History of Horseshoe Crab Harvest on Delaware Bay

Gary Kreamer and Stewart Michels

Abstract Horseshoe crab (*Limulus polyphemus*) harvest on Delaware Bay is not a new event. Early settlers to the New World reported use of horseshoe crabs by Native Americans for food, tools, and to enrich soils for growing crops. Literature from the mid- to late 1800s documents the use of horseshoe crabs for fertilizer and to supplement livestock feed. By the 1870s and for almost a century thereafter, well over a million crabs were harvested annually from Delaware Bay, in support of a regionally significant "cancerine" (fertilizer) industry. Subsequent to the cessation of the cancerine industry in the mid-twentieth century, relatively low-scale use of horseshoe crabs as bait for American eel and other fisheries existed. This use exploded in the 1990s, as eel markets expanded and use of horseshoe crabs for bait in a rapidly emerging whelk (*Busycon* spp.) pot fishery intensified along the East Coast of the United States. With horseshoe crabs spawning in mass along the shores of Delaware Bay, and little or no regulations in place, harvest pressure once again approached levels of the fertilizer use days. Simultaneously, an ongoing need for bleeding of horseshoe crabs to provide *Limulus* amebocyte lysate (LAL) for biomedical use, and growing recognition of the importance of horseshoe crab eggs on Delaware Bay as a key stopover food source for migratory shorebirds prompted concerns about observed declines in the population, resulting in implementation of significant management measures to ensure the sustainability of the species.

1 Introduction

The harvest and use of the American horseshoe crab, *Limulus polyphemus*, on Delaware Bay, is not a recent phenomenon. In this chapter, we will summarize aspects of that harvest relative to three phases, each corresponding roughly to a

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particular time period and focus of usage: (1) use by indigenous inhabitants of the bay area for food and tools in the centuries prior to European settlement; (2) agricultural (fertilizer and livestock feed) use by European settlers in the 1800s and 1900s; and (3) concentrated harvest of crabs for bait and biomedical applications during the last several decades.

Before exploring those aspects, it is important to put into context the relative timeframe for horseshoe crab/human interactions on Delaware Bay. Although Delaware Bay is clearly the current global hotspot for horseshoe crab spawning and fossil evidence shows that horseshoe crabs have been inhabiting the planet for more than 350 million years, these two facts are sometimes erroneously put together to imply that horseshoe crabs have been coming in mass into Delaware Bay to spawn for hundreds of millions of years. In fact, the Delaware Bay was formed less than 12,000 years ago after the last ice age (Kraft 1988), and development of the estuarine tidal nature of the Bay is thought to be less than 5,000 years old (Custer 1984; Fig. 1). Given these timeframes, it seems likely that the use of Delaware Bay for spawning by horseshoe crabs probably increased gradually over the last 3,000 or 4,000 years.

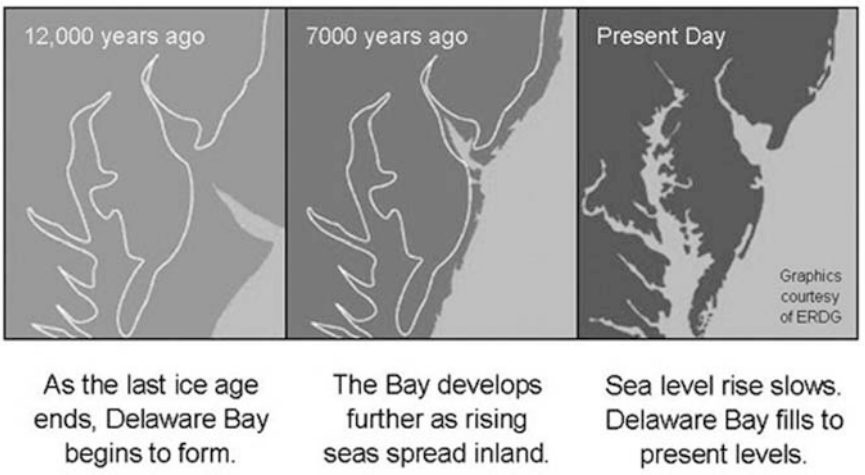

Fig. 1 The formation of Delaware Bay (graphics courtesy ERDG, www.horseshoecrab.org)

2 Native American Use of Horseshoe Crabs

We do not know precisely when humans began to use of horseshoe crabs in the Delaware Bay. Given the probable abundance and ease of harvest of spawning horseshoe crabs and the resourcefulness of native peoples in using

what nature provided, it seems likely that the nomadic hunter-gatherers who inhabited the bay area in the millennia before European settlement (Custer 1984) found ways to use *Limulus* for food and tools. One can find numerous references in the literature to the use of horseshoe crabs by native peoples, including the use of carapaces to bail out canoes and the telsons for spear tips (Grant 2001; Shuster 2003; Hall 2007). However, because no such artifacts have been discovered and documented from archaeological digs in this region, it has not been proven that such uses existed or were prominent. Because these peoples produced no written history and horseshoe crab chitin would tend not to be preserved over such extended time periods, it is unlikely that direct evidence would be uncovered to support such uses.

