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# Project Limulus: What Long-Term Mark/ Recapture Studies Reveal About Horseshow Crab Population Dynamics in Long Island Sound


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# Project *Limulus*: What Long Term Mark/Recapture Studies Reveal About Horseshoe Crab Population Dynamics in Long Island Sound

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## ABSTRACT

Project *Limulus* is a long-term study of the population dynamics of the horseshoe crab population in Long Island Sound (LIS). We have tagged over 20,000 spawning adults from >20 beaches ranging from Greenwich to Stonington, CT since 1997. Cumulative recapture rates have reached 9%. On average 90% of the crabs are recaptured within a few miles of their original tag site within the first season. Between seasons, on average, 45% of crabs are recaptured within the same locality of where they were tagged. Of all recaptures, 99% of recaptured individuals are found within LIS. This past year we expanded the study into RI, NY, and MA collaborating with many groups for a regional horseshoe crab census. Preliminary findings reveal low spawning numbers compared to Delaware Bay across the region.

## INTRODUCTION

The Atlantic horseshoe crab, *Limulus polyphemus*, inhabits the eastern coast of the United States ranging from the Yucatan Peninsula northward to Maine with spawning populations distributed intermittently along the coast (Anderson and Shuster 2003). The highest abundance and frequency of horseshoe crabs exists between New Jersey and Virginia centered on the Delaware Bay (Botton and Ropes 1987). Extensive research has been conducted on horseshoe crab populations residing around the Delaware Bay and the Southeastern United States (Rudloe 1980, Shuster and Botton 1985, Botton et al. 1988, Wenner and Thompson 2000, Smith et al. 2002) but no comprehensive regional work has been done for spawning populations in New England. In fact, until recently most data on existing horseshoe crab populations in New England were outdated (Shuster 1950, 1957, 1982, Baptist et al. 1957). While presenting important historical information on size distributions, spawning sex ratios and movement patterns within New England, these studies do not provide data relevant to spawning densities, survivorship, or recruitment.

The status of the Long Island Sound (LIS) horseshoe crab population is relatively unknown. Based on limited harvest data, the Atlantic States Marine Fisheries Commission (ASMFC) concluded that the western portion of LIS showed significant or marginally significant positive trends in population size while no trend was detected in eastern LIS (ASMFC 2006). However, the ASMFC also stated that overall indices for LIS have trended downward since their peak in the early to mid – 1990's and are at levels near or below those encountered in the mid-1980's. The only scientific evidence to support historic population levels in LIS are based on data collected from 1957-1962, and published by Sokoloff (1978) who estimated the population of horseshoe crabs in Cold Spring Harbor, NY to be ~30,000. More recent studies have focused on mating behavior (Mattei *et al.* 2007) and preliminary studies of population dynamics (Mattei, 2006).

Project *Limulus* is a community research endeavor whose participants tag and collect data on the population of horseshoe crabs that inhabit LIS. Participants learn the economic and ecological importance of horseshoe crabs to human health and the LIS ecosystem. Nonprofit environmental educational organizations, K-12 School groups, and undergraduate research assistants participate with the goal of promoting science literacy and monitoring the majority of LIS spawning beaches in Connecticut and New York. The goal of Project *Limulus* is to determine the population dynamics, migration patterns, and ecological links to other species in LIS. Started in 2003 and based at Sacred Heart University, Project *Limulus* participants have tagged horseshoe crabs that spawn

on beaches along the Long Island Sound coastline during the spawning season. We also have some participants that utilize trawling to capture horseshoe crabs who then tag and release them (e.g. The Maritime Aquarium, SoundWaters). In 2008, Project *Limulus* started surveying spawning beaches to monitor spawning density. Here we present results from the long term mark recapture study and the initial data from the 2008 spawning surveys.

