Chapter 12
Habitat Inventory Trend Analysis of *Limulus polyphemus* Populations on Long Island, U.S.A.: From the Tip of Brooklyn to the Tip of Montauk, 2003–2014

John T. Tanacredi and Sixto Portilla

Abstract Considerable concern regarding the abundance of the American horseshoe crab (HSC) *Limulus polyphemus*, along the east coasts of New Jersey and Delaware prompted past moratoriums on collecting HSC for bait in New Jersey. The parallel population decline in migratory shorebirds such as Red knots *Calidris canatus*, Ruddy turnstones *Arenaria interpres* and others that seasonally feed on the copious quantities of HSC eggs laid along this shoreline resulted in reduced HSC collection permits to numbers considered sustainable. In New York State's Marine District, which is mostly comprised of the Long Island coastline, there is no reliable or routine habitat inventory network existing for determining HSC populations or habitat. Shorebird data, which have been collected by Audubon Chapters, the National Park Service and the US Fish and Wildlife Service, as well as academia, have hinted at declining HSC populations. However, due to the lack of a formal and extensive or reliable inventory network, assessing changing trends in HSC population levels is unattainable or mostly inaccurate. Molloy College's Long Island HSC Network provides survey forms and a website to (1) collect data on Long Island sites which support HSC; (2) count HSC for as reliable an estimate of the HSC population as practical; (3) sex and age individual HSC at each site; and most importantly (4) establish a network that can be repeated annually to detect precipitous changes in HSC population numbers, distributions, and habitat. Data collection for HSC will aid in protecting the HSC population as well as bird species number which require HSC eggs as food during significant migratory periods.

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Results for the last 11 years for 68 sites monitored annually reveal (1) considerably reduced numbers of HSC than "remembered in the past"; (2) sites along the Long Island coastline now believed to support HSC have been found to have few to modest numbers of HSC; (3) a preliminary number projection of *Limulus* on Long Island at approximately 15,000 adult breeding individuals on beaches surveyed; (4) of the 68 beaches monitored since 2003, an increase of 8.2 % had been observed for the number of beaches exhibiting "no breeding activity"; and (5) there has been observed an average of 1 % per yr decline in the total number of HSC observed.

Keywords Captive breeding • Long-term monitoring • Habitat suitability • Inventory • Monitoring re-nesting

12.1 Introduction

At the turn of the new millennium in 2001 the senior author's book "*Limulus* in the Limelight" (Tanacredi 2001) portended to be a "silent siren" for conservation biologists to make all efforts to protect and conserve a group of organisms that have existed on Earth for over 445 million years, surviving mass extinction events. This last 14-year period is even more significant to our conservation efforts as biodiversity vanishes globally. We noted then that, "some of the most basic biological information about (this) species still eludes us in describing horseshoe crab biology." This statement rings true today for all of the four species of horseshoe crabs, as attempts by a recently formed team of scientists and conservationists, who are working to have them listed on the IUCN's (International Union of Conservation for Nature) Red Listing. Hopefully this may provide some added protection against the ultimate demise of the species from overharvesting and/or habitat loss. This effort has been a daunting task, as little information exists on the three Asian species, all considered to be at ordinarily low population levels (Tanacredi et al. 2009), as well as an absence of detailed inventory of numbers and habitats of the North American species. Anecdotal reports of HSC along Long Island provided the impetus to establish an inventory of habitat supporting breeding horseshoe crabs, as Long Island's HSC populations have historically been plundered for fertilizer, bait, and for bleeding.

Long Island, the largest island in the United States, provides over 1,000 miles (ca. 1,600 km) of coastline with estuarine ecosystems supporting breeding horseshoe crabs dating back to before formal records were required by fisherman to gain a permit to harvest them. The largest continuous acreage of tidal wetlands and greatest diversity of habitat in New York State (NYS) is encompassed by the south shore of Long Island (Pataki and Daniels 2001), providing a major nursery ground for juvenile fish and shellfish maturation (Roman et al. 2000). Today NYS Department of Environmental Conservation (DEC) issues permits to collect a total of 135,000 horseshoe crabs each year for bait, bleeding and education/scientific research. It is the only state along the Atlantic Coast of the US that has not placed a total moratorium on harvesting HSC during their critical breeding times. The commercial take of *Limulus* for conch (*Busycon carica*) and eel (*Anguilla rostrata*) fisheries and for pharmaceutical use, creates a lucrative industry for local fishermen and for LAL (*Limulus* amoebocyte lysate) production in the US.