Most of what we know about native use of *Limulus* has been extrapolated from sketchy accounts of early European chroniclers of the New World. One of the earliest references was in 1590 by English biologist Thomas Harriot who alluded to horseshoe crabs or "Seekanauk" (native American name for horseshoe crab) as *a kind of crusty shell fish which is good meat, about a foot in breadth, having a crusty tail, many legs like a crab, and her eyes in her back*. (Harriot 1972)

The artist John White, who accompanied Harriot as recorder, produced the scene shown in Fig. 2 illustrating native fishing methods. This piece includes the first known depiction of *Limulus* (see Fig. 2, bottom right). It also shows in the far background, natives fishing with spears, which Harriot (1972) describes in caption as follows: *They have a striking method of fishing in the rivers. For, since they lack iron and steel, they put the hollow tail of a certain fish like a sea crab onto their reeds or long rods for a point, with which at night or by day they spear fish and heap them up in their small boats*. According to certain interpretations of this passage (Feest 1978; Hulton 1984; Chartier 2006; www.virtualjamestown.org/images/white_debry_html/white.html), the "hollow tail" is the telson of horseshoe crab. However, since earlier in Harriot's writings he mentions, "sea crabs, such as we have in England," separately from his description of horseshoe crabs, it may well be that the spear tips he describes are not derived from horseshoe crabs at all, but from some form of crustacean (C. Blume, Delaware Division of Parks and Recreation, personal communication.).

Recently, we received a request from a Native American, Buddy "White Cloud" (Jett, of the Patawomeck Indian Tribe of Virginia, personal communication) for several horseshoe crab telsons, which he intends to mount on hardwood shafts "to recreate the type of fishing spears and gigs that our ancestors may have used." Mr. Jett made his request after reading Harriot's description of horseshoe crabs. We sent Mr. Jett several *Limulus* telsons for use in crafting spears, and we anxiously await the results of his efforts. Regardless of how that endeavor pans out, many questions remain to be resolved regarding traditional use of *Limulus* by native peoples.

Fig. 2 An illustration entitled "The Method of Fishing of the Inhabitants of Virginia" by John White for Harriot's 1590s writing (Hulton 1984). By Permission of The Manners' Museum, Newport, News, VA

3 Use of Horseshoe Crabs in Agriculture

By the time Europeans settled the Delaware Bay area, native people were supplementing what they fished, hunted, and gathered by growing their own food (Custer 1984). Samuel de Champlain, in his early 1600s explorations of the New World noted use of horseshoe crabs by native people living along the Maine coast to manure their corn crops (Morison 1972). According to Fowler (1946), Champlain also observed these natives using a hoe that was made from the shell of a horseshoe crab. Although not documented for Delaware Bay, it is speculated that natives there similarly learned to work dead horseshoe crabs into the soil to improve their crop yields and passed this knowledge on to the colonists (Hall 2007).

There is ample evidence that by the 1800s, farmers in the Delaware Bay area had adopted this practice (Shuster 2003). The early literature is replete with testimonials to the efficacy of this approach: "The dead bodies of the (crabs) themselves are hauled up in wagons for manure, and when placed at the hills of corn, in planting time, are said to enrich the soil, and add greatly to the increase

of the crop." (Brewer 1840); "Mr. Springer of Dyer's Creek, with a compost of 7,000 crabs, 20 loads of muck, 2 coal-pit bottoms, 7 or 8 loads of hay, and manure applied on 6 acres of sandy loam, raised 151½ bushels of wheat." (Goode 1887); and "On land which would not grow wheat at all up to that time, crops of 20, 25 and even 30 bushels to the acre have been raised by the use of these crabs composted with earth" (Fowler 1908). Similar accounts of the use