## METHODS

Each year during the first full and new moon of May and June (+/- two days for weather), Connecticut beaches were surveyed for horseshoe crab activity on receding tides. Prior to 2007, encountered animals were tagged with a yellow Floy Cinch-up fish tag. Since 2007, encountered animals were tagged with a US Fish and Wildlife disc tag. Both tags did not harm the animals in any way and similar tagging methods have been used by researchers in New Jersey, Delaware, and Florida (Swan 2005). Data collected included prosoma width (PW) (straight-line measure in cm) and sex. Breeding individuals were noted, as were their mate's tag number. If more than one male was present, additional males were recorded as satellite males. Recaptured individuals were noted as to date, locality, and mate tag number if applicable. Each tag carries a unique specimen ID number, a contact phone number, and an email address. Therefore, some recaptures are called in by the public.

Spawning density was examined beginning with the first full moon of April and every full and new moon thereafter until mid July two hours after the highest high tide. Spawning surveys were conducted on multiple beaches by researchers and volunteers using a sampling protocol developed by James-Pirri et al. (2005). At each site, a coin flip determined the starting point of the survey (north vs. south end of site). The location of the first quadrat (9m<sup>2</sup>) was randomly determined within the initial 10m of beach. All subsequent quadrats were systematically placed 10m apart (40 quadrats per site per survey). Each quadrat was located adjacent to the water's edge with the quadrat extending into the water. The number of horseshoe crabs with respect to mated pairs, mated pairs with satellite males, and solitary crabs (females and males) was counted within each quadrat. Previously tagged animals encountered within any quadrat were immediately recorded. Environmental conditions (weather, wave height, air/water temperature, and light levels) were recorded prior to the start of each survey.

## RESULTS

Over 20,000 spawning adults from more than 20 beaches ranging from Greenwich to Stonington, CT have been tagged since 1997 (Figure 1). This past summer alone, project participants deployed 6, 272 federal disc tags. Our cumulative recapture rate is 9%. Cumulative recapture rates have reached 9%. The sex ratio of tagged crabs has remained fairly constant over the past ten years (Figure 2). Of all recaptures within one month, 75% of the crabs are found within a mile of their original tagging location (Figure 3). The percentage of crabs recaptured at their original tagging site declines over time. Of the crabs recaptured 5 months after tagging, 40% of crabs are found within a mile of where they were originally tagged. In addition, male and female horseshoe crabs appear to move east and west of the tag site with equal frequency. Of all recaptured individuals 99% are found within LIS. Over 223 surveys were conducted across the Connecticut coastline during the 2008 spawning season covering 26 beaches. The seasonal spawning density of horseshoe crabs in Long Island Sound (measured as the number of mated females per meter squared) was on average 0.008 females/m<sup>2</sup>. The highest seasonal spawning density (0.02 females/ m<sup>2</sup>), averaged across 24 surveys, was found on Sandy Point in New Haven, CT. Notable spawning densities were recorded at Esker Point in Groton, Jordon Cove Beach in Waterford, Short Beach in Branford, and isolated beaches along Greenwich Point compared to other beaches (range 0.05-2.9females/m<sup>2</sup>) although these were restricted to one or two surveys. Spawning densities were typically higher during nighttime rather than daytime high tides. In general, the CT spawning density is three orders of magnitude lower than spawning populations reported from DE Bay although CT remains higher than Rhode Island or Massachusetts (Table 1).

**TABLE 1.** Median and range of spawning indices from Massachusetts, Rhode Island, Connecticut, and Delaware Bay (\*Unpublished data from Alison Leschen and Mary-Jane James-Pirri; \*\*Data from Smith *et al.* 2002)

	MA*	RI	CT	DE Bay**
Median Spawning Index (# mated females/m <sup>2</sup> )	0.002	0.006	0.008	~1.0
Range	0-0.018	0-0.01	0-0.29	0.7-3.0

