.)*:

The New Hampshire Sea Grant Strategic Plan for 2011-2013 lists the development of new techniques for monitoring critical habitats as a key activity to achieve the programmatic goal of **restoring “critical coastal habitats and their ecosystem function.”** In addition, NH Sea Grant expects “collaboration with local and state management agencies, [to] develop outreach programs to transfer critical habitat knowledge and restoration technologies to public officials and citizenry.” This project has helped the NH Sea Grant Program achieve these goals.

This project has potential management implications for horseshoe crabs in the Great Bay estuary since there remains little information about their population in this area. First, it is important to identify the critical areas where horseshoe crabs spawn and where the juveniles develop because these are very vulnerable life history stages. Second, by establishing an easy, reliable, volunteer-based survey it will be possible to track fluctuations in the horseshoe crab population and, if necessary, take appropriate actions. The absence of recruitment sources outside of Great Bay, and the extremely long maturation time of horseshoe crabs (7-11 years, Shuster 1950), means that if the local population declines, it will be difficult to reverse and potentially will cause drastic cascading effects on the rest of the estuarine system. And as horseshoe crabs face growing threats from overharvesting, housing developments along the coasts, and other anthropogenic events, it is both timely and important to learn more about the horseshoe crab population in the Great Bay estuary, and the habitats that are critical for all of their life history stages.

A major aspect of this project is the communication with managers, biologists and residents of the community. Throughout this project we communicated frequently with New Hampshire Fish and Game and compared our survey data with their monitoring program data. We have shared our results with them and we hope that in the future we may both integrate our surveys methods together to be consistent with the greater New England and Mid-Atlantic horseshoe crab surveys. In addition, interested residents of the surrounding community were invited to volunteer and participate in the horseshoe crabs spawning surveys. We held training sessions prior to conducting surveys and after surveys were completed, shared our results and the significance behind them as well as possible changes for next year. Overall the volunteers were very pleased to see the effort of their work based on the results we’ve collected. News and enthusiasm has already spread about helping us again survey next summer and we are very excited.

**Economic benefits realized to date** *(businesses retained or created, jobs retained or created, market and non-market economic benefits):*

N/A

**Tools, technologies or information services resulting from this project that are being used to improve ecosystem-based management** *(e.g., that reduce contaminants that harm coastal ecosystems and seafood consumers; that track changes in ecosystem processes, biological responses and conditions):*

In collaboration with Josh Idjadi we tested the concept of using small remote controlled planes, equipped with video cameras, to conduct horseshoe crab spawning surveys. While the technique worked well, it will require a larger plane that can cover a larger area in order to be cost effective.
Related grants and contracts (Other grants and contracts that funded this project or that were obtained as a result of this project):
UNH Marine Program Jackson Estuarine Lab Endowment Fund

Publications to date (please attach PDF or send a hardcopy if applicable):
N/A

Awards:
N/A

Additional information:
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Students Supported (see next page)
## Students Supported

<table>
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<tr>
<th>Student Name</th>
<th>Where is he/she now?</th>
<th>Institution/Department</th>
<th>Duration of support</th>
<th>Type of support (stipend, travel, supplies, etc.)</th>
<th>Type of degree: Undergrad Master’s PhD</th>
<th>Year degree awarded</th>
<th>Title of thesis if supported by N.H. Sea Grant</th>
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<tbody>
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