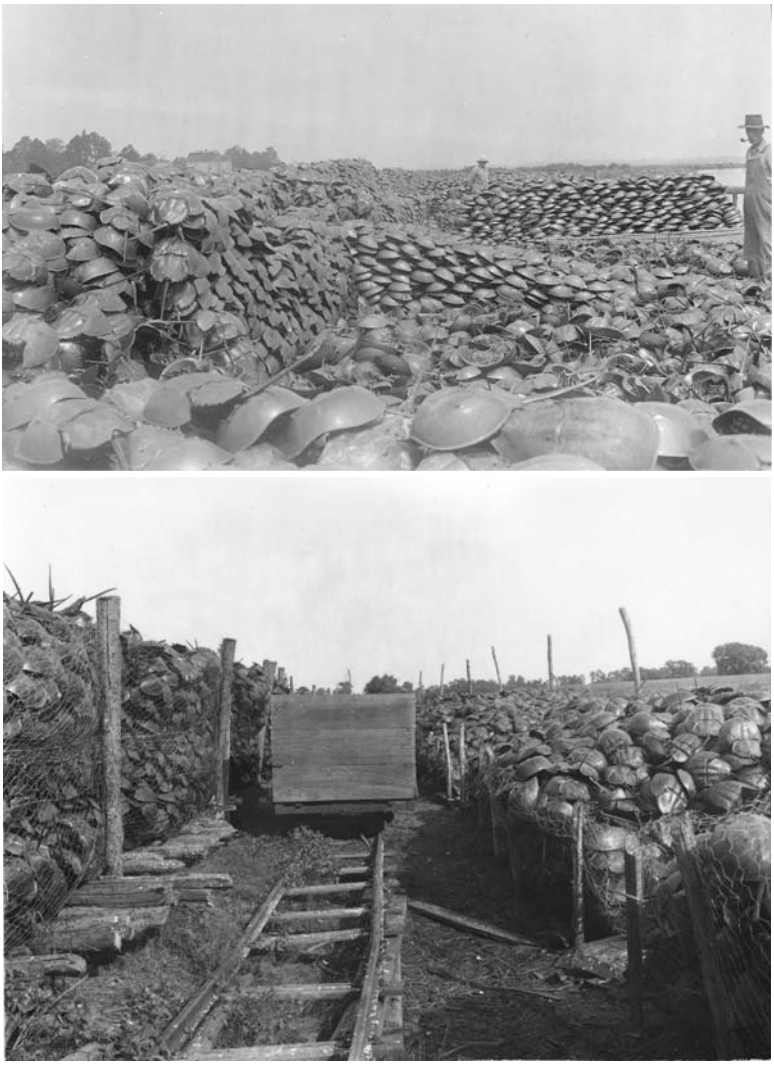

Fig. 3 "King Crabs" stockpiled to dry for fertilizer use near Bowers Beach, DE in the 1920s (photos courtesy of Delaware Public Archives)

of composted horseshoe crabs to fertilize other crops exist, including reference to their use in Delaware peach orchards during the mid-1800s (Shuster 2003).

It is also documented that farmers used a portion of the crabs gathered as food for livestock feed, either fed whole to hogs or made into a mash for chickens (Shuster 2003). Writings from that time also describe deposits of eggs so thick on bay beaches that farmers shoveled them up by the wagonload to use as chicken feed (Goode 1887).

Through the late 1800s and early 1900s, as more and more lands were cleared for farming, the need for more horseshoe crabs to fertilize the fields grew. Factories sprung up on both sides of the bay to process the masses of crabs harvested into a fertilizer meal. Because horseshoe crabs were thought to be crustaceans, the product was called "cancerine," meaning "derived from crabs" (Shuster 2003).

The magnitude of horseshoe crabs harvested for agricultural use during that period of time is astonishing. In 1856, more than a million crabs were taken from a 1-mile stretch of New Jersey beach (Cook 1857), and in 1 year (1880), over 4 million crabs were harvested from the Bay (Smith 1891). As late as the 1920s, archival photos attest to the masses of crabs harvested and stockpiled for this purpose (Fig. 3).