During the peak breeding periods along the Atlantic coastline of high tide/full moon or new moon, thousands of spawning adults gather along this tidal coastal fringe, accessible for harvesting which can "clear a beach" of all horseshoe crabs in a matter of hours. Those crabs permitted by NYS DEC to be harvested for "bleeding" are taken to Massachusetts where one company bleeds up to 135,000 animals and releases them, unfortunately to local waters in Cape Cod, not back to NYS waters as required by the NYS DEC permit. Many of those animals are "re-harvested" for bait and sold back to NYS fishermen (anonymous reference), at an average cost of US $5/crab, thus making it extremely economical to all involved.

There has been no formal, consistent or reliable, horseshoe crab habitat inventory established on Long Island. An annual survey since 2011 of eight beaches, supported by NYS DEC, by Cornell Cooperative Extension, has concentrated on characterization of the breeding horseshoe crabs on those beaches. Their annual total numbers of horseshoe crabs per site have been included as sites for the Molloy College Long Island Horseshoe Crab (LI HSC) inventory. The Molloy College inventory is identifying breeding habitats, defined by observations of breeding pairs and eggs in sand. The majority of 68 breeding sites (Fig. 12.1) have been visited at least one time each season. If a site is visited more than once in a season, the average of the count is used as "site–use" by breeding horseshoe crabs. All 68 sites have been subject to illegal harvesting, which can have untold impact on the sites productivity. There are sites with added protection against poaching such as Jamaica Bay, in New York City, where the National Park Service has a total ban restriction on harvesting crabs for bait, due to this habitat site being within the boundary of a US National Park Unit, the Gateway National Recreation Area (Tanacredi 2001).

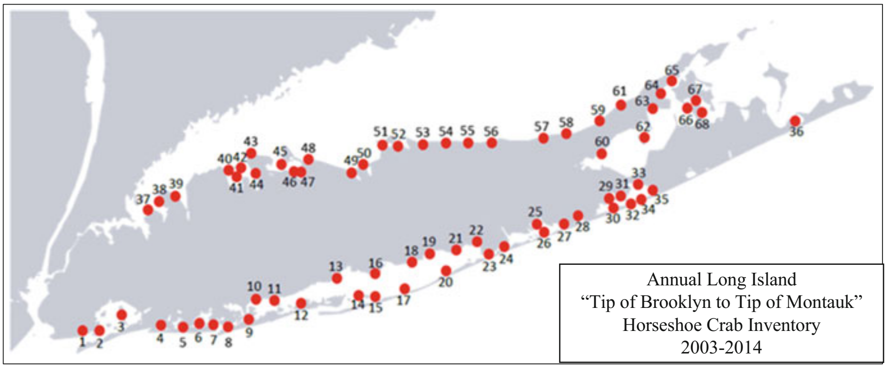

Fig. 12.1 Map of the Long Island Horseshoe Crab Inventory with 68 sites denoted by *red circles*

It has been documented that such beach inventories of spawning horseshoe crabs, with similar water quality conditions, sediment quality and limited access for harvesting, reveal inconsistencies in population numbers over time (Fig. 12.2). Geographic Information System maps of LI HSC populations establish that successive generations annually use the same beaches for breeding and that HSC exhibit considerable site fidelity (Berkson and Shuster 1999).

12.2 Materials and Methods

Annually commencing in 2003, volunteer "Beach Captains" after a 3-h orientation session, visit each of the 68 beaches identified in Fig. 12.1. The survey location was recorded by GPS (global positioning system) for repeated sampling. Over a period of 1–2 h, and a minimum of 50 yards (ca. 46 m), each beach is walked and all HSC counted. Animals are counted, sexed and any "unique observations" recorded on a standard form (Table 12.1). Additional beaches to a grand total of 101 sites mentioned may have been counted; however, only 68 beaches were monitored since 2003, the first year of the inventory because they were all "originally" identified as sites where there were horseshoe crabs historically in "large" numbers.

