

The Impact of Biomedical Use of Horseshoe Crabs

Post Pandemic Update

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Introduction

The worldwide impact of the pandemic and the remarkable response to it, has changed the way we live, work and play. The Bacterial Endotoxins Test (BET) industry is not immune to the impact and looking back at the past several years it's easy to recall some of the concerns about the industry supply lines and ability of the BET industry to rise to the demands of the COVID-19 treatments and vaccine development. Also of concern was the horseshoe crab population in the U.S. as LAL manufacturers responded to the call by the pharmaceutical industry to supply this vital assay. We are proud to report that not a single vaccine nor treatment for COVID-19 was delayed for lack of BET reagents. In fact, the BET industry responded to an unprecedented time in the world's history and satisfied the demand from billions of vaccines being administered and countless treatment options being utilized. Supply lines were robust and met the many challenges as they are designed to do. Scalability of the industry was a key element in meeting the many demands placed on vaccine and treatment development, production and delivery.

Several published articles and reports contained information that is inaccurate regarding the horseshoe crab population and its use in the biomedical industry. Associates of Cape Cod Inc. (ACC) addressed some of some of the misleading suggestions made in those publications in 2018: Impact of Biomedical PR18-033 (acciusa.com) and again in working with the pharmaceutical industry in 2021: COVID-19 and the Sustainability of the LAL Supply (pda.org). With the impact of COVID-19 largely behind us it is an appropriate time to review the status of the American horseshoe crab, post pandemic, and address some of the most recent rumors regarding the true impact of the industry.

Recently and continually, it has been suggested that manufacturers of *Limulus* Amebocyte Lysate (LAL) reagents are loosely regulated and a primary contributor to a speculative population decline of the American horseshoe crab, *Limulus polyphemus*.^{1,6,10} This article will demonstrate that the overall number of horseshoe crabs is stable; *L. polyphemus* is certainly not in danger of extinction, and is thriving in many areas of its range. The LAL industry is closely regulated and has a relatively minor impact on mortality in the horseshoe crab population, even during an event such as a pandemic. In fact, it's a fair statement

to say that in many areas where LAL manufacturers operate, the population of HSC in the US has actually grown in recent years.

Is the horseshoe crab population in the United States in decline?

The simple answer is that the total number of horseshoe crabs is healthy, stable, and there is strong evidence it is increasing. There is reliable data concerning horseshoe crab population numbers and trends for over 20 years, and analysis of that data shows no evidence of an overall decline over that time. The American horseshoe crab has a widespread distribution made up of multiple populations along the east coast of the United States and horseshoe crabs populations appear to be stable and/or growing in most regions of the US.

The largest population of horseshoe crabs on the east coast is in Delaware Bay, and the most recent data show that numbers there are stable and/or increasing. A summary of an October 5, 2016, meeting of the Atlantic States Marine Fisheries Commission (ASMFC) Horseshoe Crab Technical Committee included estimates for horseshoe crabs in the Delaware Bay from 2015.⁷ The collected data indicated the presence of approximately 8.1 million adult females and 16.4 million adult males, which is an increase from 7.9 million females and 15.2 million males in 2014.⁴ Compare that to 2021 with an estimated population of 13.5 million adult females and 39 million adult males.⁵ These data would indicate the population growing significantly, in less than 10 years in that region alone.

In the Northeast region, populations are smaller than further south. Variations in subpopulation sizes do not have a huge impact on the metapopulation; however, variations may be important locally. In New York, where there is a bait fishery but no biomedical fishery, surveying shows declining numbers. In Connecticut, where there is also a modest bait fishery but no biomedical fishery, populations have also declined. In this region management actions have included lunar closures, and prohibitions on harvesting spawning animals off the beach in an effort to protect spawning populations in hopes of reversing these trends.²

In Massachusetts, the most recent 2021 Compliance Report by the Massachusetts Division of Marine Fisheries (MADMF) for the ASMFC states: "Horseshoe crab survey results from the 2021 DMF spring and fall trawl surveys were mixed. South of Cape Cod, mean number and weight

of spring caught males and females in SNE remain near their respective time series highs, but at or below time series medians in the fall.¹¹

The American horseshoe crab has distinct, fragmented subpopulations all over the eastern seaboard, including states north of Massachusetts. These northern fisheries are so small that these states are not required to report population trends to the ASMFC. Georgia and Florida both have horseshoe crab populations that appear to be stable.