Shuster (2003) describes the methods used to collect and process horseshoe crabs to make cancerine. Masses of crabs were collected effectively on the New

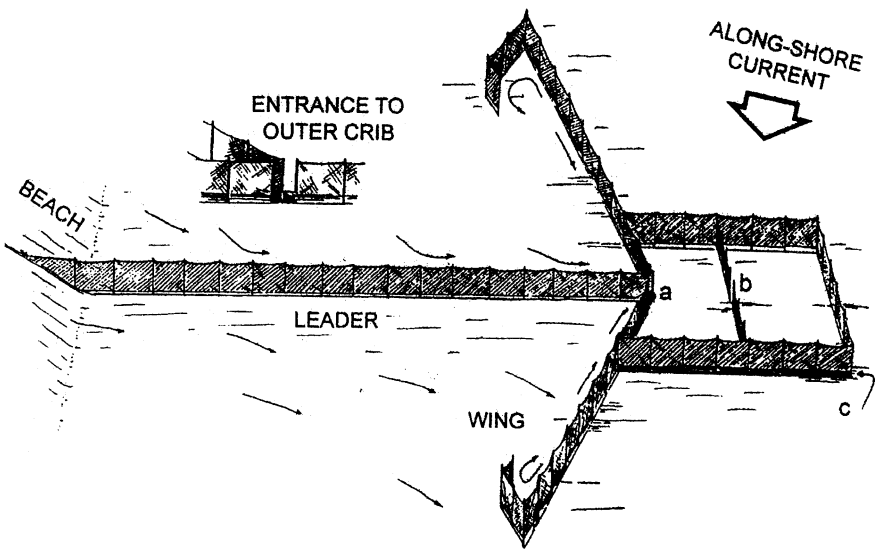

Fig. 4 The "pound" method of harvesting horseshoe crabs for fertilizer use in New Jersey. As the tide receded, crabs leaving the beach after spawning were guided by the leader and wings and trapped in the outer crib (illustration used with permission of Carl N. Shuster Jr.)

Jersey side of the bay by use of special arrays of wooden stakes called "pounds," which were strategically placed in nearshore bay waters to direct and trap large numbers of crabs as they moved to and from the spawning beaches (Fig. 4; Smith 1891; Shuster 2001).

At low tide, crabs were removed by horse-drawn wagon or scow and transported to drying areas or directly to fertilizer plants (Figs. 5, 6). Inside these

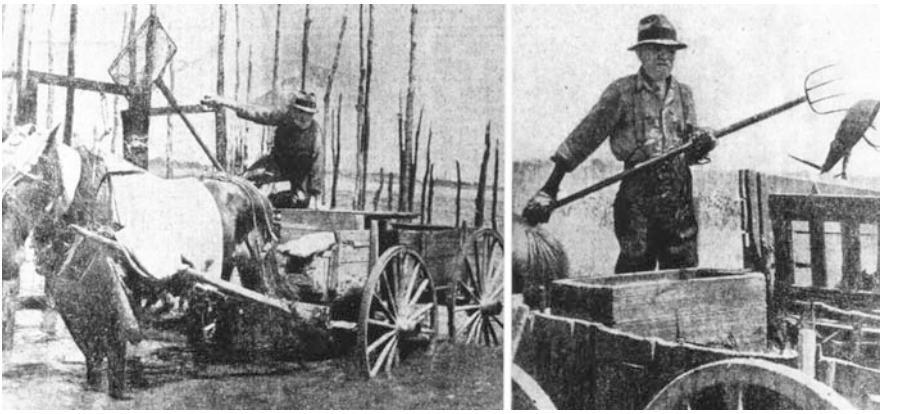

Fig. 5 In the 1800s, horse-drawn wagons were commonly used to remove horseshoe crabs from the spawning beaches (photo courtesy of Delaware Public Archives)

Fig. 6 "Cancerine" plant in Milford, DE (circa 1920s). Note the wagonload of crabs with telsons sticking up pulled up in front of the barn (photo courtesy of Delaware Public Archives)

plants were massive grinders for crushing the crabs and sometimes furnaces to steam them prior to turning them into the ground meal product that was ultimately bagged and sold to farmers for fertilizer (Shuster 2003). Over a million horseshoe crabs per year for over a half century were harvested from Delaware Bay for use as fertilizer (Fig. 7).