12.3 Results

Results of the 68 sites monitored annually reveal (1) considerable reduction of HSC population than "remembered in the past"; (2) sites along the Long Island coastline now believed to support HSC have been found to have few to modest numbers of HSC; (3) a very preliminary number projection of *Limulus* on Long Island at an average of 5,000+ adult breeding individuals on the beaches surveyed; (4) of the 68 beaches monitored since 2003, an increase of 8.2 % had been observed for the number of beaches exhibiting "no breeding activity" (Fig. 12.2); and (5) there has been observed an average of 1 % per year decline in the total number of HSC observed (Fig. 12.3).

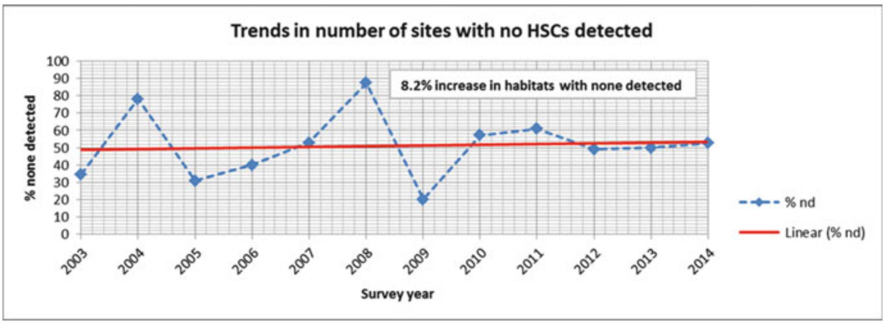

Fig. 12.2 Trend in number of spawning habitat sites with no horseshoe crabs detected

Table 12.1 Long Island Horseshoe Crab Inventory data submission form

Molloy College Long Island Horseshoe Crab Network*

Date: ____________ Year: ____________ Team # ________ (Registered Teams only)

Location: ____

____

____

GPS coordinates: _________._____N _________._____W

Tide: High ☐ Tide ☐ Tide ☐

Observations:

Number of Horseshoe Crabs at site ____________

Number of Males ______ (see back for description) Number of Females ______ (see back for description)

Prosoma Measurements (see back for description)
One measurement per box

Encrusting Organisms: ____

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____

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Recorded by __________________________ Telephone # ______________________