Is biomedical fishery a significant contributor to horseshoe crab mortality?

The process of extracting the blood from the horseshoe crabs is minimally invasive and the overwhelming majority of crabs that undergo the procedure survive the process. In fact, many studies demonstrate survivability of the animals when treated properly and carefully. One study of nearly 70k crabs bled by biomedical companies over the course of years concluded the bled crabs survival rate was as good or better than the un-bled crabs.¹² The biomedical community supports and practices a release program where crabs caught under a biomedical license are released back to the wild. The Atlantic States Marine Fishery Commission (ASMFC), which manages the horseshoe crabs along the entire east coast, attributes 15% mortality to those released crabs,² assuming an 85% survival rate for use in the manufacture of LAL.

Horseshoe crabs are also used as bait in whelk and eel fisheries in the US and abroad. Horseshoe crabs are harvested and placed in traps where the eels or conch enter but cannot easily exit. This process is fatal to the crabs and has come under significant scrutiny coast wide with several states choosing to prohibit the practice altogether. In states that do allow a bait harvest, measures such as minimum sizes, a male only harvest and/or prohibitions around harvest timing help to protect spawning stock. Coast wide from Maine to Florida, a five year average of 735,000 crabs are caught annually to be used for bait. This is roughly one half of the coastwide quota of 1.5 million allowed to be harvested for bait. This number dropped significantly during the pandemic when restaurants closed or saw dramatic reductions in patrons seeking whelk derived products.⁵

The coast wide horseshoe crab mortality is represented in the graphs below. It can be seen that the biomedical industry does not substantially contribute to overall mortality (Figure 1).⁵ The five year average estimated mortality for LAL manufacturing is ~ 94,000 crabs.

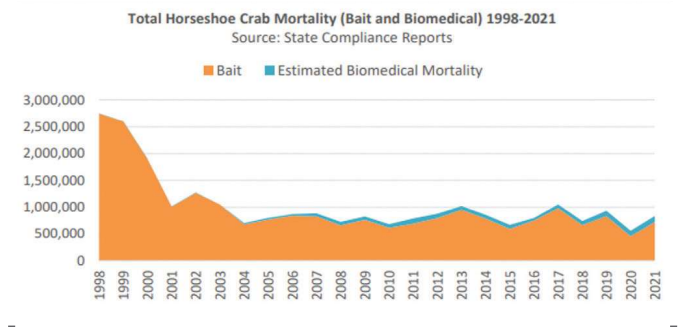


Figure 1.

To further evaluate if areas of biomedical catch and release are impacting horseshoe crab populations, an analysis of areas with biomedical manufacturers is explained below.

Horseshoe crabs are collected for biomedical purposes and for bait in the Delaware Bay and for biomedical purposes only in the coastal waters of South Carolina. Population numbers in all of these areas are either stable or increasing.

In Rhode Island, where there is a limited bait fishery and limited biomedical fishery, recent numbers are low, but data gave no indication of an increasing or decreasing trend.

In Massachusetts, where there is a biomedical fishery and a bait fishery, survey data show positive population trends, particularly in the southern region where the fisheries are concentrated. Massachusetts uses a combination of three surveys to gauge trends in the fishery; A trawl survey that is run in the Spring and Fall in waters south and North of Cape Cod, about a dozen beach surveys and market surveys capturing prosomal width of crabs sampled at both bait vendors and the biomedical facilities.