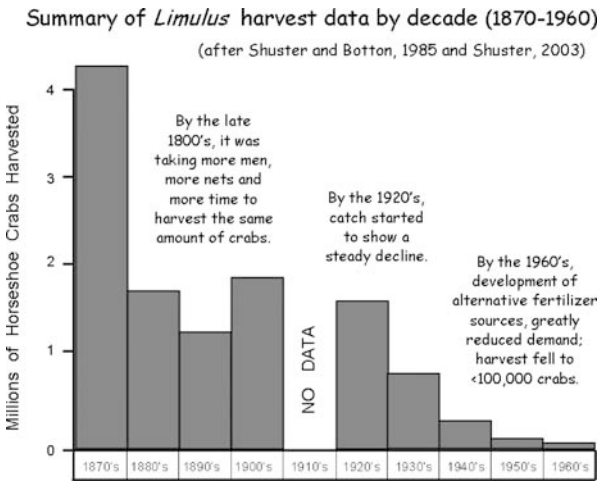

Fig. 7 A century of horseshoe crab harvest on Delaware Bay (1870s–1960s). Adapted from Shuster and Botton (1985)

By the late 1800s, there was evidence of declining populations, as it was taking more men, gear and time to harvest the levels of previous decades (Smith 1891). By the 1930s, harvest levels had declined dramatically (Shuster 2003). Fortunately by the 1960s, development of alternative fertilizer sources had offset the demand for using horseshoe crabs. By the 1970s, all cancerine plants in Delaware and New Jersey had either shut down or had been converted to other purposes (Shuster 2003). This provided the *Limulus* population on Delaware Bay with a brief chance to rebuild before the next wave of harvest pressure arrived.

Figure 8 provides a comparison of the economic value of past and present horseshoe crab harvest. Although not adjusted for inflation and other economic indicators, the value of horseshoe crabs has increased from the 1800s when a single crab was worth just a fraction of a penny to recent times when a crab is worth a dollar or more.

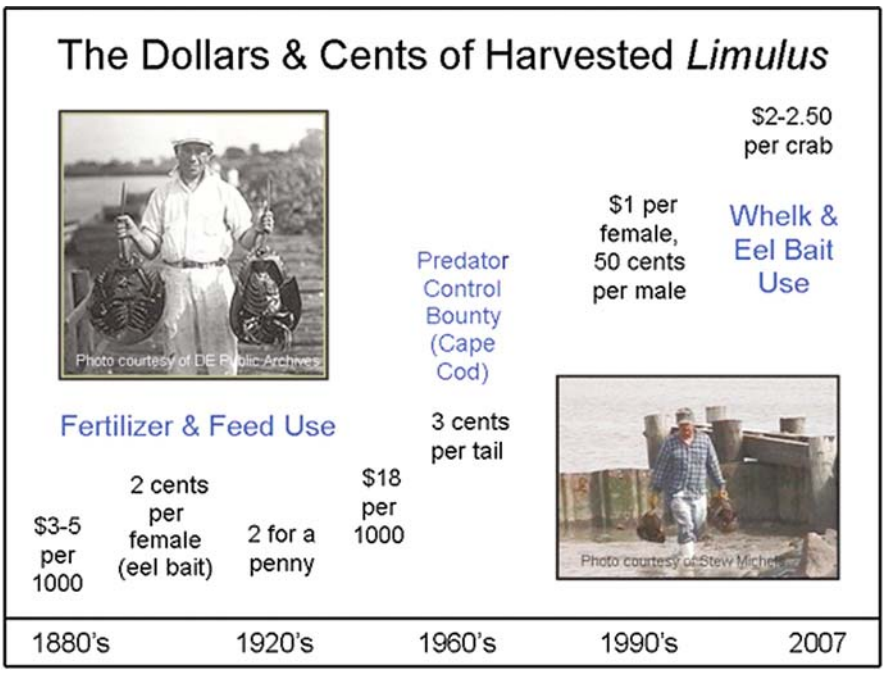

Fig. 8 A summary of data on the economic value of harvested horseshoe crabs from 1870s to the present (compiled from information in: Smith 1891 and Shuster 2003)

4 Recent Use of Horseshoe Crabs on Delaware Bay

Similar to horseshoe crab harvest in previous centuries, horseshoe crabs have continued to be used and valued in recent decades. In the 1990s, there was an explosion of use of horseshoe crabs as bait in coastwide whelk and eel fisheries and for biomedical applications. Horseshoe crabs have become important to a substantial and growing eco-tourism industry.