## DISCUSSION

In general, horseshoe crabs tagged in LIS tend to remain in LIS supporting the idea of a LIS sound subpopulation. There is evidence from other studies indicating relatively closed populations in large embayment areas such as the Delaware and Chesapeake Bays (Swan, 2005). Site fidelity is rather strong within the spawning season. Three quarters of all crabs recaptured within 30 days of the original tag date were located at or near their original spawning beach. However, between spawning seasons, site fidelity decreases. Of the 40 percent of crabs that were recaptured at their original tag location, the majority were recaptured over non-consecutive years suggesting that horseshoe crabs may not spawn annually. Horseshoe crabs do cross LIS to the northern shore of Long Island and vice versa. Interestingly, the majority (> 95%) of crabs that were recaptured on the opposite side of LIS from where they were tagged were female. Sex ratios appear relatively constant although there has been a slight increasing trend in the number of males to females since 2003. However, sex ratios in LIS are on average 1 female to 1.7 males, far lower than DE's sex ratio of 1 female to 4.9 males (Swan, Hall, and Shuster, 2007).

Spawning densities in LIS are nearly three orders of magnitude lower than Delaware Bay. Surveys conducted across the CT coastline in 2008 reveal that horseshoe crabs tend to spawn in higher densities at night than during the day. However, there were a few exceptions for some beaches where night time surveys recorded lower densities than daytime surveys throughout the season. The surveys also indicated that horseshoe crabs in LIS tend to spawn on almost any type of beach including sand, mud, cobble, and in some cases reinforced seawalls. For example, spawning surveys in Bridgeport documented horseshoe crabs attempting to deposit eggs in extremely shallow depressions among concrete and asphalt pieces at the end of a street. Furthermore, surveyors watched as a few horseshoe crabs attempted to excavate a nest in grass at the top of a cobble seawall. Spawning success in poor quality beaches is likely to be low. Why horseshoe crabs spawn on these poor quality beaches is a mystery.

In conclusion, the tag data support the notion that horseshoe crabs in LIS remain in LIS with few exceptions. Sex ratios are skewed towards males but there is a lower ratio of males to females in LIS compared to DE Bay. Horseshoe crabs exhibit moderate site fidelity within a spawning season but site fidelity decreases over time. Spawning indices are significantly lower in LIS than in DE Bay.

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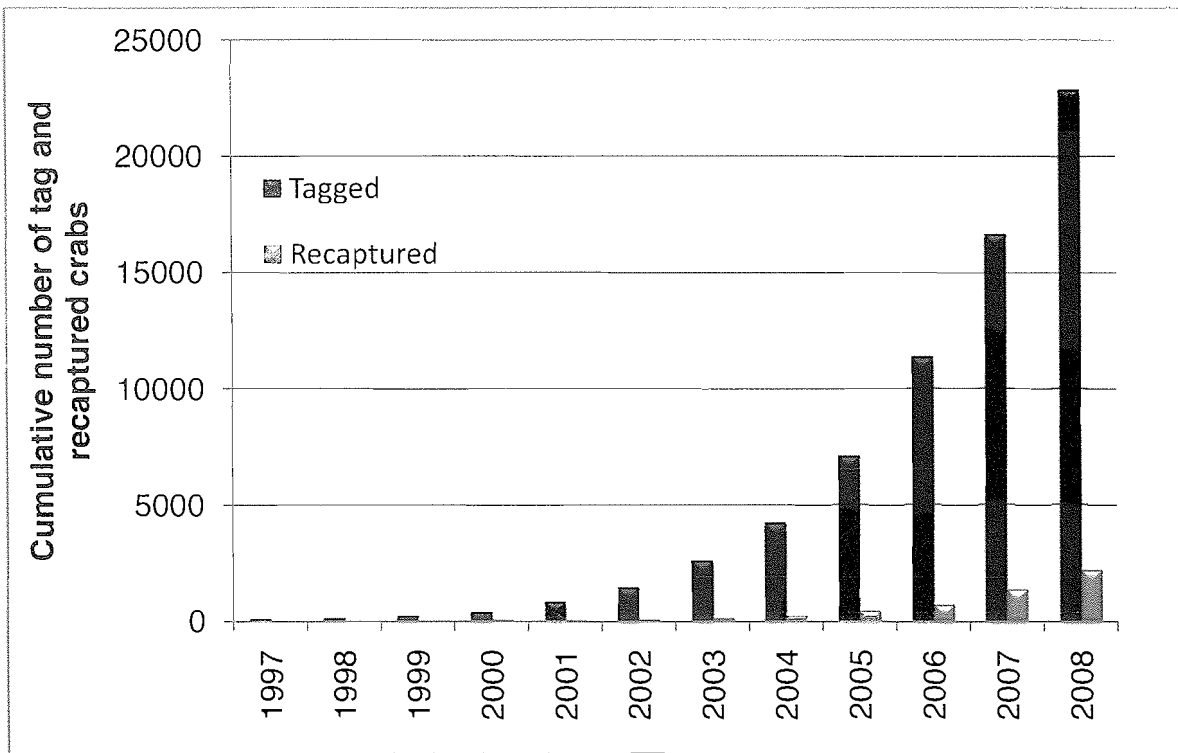