* Call Dr. John Tanacredi at (516) 323-3591 for more information

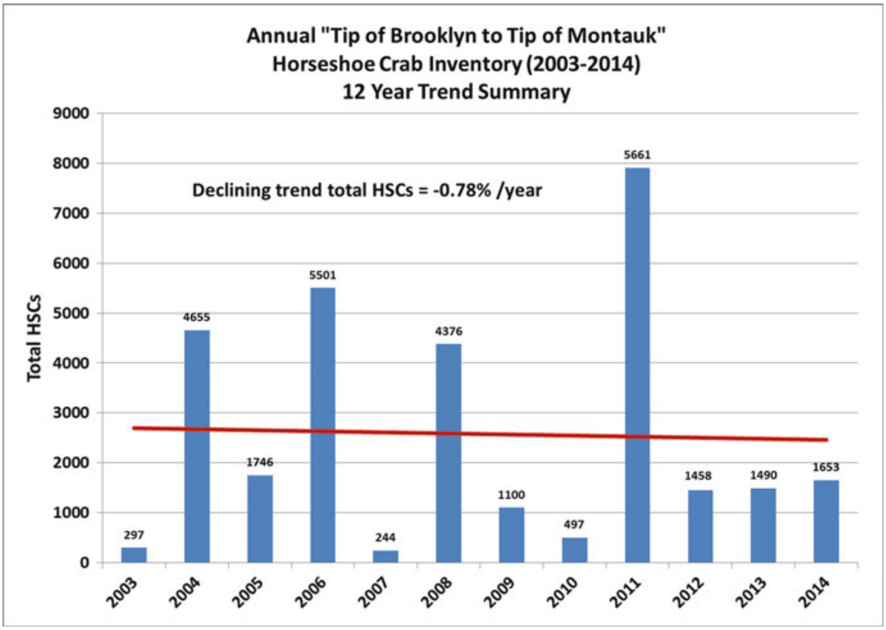

Fig. 12.3 Long Island Horseshoe Crab Inventory from 2013 to 2014

12.4 Discussion and Conclusions

Urbanization of sprawl on Long Island has increased coastal development requiring greater volumes of wastewater and surface runoff to empty into estuarine habitat resulting in decreasing water quality for natural ecosystem functioning. Comprehensive long-term monitoring programs are rarely found to be able to track all the variables that can affect sustainable populations in natural systems (Botton 2001). Moratoriums have been suggested on harvesting HSC, yet they are usually for trial periods too short to adequately investigate all symptoms contributing to potential extinction events (Sekigchi 1988). Observed declines that are not precipitous can always lull our efforts into complacency, with offers of experimenting with "reductions in harvests," "synthetic baits and pharmaceuticals" and "increased conservation efforts" to stave off the chronic reductions observed each year. Even with a fair debate of the actual numbers of HSC on Long Island, there is a clear continuous downward trend that should not be taken lightly. Considerable progress in preserving these animals by restricting their harvesting for bait and recommending alternative baits for these niche fisheries are proposed. In the pharmaceutical procedures in harvesting for blood, a single mandatory stipulation that all HSC collected for bleeding must be returned to the waters where they were collected with immediate notification to the regulatory agency responsible to observe this action as it occurs so as to assure local population maintenance. If added protection can be established with protection of "breeding beaches" or coastlines from any further habitat loss by development or habitat degradation, all the necessary ingredients for HSC protection could be applied on a global scale (Shuster 1981).

On a human scale, HSC (specifically *Limulus polyphemus*) have been of exceptional value to our health as a model for vision research (which has resulted in a Nobel Prize); used in the biopharmaceutical industry as well as in immunological products; and, in ecological terms critical in the preservation of migratory avian species with synchronous migrating patterns over eons of time. HSC will continue to provide important insights as long as humankind ensures the conservation of this rare living fossil. The future appears foreboding (Cohen and Bang 1979; Brockman 1996; Botton et al. 1998). The current status and conservation needs are *not* definitively known for all extant species. There are only four species globally (Sekiguchi and Shuster 2009). At present the IUCN lists three of these species as "data deficient". There is a need for a global assessment of the ongoing research and conservation needs for HSC including such aspects as "by-catch" impacts, prime habitat loss, shoreline development pollution concerns, pharmaceutical harvesting, food consumption and use for bait in eel and conch fisheries (Botton 2001).

Horseshoe crabs are relicts of an ancient class of Arthropods, most members of which have been extinct for hundreds of millions of years. The eggs of these "living fossils" (Eldredge and Stanley 1984) laid each spring on intertidal shores from Maine to the Yucatan in Mexico, with their reproductive epicenter located in Delaware Bay, provide the vital nourishment for hundreds of thousands of migrating shorebirds. This annual spectacle of HSC spawning and bird feeding is critical to the survival, or, most certainly the individual species that maintain their sustenance, to get from South America to breeding grounds in the Arctic. Adult HSC are also food for Loggerhead sea turtles (*Caretta caretta*) and their eggs are food for a variety of juvenile fishes (see http://www.horseshoecrab.org/nh/eco.html).

Limulus amoebocyte lysate is today a required test on most injectable drugs. LAL is a product from the blue blood of HSC (copper based) and is a rapid test for endotoxemia, saving countless lives in hospital stays. Even National Aeronautics and Space Administration (NASA) had used LAL to determine more precisely the level of contamination from microbes, whether dead or living, that may cause "life-detection instrument systems" on the Mars missions to be fooled in our search for extra-terrestrial life forms. Exploration of the HSC genetics is also critically important to determine future local population pressures.

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