4.1 American Eel Pot Fishery

Horseshoe crabs serve as a primary bait source in the American eel (*Anguilla rostrata*) pot fishery in the Delaware Bay region. The use of horseshoe crabs for this purpose dates back to at least the 1800s when eels were landed to supply domestic food markets (Goode 1887). Eels landed in recent years have been used to supply domestic and international (Europe and Asia) food markets (Manion et al. 2000). Annual reported eel pot landings in the mid-Atlantic declined from the late 1980s to the present. However, this decline may not reflect a decreasing demand for horseshoe crabs as bait, as eel prices remained high (Fig. 9) (http://www.st.nmfs.noaa.gov/st1/commercial/). In the 1990s, eel

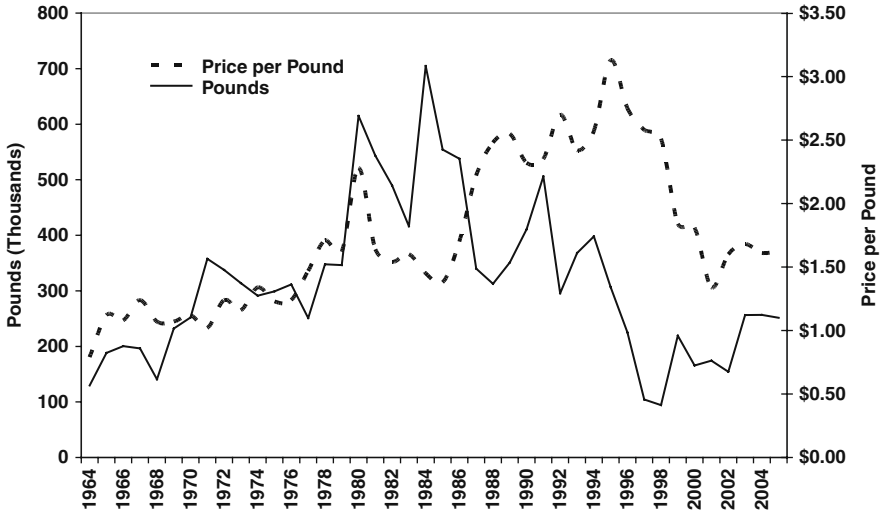

Fig. 9 Annual reported US mid-Atlantic American eel pot landings (thousand of pounds) and price per pound (exvessel value updated to 2007 dollars). Source: http://www.st.nmfs.noaa.gov/st1/commercial/

landings shifted to smaller eels to use as bait for recreational fishing of striped bass (*Morone saxatilis*).

Through the 1990s Delaware Bay eel potters typically used a half to a whole horseshoe crab to bait each pot (Munson 1998). The eel pot fishery in the Delaware Bay area almost exclusively uses female horseshoe crabs. Fishermen

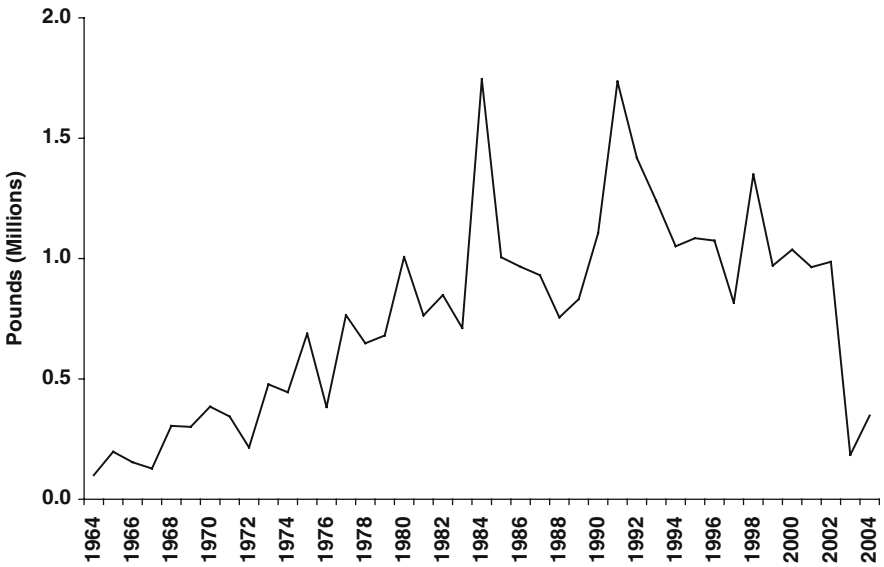

Fig. 10 Annual reported whelk (conch) pot landings (millions of pounds) for the US Atlantic Coast. Source: National Marine Fisheries Service

routinely report that horseshoe crabs are by far the best bait that can be used to pot eel, though many have tried alternatives, such as clam, shrimp heads, and cat food.