Most telling is the trawl survey which began in 1983 Shown below are data from the Massachusetts spring and fall surveys depicting male and female catches per tow. South of Cape cod where 85% of the fishery exists (Figure 2) and North of Cape Cod (Figure 3).¹¹

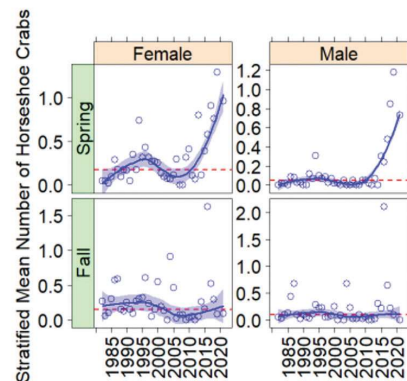


Figure 2.

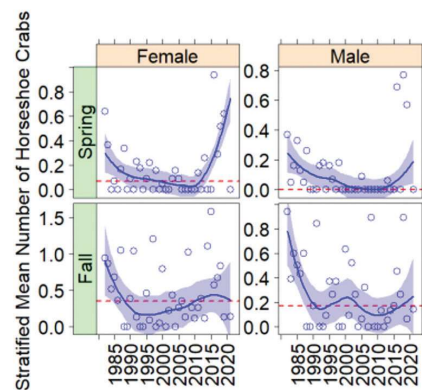


Figure 3.

In summary, these reports give no indication of a correlation between the biomedical fishery and population decline. In the regions with the largest biomedical fisheries, numbers are stable or even increasing.

Is the horseshoe crab fishery monitored?

All states which have a significant harvest of crabs for use in the bait and/or biomedical industry are required by law to report information regarding the number and sex of crabs harvested to the ASMFC.

For LAL manufacturing, data containing the sex, number, origin, and dead loss must be reported. That is to say that every crab that enters a LAL facility is counted, sexed and reported to the state. In turn the state reports these data to the ASMFC which then produces annual reports, guidelines and quotas for the coast wide fishery and individual states. States can use the quotas as a regulation or reduce but never increase the quota. Some have reduced or eliminated harvest for bait altogether.

Many states protect the populations of crabs by limiting access to spawning populations and or/ females. This is done with lunar closures prohibiting harvest at peak spawning time, delaying harvest till after peak spawning and requiring Male only fisheries for bait. Size limits can ensure mature animals are harvested.

It should be noted that LAL manufacturers are subject to audits and inspection by any number of entities including the US FDA, ISO, fisheries managers, law enforcement, customers, and potential customers among those that routinely visit on site. These can happen anytime with or without notice.

Additionally, the management of the fishery by the ASMFC and state fishery departments has ensured that the use of the horseshoe crabs in both bait and biomedical industries is closely monitored.

Media

Recent articles, podcasts and similar media often suggest that the handling of the horseshoe crabs results in a higher mortality than is estimated by the ASMFC.^{6,10} In part because some experimental studies focused on the after effects of the simulated process on horseshoe crabs, that are handled and kept under more stressful conditions than those used by the LAL manufacturers. This resulted in reports of high mortality and sub-lethal effects. Like all animals, if horseshoe crabs are not treated well, they do not fare well. Proper handling of horseshoe crabs is important to maximize the survival of horseshoe crabs returned to the water. This is recognized by the ASMFC, who manages the horseshoe crab fishery according to a fishery management plan (FMP) A code of best management practices (BMPs) has been formulated between the ASMFC, the states, and biomedical companies, which builds on the catch and release practices that have been in place for many years. These BMP's were reviewed and updated by stakeholders

and scientists in 2023.³ In Massachusetts, there is a regulatory requirement to adhere to specific best practices as a condition of the biomedical license.

Summary

In conclusion: The management of horseshoe crabs is highly regulated in the United States on both a regional and state specific level. The population successfully supports both a bait industry as well as a LAL manufacturing industry and there is encouraging evidence that the population is growing in many areas. Though life has changed for many of us after the major impact of COVID-19 has begun to wane. At least one aspect, the overall population of horseshoe crabs in the US, is stable and/or increasing. This is of course good news and serves as evidence that responsible use and good management of the fishery pays dividends.

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