FIGURE 1. Cumulative number of crabs tagged and recaptured by Project *Limulus* Participants since 1997.

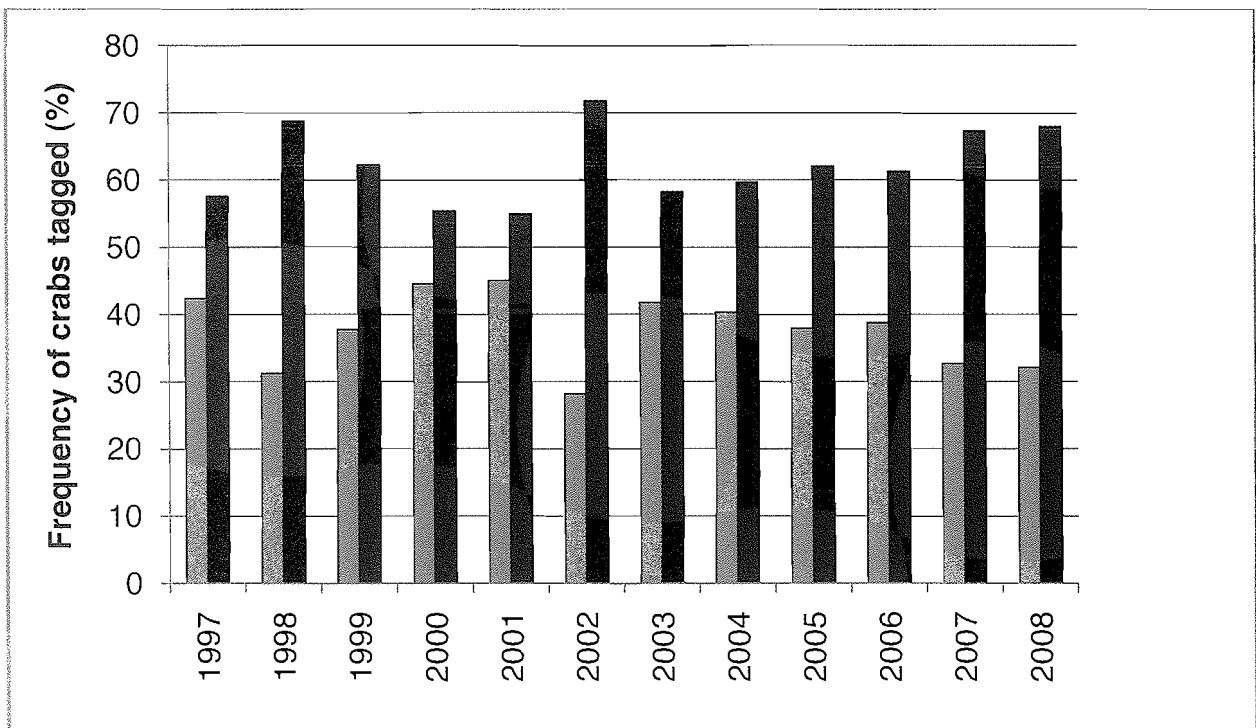
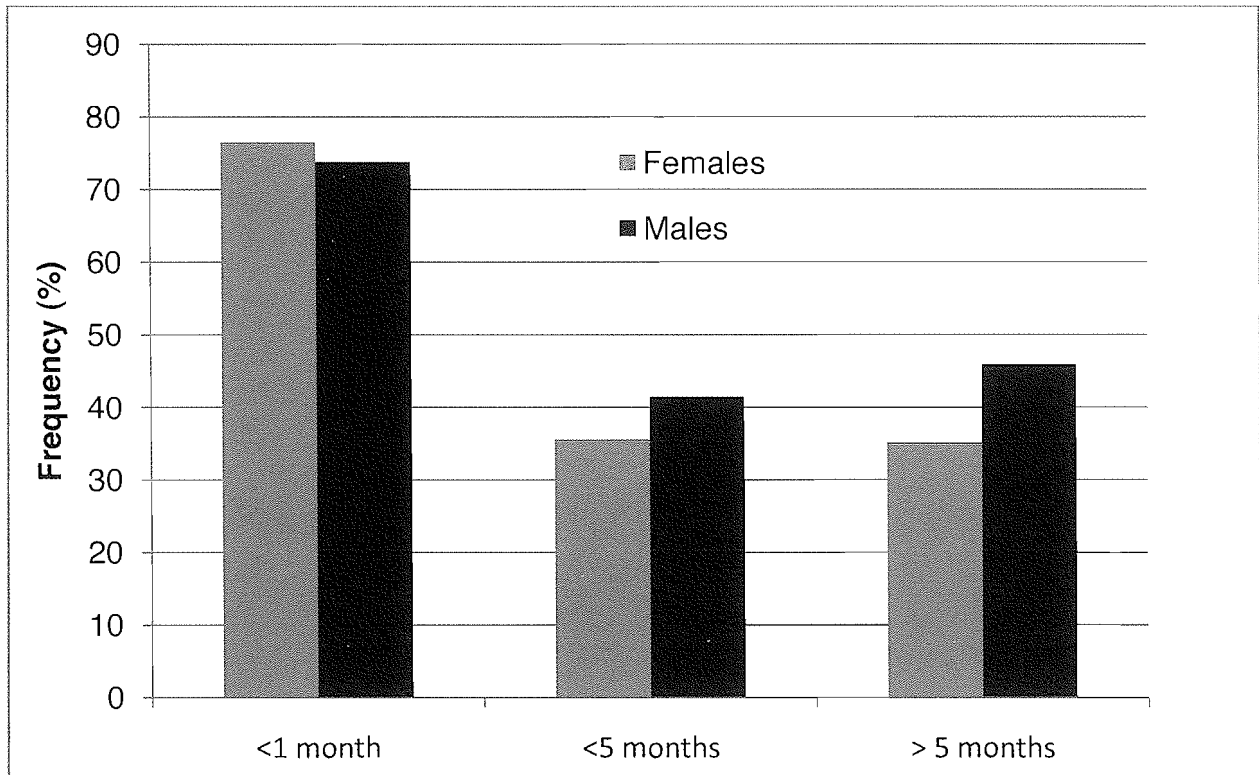


FIGURE 2. Number of crabs tagged by sex from 1997-2008. Gray indicates the percentage of females and black indicates the percentage of males.



**FIGURE 3.** Frequency of crabs by sex that were recaptured at the same location they were tagged less than 1 month after tagging, less than 5 months after tagging, and greater than 5 months after tagging.