4.2 Whelk Pot Fishery

Horseshoe crabs are also used as bait in the Delaware Bay whelk (*Busycon* spp.) pot fishery. Whelk landings support domestic and international food markets. Domestically, whelk meat is used principally in ethnic markets in the Northeast United States, whereas international use is concentrated in Asia (Manion et al. 2000). Coastwide-reported whelk pot landings increased substantially in the mid-1980s and remained high through at least 2002 (Fig. 10) (http://www.st.nmfs.noaa.gov/st1/commercial/). Growth of this fishery was attributable to restrictions and declines in other fisheries, which forced fishers to find alternative sources of income.

The whelk pot fishery uses male and female horseshoe crabs, though female crabs are preferred. Through most of the 1990s, whelk pot fishermen typically used a whole female or two male horseshoe crabs to bait each pot.

4.3 Other Fisheries

Horseshoe crabs in the Delaware Bay were also used as bait in the catfish (Ictaluridae), minnow (Cyprinidae), and killifish (Cyprinodontidae) trap fisheries. There is no documented information on the extent to which horseshoe crabs are used in the catfish fishery, but use for this purpose is generally considered minimal relative to the eel and whelk pot fisheries. Munson (1998) reported that four minnow/killifish harvesters operating in NJ used an average of 4,125 horseshoe crabs annually. There were no similar records of horseshoe crab use in this fishery from Delaware, though there are anecdotal reports of individuals using horseshoe crabs for this purpose.

4.4 Biomedical Horseshoe Crab Fishery

Horseshoe crabs have been harvested from the Delaware Bay for use in the manufacture of *Limulus* amebocyte lysate (LAL) since 1982 (B. L. Swan, Limuli Laboratories, personal communication). LAL is used as the worldwide standard for detecting bacterial endotoxins in intravenous drug and medical devices. Horseshoe crabs are bled and returned to the water alive. There is some mortality associated with the harvesting, transport, and bleeding process. Reported mortality associated with bleeding has ranged from 2.1 to 15% (Swan 2001; Thompson 1999). There is only one biomedical bleeding facility located on the Delaware Bay and it is the smallest of the facilities coastwide. Biomedical landings specific to the Delaware Bay are not available due to confidentiality concerns; however, the use of horseshoe

crabs for this purpose is annually monitored by the Atlantic States Marine Fisheries Commission (ASMFC). Coastwide mortality associated with bleeding horseshoe crabs has remained below 57,500 crabs since 1998 (ASMFC 2007).

4.5 Horseshoe Crab Bait Landings

Reported horseshoe crab landings increased in response to demand of the crabs for bait through the late 1990s (Fig. 11) (http://www.st.nmfs.noaa.gov/st1/commercial/). Though true increases are difficult to assess due to incomplete reporting, corroborating evidence suggests that a precipitous increase in landings occurred. For example, the number of horseshoe crab hand harvest permits issued in Delaware increased from 10 in 1991 to 132 by 1997 (Whitmore and Greco 2005). Based on estimates from the ASMFC, average Delaware Bay area (DE, NJ, MD, PA and VA) landings were nearly 2 million crabs annually for the years 1995–1997 (ASMFC 2007) (Fig. 12). Virginia landings were included in the estimates, as a large proportion of the Virginia's harvest occurred in federal waters just off the mouth of Delaware Bay until establishment of the Carl N. Shuster Sanctuary in 2001. Development of the Interstate Fishery Management Plan for Horseshoe Crab (FMP) and its subsequent addenda, the use of bait savings devices by American eel and whelk fishermen, and the establishment of the Horseshoe Crab Sanctuary reduced the horseshoe crab harvest in the Delaware Bay area to less than 500,000 crabs by 2004.

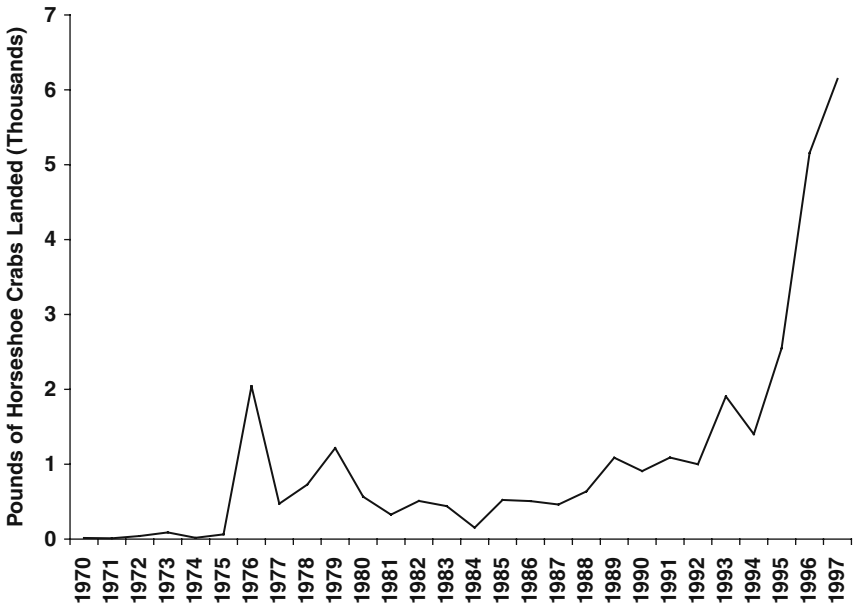

Fig. 11 Annual reported horseshoe crab landings (thousands of pounds) for the US Atlantic Coast. Source: National Marine Fisheries Service

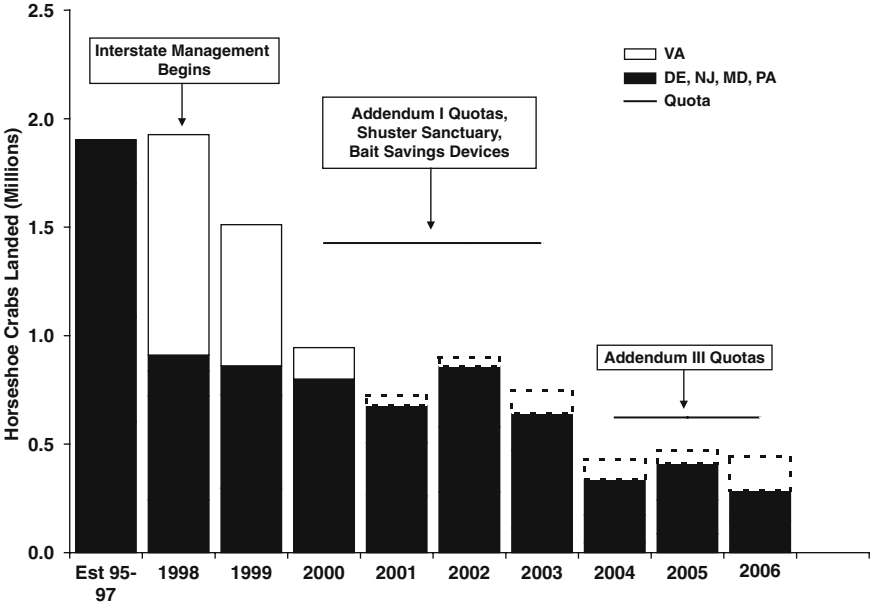

Fig. 12 Annual reported horseshoe crab landings (millions of crabs) from the states of DE, NJ, PA, and MD (*black bar*) and VA (*white bar*). Solid outline around white bar indicates a large proportion of these landings were Delaware Bay origin crabs; dashed outline around white bar indicates large proportion of landings from crabs not of Delaware Bay origin. Atlantic States Marine Fisheries Commission's mandated quota represented by solid horizontal line. Source: Atlantic States Marine Fisheries Commission

4.6 Ecotourism

An important non-consumptive use of the horseshoe crab comes in the form of ecotourism. The relationship between migratory shorebirds and horseshoe crab eggs in the Delaware Bay became well established by the early to mid-1980s. The crabs spawning and migratory shorebirds feeding upon their eggs attract birders, naturalists, researchers, and film crews to the Delaware Bay from around the world to view and document the spectacle. These visitors significantly contribute to local economies. Manion et al. (2000) estimated that expenditures related to horseshoe crab/migratory shorebird viewing contributed $6.8–$10.3 million per year to the economy of greater Cape May, NJ.

The birding and conservation communities have been the driving force behind horseshoe crab conservation efforts. Birding and conservation groups were largely responsible for the first horseshoe crab legislation aimed at protecting Delaware Bay horseshoe crabs in 1990 and they have played a prominent role in local and coastwide management since. Though there are indications that the Delaware Bay segment of the horseshoe population is stable or improving (Michels et al. 2007; Hata 2007), there continues to be a significant

concern that current population levels are not sufficient to support migratory bird populations. Thus, precautionary horseshoe crab conservation efforts continue, primarily in the form of fishery regulations, but also including habitat protection and beach augmentation. It remains to be seen how the horseshoe crab population on Delaware Bay will respond in the long term to these conservation measures, and how this translates to future developments in the rich and growing history of human connection to and reliance on these animals.

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